



An Australian Government Initiative



Fifteen Years of the Joint Venture Agroforestry Program

Foundation research for Australia's tree crop revolution

Pub. No. 09/063



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Innovation for rural Australia

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ISBN 1 74151 865 2
ISSN 1440-6845

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Publication No. 09/063
Project No. PRJ-004341

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Researcher Contact Details

John Powell
Optimal ICM
Woodvale 301 Old Gap Road
YASS NSW 2582

Phone: 02 6226 5298
Mobile: 0427 265 298
Email: jpowell@optimalicm.net.au

In submitting this report, the researchers have agreed to RIRDC publishing this material in its edited form.

RIRDC Contact Details

Rural Industries Research and Development Corporation
Level 2, 15 National Circuit
BARTON ACT 2600

PO Box 4776
KINGSTON ACT 2604

Phone: 02 6271 4100
Fax: 02 6271 4199
Email: rirdc@rirdc.gov.au
Web: <http://www.rirdc.gov.au>

Bookshop: www.rirdc.gov.au
1300 634 313

Electronically published by RIRDC in June 2009
Print-on-demand by Union Offset Printing, Canberra at www.rirdc.gov.au
or phone 1300 634 313



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Foundation research for Australia's tree crop revolution

by John Powell

RIRDC Publication No 09/063

June 2009

About the Author

John Powell (B App Sc, Cert IV in Workplace Training and Assessment) established his consulting business ‘Optimal ICM’ in March 2001. It is a national firm specialising in agricultural and natural resources research management, and extension and adoption of research results. Key clients are research funders and providers, public policy analysts and program managers, regional NRM organisations, and farming and grazing groups and networks.

John has had a 27 year professional career in natural resources management that has included: developing and managing Australian Government and Murray-Darling Basin Commission (MDBC) landcare funding programs; establishing joint ventures in dryland farming systems R&D between MDBC and rural industry Research and Development Corporations; directing and managing the MDBC Dryland R&D program for seven years; and designing and drafting the 15-year MDBC Basin Salinity Management Strategy.

John has been a commercial-scale wool and meat producer and farm forester in the Yass Valley near Canberra for 21 years.

Acknowledgments

Reviewing the large volume of JVAP-related material and synthesising it down to this report has been a challenging task.

Support and assistance from the following people has been invaluable:- current JVAP Research Managers Bruce Munday and Lisa Robins; draft report reviewers Andrew Campbell and Glen Kile; members of the JVAP Technical Advisory Committee; LWA’s Manager Landscapes R&D Jim Donaldson; the founding JVAP Manager Roslyn Prinsley; RIRDC’s General Manager Research Margie Thomson; RIRDC’s Project Manager Helen Moffett; and RIRDC Publications staff Cecile Ferguson and Christine Joannides.

Abbreviations

ABARE	Australian Bureau of Agricultural Resource Economics
AFG	Australian Forest Growers
ALRTIG	Australian Low Rainfall Tree Improvement Group
CRC Salinity	Cooperative Research Centre for Plant-based Management of Dryland Salinity
FFI CRC	Future Farm Industries Cooperative Research Centre
FWPA	Forest & Wood Products Australia
JVAP	Joint Venture Agroforestry Program
LWA	Land & Water Australia
MDB	Murray-Darling Basin
NLWRA	National Land and Water Resources Audit
PNF	Private Native Forest
RIRDC	Rural Industries Research and Development Corporation

Foreword

The Joint Venture Agroforestry Program (JVAP) was established in 1993. The Program invested a total of about \$29 million, while leveraging an equivalent amount from research providers and industry. R&D Plans were developed for each phase to guide its investments. Although JVAP adapted over the years to address new issues as they emerged, there were several common themes over its duration:

- national leadership, funding support and coordination for Research, Development and Extension (R, D & E) to build confidence in agroforestry's capacity to enhance agricultural sustainability while providing additional public benefits
- an aspiration for agroforestry to be commercially viable, through either combined returns from public and private benefits, or from having sufficient scale to be profitable in its own right
- consultation with the industrial plantation forestry sector, without seeking to be a principal funder of R, D & E for that sector

The aim of this report is to increase public awareness of the role, value and potential of farm forestry and agroforestry and to highlight the importance of focussed national research and development. It highlights the broad scope of JVAP and its main achievements, and comments on how significant the knowledge being generated by JVAP was at the time. The report synthesises what is currently known, mostly from JVAP research, about four main agroforestry topics: Farm forestry for multiple benefits; Products and markets; Public policy, investment options, grower initiatives; and Socio-economic issues, training and extension. Importantly, this report interprets the relevance of the knowledge for today's issues. In writing the report, more than 200 research reports, papers, articles and websites were reviewed. For the most part, these were accessed from the RIRDC website, and from the JVAP hard copy library in Canberra.

This project was funded by the Joint Venture Agroforestry Program (JVAP), which is supported by three R&D Corporations—Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia (L&WA), and Forest & Wood Products Australia (FWPA). The R&D Corporations are funded principally by the Australian Government.

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

Most of RIRDC's reports are available for viewing and free downloads from www.rirdc.gov.au. Reports can also be purchased online from www.rirdc.gov.au or by phoning 1300 634 131.

Peter O'Brien

Managing Director

Rural Industries Research and Development Corporation

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Executive summary



What the report is about

The report synthesises the knowledge generated by 15 years and about \$29 million dollars in investment in farm forestry research, development and extension (R, D & E). The report covers four main agroforestry topics: *Farm forestry for multiple benefits; Products and markets; Public policy, investment options, and grower initiatives; and Socio-economic issues, training and extension*. Importantly, this report interprets the relevance of the knowledge for today's issues and identifies future woody crop research, development and extension (R, D & E) priorities.

Who is the report targeted at?

Various parts and sections of the report will be of more interest to some readers than others. Its target audience is expected to encompass: government natural resources management program managers and policy advisers, rural industry R&D corporations, groups previously represented by Private Forestry Development Committees, agroforestry advisers, agroforestry and farm forestry networks including branches of Australian Forest Growers, forestry companies managing joint ventures and the like with farmers, informed landholders, regional NRM bodies, Greening Australia, regional development organisations and other State and local government agencies.

Background

This report was commissioned by JVAP to increase public awareness of the role, value and potential of farm forestry, and to highlight the significance of JVAP's research achievements over the past 15 years.

Aims and objectives

The aim of the report is to capture the significance of earlier JVAP research, but profile it in the context of today's issues. These include emerging markets around carbon sequestration, the proposed *Carbon Pollution Reduction Scheme*, environmental services, along with issues such as water shortage and access rights, and regional natural resources management.

Methods used

The report is a desktop study conducted by the author, in consultation with JVAP Research Managers (and also the inaugural Manager), the JVAP Technical Advisory Committee, and other leading agroforestry experts. In writing the report, more than 200 research reports, papers, articles and websites were reviewed. For the most part, these were accessed from the RIRDC website, and from the JVAP hard copy library in Canberra.

The JVAP Technical Advisory Committee has accepted the report as an accurate assessment of JVAP's 'body of work'.

Results and key findings

Although JVAP has adapted to changing circumstances over its three five-year phases (1993-1998, 1999-2004, and 2004-2009), it has had three common themes for its duration:

- National leadership, funding support and coordination for Research, Development and Extension (R, D & E) to build confidence in agroforestry's capacity to enhance agricultural sustainability while providing additional public benefits
- An aspiration for agroforestry to be commercially viable, through either combined returns from public and private benefits, or from having sufficient scale to be profitable in its own right
- Consultation with the industrial plantation forestry sector, without seeking to be a principal funder of R, D & E for that sector

In writing this synthesis report, ten key messages concerning farm forestry emerged:

1. Except for short-rotation pulpwood, the profitability of 'traditional' farm forestry, including thinning private native forest (PNF), is generally marginal in higher rainfall areas. In medium to low rainfall areas, 'traditional' farm forestry is for the most part unprofitable
2. Emerging markets (in carbon sequestration, bioenergy and biofuels) have the potential to profoundly change the profitability of farm forestry. Carbon 'farming' appears to offer significant potential for 'mainstream' farmers to add to and diversify their income streams, and/or mitigate emissions from their livestock and cropping operations – this introduces the concept of 'woody crops' to the realm of agroforestry
3. There are encouraging signs that the lack of early financial returns for 'traditional' farm forestry are being overcome by innovative processing technologies that enable high-value products such as appearance grade timber to be produced from short-rotation pulpwood grown in higher rainfall areas and pruned sawlogs
4. The 38 million hectares of private native forests (PNF) have significant potential to augment diminishing hardwood sawlog supplies from public native forests. Enhancing research into the biodiversity outcomes of good silvicultural management, combined with development of metrics to underpin markets in environmental services from PNF will assist in realising their potential
5. JVAP and other programs have greatly enhanced understanding of the water and salinity effects of tree and shrub plantings. Although the research was driven by the paradigm of managing excess water in the landscape,

the knowledge has much to offer the new, more complex challenge – how to achieve an optimal balance between recharge control and runoff

6. There are considerable costs associated with developing Market-Based Instruments (MBIs) for farm forestry. MBIs appear to have particular value for PNF management where there are commercial trade-offs associated with meeting community expectations and standards for biodiversity conservation
7. With increasing rainfall predicted for northern Australia, there appears to be significant potential for good returns on investment from research into farm forestry in the wet and dry tropics.
8. JVAP has supported excellent extension and training initiatives, including the Australian Master TreeGrower program (AMTG) and plain-English syntheses of its major R&D areas. Apart from AMTG, there is limited understanding of the farm forestry-related knowledge, skills, attitudes and aspirations of JVAP's target audiences. Hence there is scope for improving communication and extension initiatives
9. Research to elicit the key drivers and barriers that influence behaviour of target audiences can optimise time, resources and effort in developing the farm forestry sector
10. It is critically important to engage key regional interests in consultation and planning for R, D & E and on-ground action, particularly where large scale plantings are proposed

Priority issues for a future woody crops R, D & E program, that involves key forestry and rural industries R, D & E organisations, are:

1. Tree crops for carbon sequestration and biomass-related industries
2. High-value, farm-grown, wood-based industries, such as short-rotation sawlogs, cabinet timbers in the wet tropics, and timber products in the dry tropics
3. The social trajectories, and relevant knowledge, attitudes, skills and aspirations of farming and regional communities who may become involved in growing the tree crops in 1 and 2
4. Integrating knowledge from 1, 2 and 3 in holistic assessments of the social, economic, water, biodiversity and agricultural export outcomes of various carbon sequestration, biomass-related and high-value wood-based industry scenarios and designs
5. Unlocking the potential of private native forests (PNF) through improved metrics and Market-Based Instruments

6. Knowledge sharing between research program investors and managers, researchers, and research users, to improve the direction and operation of research projects, and maximise adoption of outcomes

As a successful extension and adoption initiative, the Australian Master TreeGrowers brand and logo should be retained as the trusted and credible deliverer of woody crops knowledge through face-to-face learning activities.

Implications for relevant stakeholders

This report constitutes a valuable reference document, distilling 15 years of JVAP and some other relevant research. Consistent with JVAP's broad coverage of agroforestry-related issues, this report is also broad in its scope:

- PART A presents JVAP's funding partners, program goals, and how these have evolved over JVAP's 15-year history
- PARTS B, C, D & E synthesise what is currently known, mostly from JVAP research, about four main topics: *Farm forestry for multiple benefits; Products and markets; Public policy, investment options, grower initiatives; and Socio-economic issues, training and extension*
- PART F comments on where JVAP research has brought us, the opportunities which now exist for woody crops, and future priority issues

This report is a necessary first step in condensing and synthesising possibly 6000-10,000 pages of information from over 200 research reports down to about 75 pages. However, it cannot stand alone as an 'extension tool' to reach everyone within its intended audiences. Resources permitting, a series of more user-friendly extension products should also be produced, that could be appropriately tailored to each audience's needs and delivered to them according to their preferred learning styles.

Although some non-JVAP research findings have been referenced, it has not been possible within the time and resources available to the project to review all relevant research. Hence it is possible that some readers may reach different conclusions about some issues, based on their particular experience and knowledge.

Recommendations

It is recommended that forestry, woody crop, and meat, grains, wool and dairy R, D & E interests take this report into account during consideration of any future woody crops R, D & E program, and in developing activities to communicate and extend knowledge generated by JVAP over its 15-year history.

Introduction



The 'business case' for JVAP

When JVAP commenced in 1993, Government programs such as Landcare were encouraging broad-scale agroforestry (trees on farms) as a solution to problems such as salinity and soil erosion. There was also a vision that widespread agroforestry could provide additional wood supplies to offset the reduction in supplies from public native forests.

However, there was limited understanding of which trees would grow where, for what products and benefits, and how best to integrate trees into agricultural systems. Some on-ground investments in tree planting appeared to be mis-directed. Past agroforestry research had been limited and fragmented, and research results had not been widely published.

Leadership from key people within the Rural Industries Research and Development Corporation (RIRDC) and Land & Water Australia (LWA) initiated JVAP, which then became a 15-year partnership between RIRDC, LWA, and Forestry & Wood Products Australia (FWPA).

Over its duration, additional funding was provided by the Murray-Darling Basin Commission, the Grains R&D Corporation, the Commonwealth Department of Agriculture, Fisheries and Forestry (through the Natural Heritage Trust), and the Department of Environment and Heritage Australian Greenhouse Office.

Definitions and areas

Throughout this report, **higher rainfall areas** are considered to be those receiving annual average rainfall of about 600 mm and above. **Medium to low rainfall areas** are those receiving annual average rainfall of about 600 mm and below.

Agroforestry is considered to be synonymous with farm forestry, where landholders establish and maintain their own plantations, private native forest (PNF) or commercial trees integrated with agriculture for multiple uses such as windbreaks, strip plantings and corridors. Typically, when landholders establish their own farm forests, the forests average 30 hectares (Schirmer 2008). There are an estimated 155,000 ha of farm forestry plantations in Australia, representing around 9% of the total plantation area. There are around 38 Mha of PNF (URS 2008).

Bioenergy describes the energy recently stored in biomass and usually derived from photosynthesis. Biomass may include the leftovers from farming activities ranging from animal manure to crop residues, but can also come from woody crops grown and harvested principally as a fuel source, as an intended co-product from woody crops with other uses (e.g. oil mallees), or as a by-product from forestry operations..

Biofuel is a renewable energy source (e.g. ethanol, methanol) associated with biological material (and therefore a source of bioenergy).

Industrial plantation forestry is larger in scale than agroforestry, with an average of 331 ha established when a property was sold to a plantation company, and an average of 203 ha established when land was leased to a plantation company (Schirmer 2008). The majority of hardwood plantations consist of Blue Gums (*Eucalyptus globulus*) grown for short-rotation pulpwood, while softwood plantations are grown for sawnwood as well as pulpwood products (Schirmer 2006). Excluding farm forestry plantations, industrial plantations cover an area of about 1.6 Mha.

Woody forage shrubs comprise Tagasaste (*Chamaecytisus proliferus*), Old Man Saltbush (*Atriplex nummularia*), Leucaena (*Leucaena leucocephala*), Orange Wattle (*Acacia saligna*), and Rhagodia (*Rhagodia preisii*). There are around 400,000-500,000 ha planted with woody forage species across Australia (URS 2008).

A. Evolution of JVAP priorities



Common JVAP themes over 15 years

- National leadership, funding support and coordination for Research, Development and Extension (R, D & E) to build confidence in agroforestry's capacity to enhance agricultural sustainability while providing additional public benefits
- An aspiration for agroforestry to be commercially viable, through either combined returns from public and private benefits, or from having sufficient scale to be profitable in its own right
- Consultation with the industrial plantation forestry sector, without seeking to be a principal funder of R, D & E for that sector

A1. Origins

In the 1970s and 1980s, Australia's environmental consciousness became more highly developed, and legacies of the past such as salinity and biodiversity loss became more noticeable (Cullen *et al.* 2003). Large scale forestry operations in public forests were beginning to be seen as 'devastation' of the forest environment (Thompson and Connell 2009).

With the emergence of landcare in the mid-1980s, planting trees on farms (agroforestry) to address natural resources management issues became increasingly common. Agroforestry was seen as having the potential to become a widespread land use, improving the sustainability and profitability of agriculture, and reducing pressure on public native forests.

However, in many parts of Australia the advantages and disadvantages of planting trees on farms were not well understood. There was scant information about its practice in Australia or the research that was being carried out (Prinsley 1991). Agroforestry as an industry was very much in its infancy. In keeping with its charter to support research and development into new and emerging industries, RIRDC supported two pivotal events in the early 1990s which led to establishment of the Joint Venture Agroforestry Program in 1993.

Firstly, RIRDC commissioned a study on the role of agroforestry, its current extent, drivers and barriers to adoption, current research, and future research priorities (RIRDC 1991). Secondly, RIRDC supported the *Role of Trees in Sustainable Agriculture* conference in Albury in October 1991 (Prinsley 1991) at which leading researchers

comprehensively reviewed previous agroforestry research. In combination, these two initiatives found that agroforestry research had been limited, was largely fragmented, and many research results had never been published and were unknown. Furthermore, most agroforestry research was single-discipline, whereas agroforestry comprises many disciplines.

A2. Partners

Established in 1993, JVAP was a partnership between three Australian Government agencies: Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia (LWA), and Forest & Wood Products Australia (FWPA). It was agreed that RIRDC would be the JVAP managing agent. Through these partners, JVAP combined the resources of organisations interested in developing new industries, investing in natural resources management, and developing future wood resources.

Additional funding was provided for some JVAP activities by: the Natural Heritage Trust; the Department of Agriculture, Fisheries and Forestry; the Murray-Darling Basin Commission; the Grains R&D Corporation; and the Australian Greenhouse Office. JVAP also jointly funded some collaborative projects with CSIRO, the Future Farm Industries Cooperative Research Centre, the CRC Salinity, Greening Australia, and Meat & Livestock Australia. These partnerships enabled significant investments into additional research areas such as private native forests (PNF), agroforestry in medium to low rainfall areas, and biodiversity conservation.

Uniquely, JVAP represented the mix of public and private interests in trees on farms where there was no national sectoral champion. It ran for 15 years as three five-year phases, each with a strategic plan outlining its R, D & E priorities.

A3. Earliest priorities

In the early 1990s, the most significant policy drivers for expanding agroforestry were addressing land degradation and augmenting wood supplies for forest industries as access to native forests was being reduced. JVAP management had a clear view of key elements of agroforestry systems (e.g. trees for wood products, salinity management, soil conservation,

shade, shelter and fodder, nature conservation) and how the elements might fit together to achieve multiple objectives.

However, from the RIRDC initiatives that preceded JVAP it was clear that basic knowledge gaps and research coordination had to be addressed before a more comprehensive research program could be put in place to realise the vision. In summary, JVAP's earliest priorities covered:

- Investigating **impediments** to agroforestry, including socio-economic reasons for non-adoption of technically-sound agroforestry systems
- Improving understanding of **how different species perform in different areas** by collating data from species trials and entering it into the CSIRO TREDAT database
- Quantifying the effects of trees on crops, pastures and livestock, including the effects of **windbreaks**, to underpin economic research
- Using results from research into windbreaks and species trials as input to research into the **economics and marketing** of farm trees, to demonstrate financial benefits

A3.1 Research Working Group 11

Research Working Group 11 (RWG 11- Farm Forestry) under the Standing Committee on Forestry was formed in 1989 to guide farm forestry research. Its members and observers were drawn from State, Territory and Australian Government agencies, as well as other key farm forestry organisations such as universities, Greening Australia, Australian Forest Growers and JVAP.

A report for RWG 11 (Race and Robins 1998) made recommendations grouped within five themes: farm forestry systems; low rainfall systems; tree-agriculture interactions (capturing multiple benefits); social-economic and policy issues; and education, training and extension. The report also identified three research areas spanning all five themes that required particular attention: sustainable management of private forests; the contribution of farm forestry to farm and regional biodiversity values and environmental benefits more generally; and the role and potential for carbon credits and carbon trading in farm forestry development.

JVAP adaptive management

1993-1998

Debates about public native forest management were intensifying. The *National Forest Policy Statement* sought to protect an extensive and permanent native forest estate. Land degradation issues in agricultural areas were becoming more prominent. Agroforestry was seen as having potential to reduce pressure on public native forests and enhance agricultural sustainability.

There were Government grants for landcare works. Trees were planted on farms mainly for shade, shelter, crop protection and landcare benefits including salinity management. Tree species trials were scattered and research was fragmented. There was scant knowledge about what trees and shrubs would grow where, and about products, species, and markets, especially in medium to low rainfall areas. In higher rainfall areas, State forest agencies dominated supply to industry.

JVAP had a strategic vision about the key elements of agroforestry systems and how they could fit together, but basic research and better coordination were necessary first steps. JVAP's emphasis was on addressing impediments. These included lack of coordinated species trials, lack of empirical knowledge about windbreak effects, and public policy and legislative issues such as industry dominance by State forest agencies, native vegetation protection legislation, and restrictive local government planning requirements.

1999-2004

New plantations were seen as the main avenue for offsetting the reduction in wood supplies from public native forests. The *Plantations 2020 Vision* was introduced to give effect to the *National Forest Policy Statement*. Wood supplies from private native forests increased. Salinity became the dominant natural resources management issue, particularly in medium to low rainfall agricultural areas. Governments introduced major salinity management initiatives. Broad scale tree planting on cleared farmland was seen as a major part of the solution, but the actual effects of tree planting were not well understood due to variations in salinity processes in different landscapes.

JVAP's emphasis was on addressing impediments to commercial agroforestry and on researching species, products and markets. It had a greater focus than previously on addressing salinity in medium to low rainfall areas, and on collating results from multi-disciplinary research into design principles for farms in those areas. It continued its emphasis on the need for products from agroforestry systems to drive greater establishment. In JVAP's *R&D Plan*, there were references to environmental services, carbon sequestration and research into private native forests including silvicultural regimes for regrowth.

2004-2009

The plantation estate had rapidly increased, mainly due to managed investment schemes. Drought, climate change and carbon overtook salinity as nationally important issues. There was increasing community concern about water interception by tree planting in higher rainfall areas, and about the social impacts of extensive Blue Gum plantations. World oil prices rose significantly. Governments foreshadowed introduction of emissions trading and renewable energy initiatives.

JVAP continued work that commenced in the 1999-2004 phase, focusing more on generating knowledge to move new plantings beyond the demonstration phase to realising sufficient scale to be profitable industries, in both higher rainfall zones and in medium to low rainfall zones. It supported regional approaches to market development, introduced bioenergy as a potential product, recognised potential impacts of agroforestry on catchment water yields, and enhanced the focus on investment options. In the 2004-2009 *R&D Plan*, private native forestry was referred to only in the context of providing environmental services.

A4. Salinity emerges

From the mid to late 1990s, there was a substantial increase in awareness about dryland salinity in Australia generally and within the medium to lower rainfall areas in the Murray-Darling Basin in particular. A 1996 ABARE report noted that local councils, public utilities and State government agencies in the MDB were spending \$12.5M annually on salinity-related repairs and maintenance, and \$15.2M annually on activities to address salinity problems (ABARE 1996).

The MDBC was conducting investigations into dryland salinity processes, impacts and management options. In 1997, the *Salt Trends* report revealed an alarming increase in both salt concentrations and salt loads in the rivers and streams of the Murray and Darling Drainage Basins (MDBC 1997).

Subsequent reports, *The Salinity Audit of the Murray-Darling Basin: A 100-year perspective* (MDBC 1999), *The cost of dryland salinity to non-agricultural landholders in selected Victorian and New South Wales catchments* (MDBC 2000), *Australian Dryland Salinity Assessment 2000* (NLWRA 2000) and *Basin Salinity Management Strategy 2001-2015* (MDBC 2001) all reinforced the view that salinity was a national issue requiring urgent action.

The consensus was that revegetation of cleared farmland, drawing on results of JVAP and other research, would be a major part of the solution.

A5. JVAP R&D Plan 1999-2004

Following JVAP's development of *A Strategy Framework for Commercial Farm Forestry in Australia* (AACM 1997), an economic analysis of agroforestry by the Centre for International Economics, and additional consultation, RIRDC released its *R&D Plan 1999-2004* (RIRDC 1999).

The *Plan* noted that the public benefits of widespread adoption of agroforestry would be substantial, addressing loss of productive land to salinity and other forms of soil degradation, biodiversity conservation, loss of water quality, and damage to public infrastructure. Through the *Plan*, and through the partnership with the Natural Heritage Trust's (NHT) Farm Forestry Program, an additional \$1.5M from the Natural Heritage Trust was committed to R&D into timber production elements of agroforestry and sustainable management of private native forests (PNF). A further \$2.5M from the NHT was for assessing new tree crop products and industries, particularly in medium to lower rainfall areas, and to support work on biodiversity issues. The *Plan* emphasised:

- Overcoming **impediments** to farm forestry by investigating: cultural, legislative, policy and legal impediments; commercially-viable species, products and markets; and cost sharing for environmental services, especially in medium to low rainfall areas

- Generating **knowledge** about: the impact of trees (for example, windbreaks) on farm productivity; trees for production of wood and other products; environmental benefits of trees (for example salinity management, biodiversity conservation, and carbon sequestration); trees on medium to low rainfall grazing and cropping farms for multiple benefits
- **Collating results** from the above activities with results from private native forest management research into design principles and tools to assist landowners to make decisions about agroforestry
- **Communicating** research results to forest growers and their advisers.

In summary, the *R&D Plan 1999-2004* saw JVAP continuing to invest in research into impediments, species, products and markets, giving greater focus to medium to low rainfall areas, environmental benefits, impacts on farm productivity, and placing greater emphasis on collating results from multi-disciplinary research into design principles. It made explicit references to environmental services, carbon sequestration and private native forests.

A6. JVAP R&D Plan 2004-2009

An extensive review of JVAP was conducted in 2003 (Agtrans 2005). Research priorities (briefly summarised) recommended by that review were:

- **Products and markets** (species, products, markets; environmental services to inform market development; trading for environmental services; bioenergy)
- **Integration** (regional integrated solutions; information for regional and catchment NRM plans; new low rainfall industries; impacts on water yields, effects of climate change on tree growth; production efficiencies; value adding; private native forest management, particularly regrowth management; integration with existing agricultural systems, including the value of shelter)
- **Policy and people** (better understanding of investment decision-making processes; investment and risk-sharing arrangements including environmental services markets; improved delivery of outputs)

The subsequent *R&D Plan 2004-2009* (RIRDC 2004) had an increased emphasis on identifying the most prospective products and systems, marketing and supply issues, and quantifying ecosystem services. Its goal was to:

'build a knowledge base that underpins investment in agroforestry products and systems so they move beyond demonstration phase to realising sufficient scale to be profitable industries. As part of this, agroforestry can deliver services and products relevant to natural resources management needs.'

The *Plan's* objectives emphasised:

- **Products** (quality and volume of products and services, including environmental services; growing, managing, processing)
- **Product-market linkages** (regional market assessments for tree products, including interactions with industrial plantation supply)
- **Integration and optimisation** (better design of systems for regional and catchment benefits, including prioritisation of regions, development of environmental services markets and new institutional arrangements to increase investment)
- **Communication, knowledge and adoption** (through regional NRM bodies, farm forestry and rural advisers including Private Forestry Development Committees, Greening Australia, Australian Forest Growers and Government agencies)

The *Plan* provided for increased research in medium to high rainfall zones by assessing interactions between regional agroforestry and industrial plantation supply, introduced bioenergy as a potential product, recognised potential impacts of agroforestry on catchment water yields, and enhanced the focus on investment options. Private native forestry was referred to only in the context of providing environmental services.

A7. In a nutshell.....

JVAP was originally driven by the vision of multi-purpose trees integrated into Australian landscapes to address serious land degradation issues and augment timber supplies from public native forests. It was assumed that value propositions for the adoption of integrated trees on farms would be found relatively easily, and that JVAP's role would be to communicate the vision and demonstrate the benefits to achieve widespread adoption.

However, as JVAP progressed, the benefits proved more difficult to demonstrate, more complex and more dependent on the particular geographic context, commodity markets and other factors. Consequently more effort was put into research into specific products environmental services and social and institutional constraints to adoption.



B. Farm forestry for multiple benefits



Highlights – Where have we got to?

Integrated designs (shelterbelts, alley farming, phase farming)

The National Windbreaks Program (NWP) into the effects of windbreaks on crops generally resulted in findings that debunked initial expectations. In the Australian context, windbreaks did not significantly increase cereal crop yields, as they often did overseas. However, in extreme conditions a well designed windbreak can make the difference between a reasonable crop and none at all. The NWP was essential in explaining how windbreaks work in the Australian context, their effects on factors that might limit productivity, and how to design and maintain an effective windbreak system.

JVAP researchers have spearheaded innovative concepts for salinity management, including alley farming with trees, alley grazing with fodder shrubs, and phase farming with trees. These studies have significantly advanced our knowledge about water and productivity impacts of these systems in different landscapes. For the most part, incorporating trees and shrubs into the landscape for salinity management, if carefully planned, can address salinity while minimising direct impacts on crops and pastures.

Results to date suggest that alley grazing with fodder shrubs generates useful benefits with few downsides, and has good prospects for assisting farmers to cope with climate change.

Alley cropping and grazing with woody shrubs and trees is more problematic, with several barriers to adoption, and increasing concerns about how to simultaneously optimise recharge reduction and runoff for downstream uses. In a carbon-constrained future the outlook for these systems is bright however, as unavoidable negative effects on crop yields may be more than offset by income from carbon sequestration.

Farm forestry and biodiversity

Research supported by JVAP and other organisations has revealed key principles that can maximise biodiversity conservation in private native forests, industrial plantations, and mixed tree and shrub plantings on farms. As a rule, these principles align with the ways in which natural forests are structured and function. Lack of knowledge about the gross biodiversity outcomes of practices based on these principles should no longer be an impediment to their application, despite continuing debate about metrics for biodiversity and habitat values. The unresolved issue is that the public benefits are either intuitively insufficient or cannot be valued accurately enough to underpin markets in which the value of the commercial trade-offs they entail can be captured by private sector interests.

Farm forestry and water

JVAP has been a relatively minor investor in research into trees for salinity management, but was a leader in synthesising knowledge and in setting future research priorities

The *National Classification of Catchments* was a highlight for JVAP and the other organisations involved in its development. For the first time, the *Classification* and its Groundwater Flow Systems framework enabled cost-effective modelling instead of expensive site-based investigations to estimate the likely effects of salinity management options. It dramatically improved confidence in the outcomes of tree-based plantings for salinity management.

JVAP has been the ‘honest broker’ in contributing balanced and objective information to the debate about the effects of plantations on water resources. The conclusions of the JVAP *Agroforestry and Hydrology* workshops (expanded by subsequent research, particularly by CSIRO) continue to influence plantation policy development. The emerging issue is that this, along with new knowledge, will be essential in planning carbon plantings, which potentially could cover a much wider area than pulpwood plantations.

Farm forestry and carbon sequestration

For the first time, it appears that the ‘perfect opportunity’ of strong market demand, favourable economics, large areas of suitable land, many willing growers, and a supportive policy and regulatory environment, will finally overcome the key impediments to large-scale revegetation and diversification in Australia’s rural sector, particularly in medium to low rainfall areas. These factors have already catalysed new, large-scale carbon plantings which must avoid the undesirable consequences associated with the rapid expansion of Blue Gum (*Eucalyptus globulus*) plantations. In view of the great potential but risks and uncertainties associated with carbon farming, a priority for future research should include knowledge essential for the effective operation of carbon markets.

Farm forestry and bioenergy and biofuels

JVAP-Enecon research has concluded that a commercial scale Integrated Wood Processing plant, similar to the pilot plant at Narrogin in Western Australia, would be financially viable. Conclusions from research into the use of biomass for bioenergy and biofuels are more positive for bioenergy than biofuels, but there are regulatory impediments to the use of new forests and wood wastes for bioenergy.

B1. Integrated designs (shelterbelts, alley farming, phase farming)

JVAP’s early research priorities were strongly influenced by intuitive assessments of issues that would yield the greatest return on investment. Integrated tree and shrub plantings to manage salinity while enhancing and diversifying agricultural production, and quantifying the effects of windbreaks were classic research initiatives to address conventional but untested wisdom.

Salinity had been widespread in Western Australia for many years, and was still rapidly expanding in the 1990s, rendering good agricultural land, particularly in wide valley floors, unproductive. The predicted equilibrium suggested as much as 30% of the landscape could become salt affected. This outcome would have enormous implications for the State’s economy as well as the needs of people and their communities. Similarly, in the Murray-Darling Basin, salinity’s extent and rate of spread were cause for serious concern. Up to one million ha was at risk. In some areas it had ‘grave implications’ for water quality, land and environmental degradation, and the economic and social viability of individuals, communities and regions (MDBC 1993).

For windbreaks, Northern Hemisphere research had consistently shown that their costs could be recouped by increased agricultural productivity. There had been only two Australian studies, in South Australia in the 1980s, and these also showed increased productivity – for example wheat yield

gains of 20-25 %, oat yield gains of 47%, and 27-30% gains in lupin yields (Cleugh *et al.* 2002).

And yet research into interactions between trees and crops in water-limited environments in Africa indicated high levels of competition for water, which frequently outweighed benefits to crops through microclimate, soil conservation and soil fertility. These conditions appeared more relevant to much of Australia’s cropping zone than the original windbreak research in the Northern Hemisphere. The potential benefits, and the potential scale of adoption across cropping regions, set against the uncertainty of extrapolating results from very different environments, made a strong business case for investing in windbreak research in the Australian context. These issues prompted critical, multi-disciplinary research questions around issues such as:

- Optimal spacings of belts and alleys for different landscapes
- The best agroforestry designs for multiple benefits
- Alley farming with trees to control recharge while sheltering crops and livestock, but trading-off with crop yields
- Tree root pruning to minimise competition with crops
- The effect of shelterbelts at different densities, spacings, and angles to the prevailing wind.

Phase farming with lucerne had proven popular as a salinity management option on neutral to alkaline soils in the eastern

States, but there was limited enthusiasm for lucerne in Western Australia. This raised further research questions for that State – would phase farming with short-rotation tree crops work? What would be optimal designs for these systems?

The early phases of JVAP focused much of its trees, shrubs and water research on productive farm forestry based on using up excessive water in the landscape. The prevailing paradigm was to ‘use water where it falls’, and control salinity by mimicking the function of native vegetation prior to clearing. During the mid to late 2000s, however, this paradigm almost reversed with extensive drought covering much of southern Australia. This has introduced a new balancing act – how tree crops can minimise waterlogging and salinity in wetter than average years, while allowing sufficient runoff for downstream users in extreme drought and during the hotter and drier periods forecast to occur as a result of climate change.

JVAP has adapted to these changing needs with increased investment in understanding how trees and shrubs use water, providing a very solid foundation for the next, more complex phase.

B1.1 Design principles

Prior to the 1990s Australia’s limited agroforestry research was fragmented and often unpublished. JVAP partners ushered in a more coordinated and strategic research program that was perhaps symbolised when they commissioned leading experts to synthesise the key findings from previous research. For the first time, farmers would have, in one place, up-to-date knowledge to enable them to design and implement the right system for their needs. The book – *Design Principles for Farm Forestry: A guide to assist farmers to decide where to place trees and farm plantations on farms* (Abel et al. 1997) see Box B1 – delivered on this promise.

Box B1 Design Principles – a ‘one stop shop’

Design Principles for Farm Forestry: A guide to assist farmers to decide where to place trees and farm plantations on farms is an easy-to-read synthesis of knowledge to 1997 about key elements of agroforestry systems, and how they could be integrated on-farm to achieve multiple objectives.

At the time of its release, *Design Principles* identified knowledge gaps requiring further JVAP investment (actioned in the *JVAP R&D Plan 1999-2004*), and served as a manual for the *Australian Master TreeGrowers* program. Recognising that agroforestry – the productive use of trees on farms – was a new concept to most Australian farmers, *Design Principles* delivered some key messages that still resonate today:

- Trees are a long-term investment
- Trees give indirect benefits to other farm enterprises
- Trees are deep-rooted and therefore access water-tables and recycle nutrients that are unavailable to most other forms of production

B1.2 Shelterbelts

The five-year National Windbreaks Program launched by JVAP in 1993 was the most comprehensive study of windbreaks in the world (Cleugh 2003) with research sites across all southern Australian agricultural regions.

The NWP assessed the impacts of windbreaks on crop and pasture yield through their effects on microclimates. Through a combination of field measurements, wind tunnel simulations, intensive meteorological observations, and crop simulation modelling, it developed a quantitative understanding of the interactions between windbreaks, microclimate, and crop and pasture productivity. From this emerged a predictive capacity for planning windbreak design and implementation, based on the key findings summarised below:

- Two broad areas of crop and pasture response can be identified downwind of a porous windbreak: a zone of reduced yield associated with competition with the windbreak trees and a zone of unchanged or slightly increased yield
- Averaged over the paddock, yield gains due to the effect of shelter on microclimate were smaller than expected — especially for cereals. Economic analyses found that windbreaks will either lead to a small financial gain or be cost neutral
- The relatively small changes in yield measured at the field sites was partly due to the variable wind climate which meant that the crop was only sheltered for a small proportion of the growing season

- Trees also have an important influence on natural systems and biodiversity which, with good planning, can benefit the farm and region
- Special consideration should be given first to the best places to plant trees in a catchment and second to the best layout of trees in the paddock, in order to improve the productivity of the farm, protect the soil and water resources and enhance the beauty and conservation value of the land
- Some environmental aspects, such as rising water-tables, will take as long to reverse as they did to emerge
- Multiple uses of trees on the farm will increase management demands – but it will be worth the effort

Acknowledging Australia’s widely differing climatic regions, the authors concentrated on design principles that hold true across all regions. At the same time they encouraged farmers to “think of trees as just another crop! The same care in paddock preparation, weed and insect control and species selection will be equally rewarding as for any other crop.”

- Protection from infrequent, high magnitude wind events that cause plant damage and soil erosion lead to the largest yield gains
- The effects of shelter on temperature and humidity were smaller than the effect on wind speed indicating that fewer windbreaks are required to achieve reductions in wind damage than for altering the microclimate
- The wind tunnel experiments illustrate the important aspects of windbreak structure that determine the airflow downwind, and subsequent microclimate changes, enabling guidelines for designing windbreaks for Australian agricultural systems

Seventeen papers in a special edition of the *Journal of Experimental Agriculture* provide detailed descriptions and discussion about the specific research sites and research methods used, in addition to interpreting and discussing the results.

The main findings of the Windbreaks Program were also described and discussed in the 'plain English' JVAP book *Trees for Shelter* (see Box B2), which included findings from a further three-years' research into wind damage in crops. The book explained the way windbreaks work, their effect on factors that limit crop productivity, and how to design and maintain an effective windbreak system for Australian conditions.

It should be emphasised that although the direct benefits of windbreaks to crops were found to be lower than previously thought in some conditions, they were found to be highly valuable in protecting crops from damage in extreme wind events. The ability of windbreaks to generate significant benefits for crops in extreme events has been replicated by windbreaks for livestock.

For example, Campbell (1991) reported that in summer storms near Hamilton in February 1987, during which the temperature did not drop below 16 degrees, high winds and heavy rain immediately following a heat wave killed tens of thousands of off-shears sheep irrespective of their condition. Many farmers lost more than 90% of their flocks, however farmers who actively moved sheep into their shelterbelts and woodlots avoided such losses. Similar experiences have been reported from the eastern Mount Lofty Ranges in South Australia (Munday B, personal communication). Giving substance to such anecdotal reports was an important achievement of the NWP.

The significant uptake of minimum tillage over the past two decades tends to conceal the importance of shelter to minimise wind erosion. However wind speed is still a critical influence on the severity of wind erosion, and by substantially reducing the force of the wind at ground level, windbreaks can play a major role in protecting paddocks from wind erosion over the longer term.



In extreme conditions, shelterbelts can prevent large stock losses

Box B2 Trees for shelter – busting myths about effects on crop yields

The significant crop productivity improvements experienced in overseas windbreak studies could not be replicated in Australia. Key messages from *Trees for Shelter* (Cleugh 2003) are:

- Windbreaks are no ‘magic bullet’ – they will improve agricultural productivity only if they modify some factor that is already limiting. The best windbreak design will depend on the benefits sought (including salinity mitigation, by-products such as timber and amenity) and the cost of implementation and management
- In areas prone to wind erosion, windbreaks should be oriented to provide a high level of shelter from the winds most likely to damage crops. Also, stock should be kept away from those windbreaks, and action – such as root pruning – should be taken to reduce competition by trees for water and nutrients needed by the crops and pasture
- Windbreaks did not significantly reduce overall paddock yields. Farmers can plant windbreaks confident that their effect on overall paddock yields will often be a net gain in dry years, especially if a wind erosion event is likely. In other years, yields will be unaltered by shelter. There will be an overall net cost whose amount will depend on the costs of establishing and maintaining the windbreak and the losses associated with competition
- In Western Australia in dry, windy years when exposed crops were subjected to sandblasting and other wind damage, average yields within 20 tree heights of a windbreak were around 25 per cent greater than those of unsheltered crops that suffered sandblasting. In some cases, the windbreaks provided useful protection out as far as 40 tree heights
- Economic modeling for south-east WA estimated the influence of windbreaks planted 34 tree heights apart on the profitability of cropping and wool growing. The model predicted that if potentially crop-damaging winds occurred in approximately ten percent of years, the value of protection would exceed the tree establishment costs and production losses from the reduced cropping area and tree competition. Timber production can further offset the costs of windbreak protection

B1.3 Alley cropping and grazing with trees

Many farmers plant belts of trees to provide shelter and/or to address dryland salinity and then manage crops and pastures in alleys between the trees. Belts of oil mallees are common in the central wheatbelt of Western Australia, whereas mixed species environmental plantings are common in the eastern States.

Tree belts (or bands) compete with crops and pastures for light, water and nutrients. Therefore the density and arrangement of the trees is critically important for balancing agricultural productivity with the need to reduce recharge (Stirzaker et al. 2002).

JVAP’s extensive research into alley farming designs has provided direction to achieving the desired balance between agricultural production and recharge control. In recent years, there have also been investigations into a third consideration – allowing sufficient runoff for downstream users.

Alley cropping with trees

In an important collaboration between JVAP and Grains Research and Development Corporation, Oliver *et al.* (2004) confronted a significant challenge facing Australian cropping systems. Building on the principles developed in *Trees, Water and Salt and Trees for Shelter* (Stirzaker *et al.* 2002), the research sought to optimise the trade-off between production and water conservation through designs that take advantage of site and system characteristics to minimise competition and maximise the trees’ hydrologic footprint.

This research measured the relative impacts of trees (eucalypts and pines) on yield and recharge at 32 sites across southern Australia, concentrating on tree-crop interfaces to inform a range of tree-crop combinations – integration (such as in alley farming), segregation (in plantations or block plantings), or rotation. From this they developed guidelines for agroforestry as a water management tool in dryland cropping areas.

The researchers found that **‘win-win’ outcomes, where recharge was reduced and crop gross margins were increased, occurred at only four sites.** At the majority of sites (19), reducing recharge by up to 30% resulted in a gross margin loss of over \$100/ha. At a further nine sites, reducing recharge by up to 30% resulted in a gross margin loss of up to \$120/ha.

As with other windbreak research, seasonal conditions strongly influenced the trade-off between water management and yield, with some sites being positive one year and negative the next. Beyond this, the researchers concluded that the factors most likely to minimise both crop competition and recharge were: water-gaining sites; a west through to south-east aspect; tree age; and lower rainfall.

Alley grazing with mixed species plantings

A rare study based on 13 years of measured hydrological data by Crosbie *et al.* (unpublished) quantified trade-offs between runoff and recharge following a change from annual cropping to tree belts and perennial pastures in southern New South Wales.

The Crosbie *et al.* study found that **groundwater levels fell dramatically due to almost no recharge, runoff was significantly reduced, and the salt input:output ratio halved.** The authors suggest that 'the benefits in terms of salinity will continue to increase for the next few decades.' Their report indicates that in a 129 ha sub-catchment receiving about 600 mm rainfall, the tree belt-perennial pastures system reduced runoff from about 30 ML/yr to less than 10 ML/yr. Whether this reduction in runoff is an acceptable trade-off for the reduction in groundwater levels and salinised land, depends on contemporary views about the value of water for downstream users (see findings by Ellis *et al.* below).

Optimising recharge management and runoff with 'banded' agriculture

Trees, water and salt provided the starting point for Ellis *et al.* (2005) to develop a design framework for the arrangement of different types of vegetation on farm hill-slopes to meet a desired water yield in the eastern States.

The Ellis *et al.* study reflected a fundamental change in thinking about water management objectives, brought about by the record dry period experienced in south eastern Australia since 2002 and the predicted longer-term effects of climate change on rainfall and runoff. Whereas *Trees, water and salt* focused on managing excess water and salinity by minimising deep drainage and overland flow (as does the Crosbie *et al.* study above), the Ellis *et al.* study recognises that **water is a scarce resource and that there are a number of valid uses, on and off site,** for the rainfall that falls on the hill-slope.

Ellis *et al.* suggested that the answer to the question 'How much water do we want to leave the hill-slope or the subcatchment?' depends entirely on the users who lay claim to that water (local landholder, downstream water user) and any negotiated apportioning of that resource. This broadens the role of alleys beyond recharge management, and could for example include capturing excess runoff and suspended sediment.

Ellis *et al.* used a naturally banded (belted) mulga landscape near Louth in western NSW as a conceptual model for their design framework for a banded agricultural system. Their design framework allows a catchment manager, having determined a desired water yield for a sub-catchment, to identify the yields required from the sub-catchment's hill-slopes, and design banded systems that will deliver the yield target.

Competition between tree belts and perennial pastures

The perceived negative impact of trees on annual crops constrains the adoption of agroforestry. However, in light of current interest in perennial pastures for both economic and resource management goals, Sanford and Sudmeyer (2007) undertook a one-year scoping study to determine whether perennials could compete better than annuals with trees for water, nutrients and light in the medium to low rainfall zone in south-west Western Australia. They also investigated the effect that perennial pastures had on tree root morphology and water use compared with annual pastures.

Key findings were that, within the tree root zone, **annual pasture yields declined by up to 53%, but perennial pasture yields declined by at most 10%.** The design of agroforestry systems in the south west of Australia should therefore include drought-tolerant perennial grasses if the objective is to minimise losses of forage production. At the same time, perennial pastures will affect tree growth, which may be an issue if the trees are being grown for commercial benefits.

B1.4 Alley grazing with fodder shrubs

Alley farming with fodder shrubs, principally Tagasaste and Saltbush, has been used for many years to enhance resilience in farming and grazing systems in Western Australia, while managing specific issues such as salinity. From farmer interviews, fodder shrubs are valued for their positive effects on: reducing the risk of wind erosion and dryland salinity; increasing confidence in feed supply at a time when a feed gap is typically experienced; reducing labour demands at the break of season when cropping activities are in progress and when hand feeding livestock competes with other labour and management priorities; and providing shade and shelter for livestock (Revell *et al.* 2008 unpublished).

Water management and nutrient cycling

Lefroy *et al.* (2005) added to the understanding of where alley farming is appropriate, with a detailed study of water use and crop yield trade-offs with tagasaste in alley and plantation layouts. On sandy soils, typical of much of the salinity recharge land in WA and SA, they found that **for water management, plantations would be a better strategy than alley cropping** because trees in alleys used no more water than trees in plantations, but reduced crop yield by an average of 20% over the second and third years after planting. Furthermore, they relied heavily on the presence of a shallow fresh aquifer, which was a localised phenomenon at the catchment scale.

The researchers qualified their conclusion, noting that alley cropping would have an advantage where deep drainage is high, where the tree has extensive lateral roots that can access water below the crop root zone, and where the value of tree products cancels out the effects of displacement and competition with annual crops. An important conclusion

from this work was that **locating trees in the landscape with high water availability in summer is more relevant to water management than the search for so called high water use tree species**. Secondly, adaptive features of *Tagasaste* indicate that exotic soft-leaved trees can adapt well to the harsh Mediterranean-type environments of southern Australia, and the search for suitable agroforestry species need not be limited to endemic tough-leaved species.

Enrich – mixed shrubs and pastures

In December 2004, JVAP, along with the Cooperative Research Centre for Plant-based Management of Dryland Salinity, Australian Wool Innovation Limited and Meat & Livestock Australia, convened a national workshop of specialists in livestock production, agronomy, ecology, botany, and agroforestry. They explored the current state of knowledge on the use of perennial shrub species in grazing systems (Revell and Bennell 2006). This workshop was the genesis of the *Enrich* project that has excited graziers and land managers across southern Australia.

The impetus for the workshop was the emerging awareness that prolonged drought and changes in rainfall patterns were making land use dominated by cropping and annual pastures unsustainable, especially in medium to low rainfall areas. These events presented an opportunity for large-scale change to livestock industries, where blending feed production from woody and herbaceous perennials with traditional pastures could become the preferred productive and less risky land use for the future (Revell *et al.* 2008, unpublished).

Enrich is the icon of the woody revolution in medium to low rainfall areas in Australia, and was a continuing project at the time of writing this report. It is investigating a broad range of activities aimed at developing profitable and sustainable integrated farming systems in the livestock-cropping zones. The *Enrich* design principles encompass: identifying the optimal area of a farm established to forage shrubs; grazing time for optimal use; scale and layout; plant establishment and productivity; nutritive value traits; and bioactivity.

One of the *Enrich* activities involves modelling new farming systems that incorporate shrubs in different areas of the livestock-cropping zone, exploring scenarios based on biological, economic and environmental issues likely to affect the whole-farm profitability of shrubs. The MIDAS model has been used to optimise profitability against familiar factors such as plant density, biomass, nutritive value, establishment cost, and commodity prices. Under a 'typical' central wheat belt mixed farm in Western Australia, modelling indicated that about **10% of a farm allocated to perennial shrubs would increase whole-farm profit in the order of 20%**. This conclusion held across a range of scenarios.

If agriculture is included in the *Carbon Pollution Reduction Scheme* proposed by the Australian Government, forage shrubs could provide additional income for farmers through carbon sequestration, or assist them in mitigating greenhouse gas emissions from their livestock and cropping enterprises see **Potential industries and markets**, section C2.2).



Enrich mixed forage comprising woody and herbaceous perennials

B1.5 Phase farming with trees

Throughout the Western Australian wheat belt, experience has shown that phase farming with lucerne to manage salinity, even where technically feasible, has been adopted only in limited cases. This is mainly because it is incompatible with farmers' livestock management objectives. In the late 1990s JVAP scoped phase farming with trees (PFT), referred to as 'kamikaze forestry' in which short-rotation woody crops are grown for a few years, then harvested and the area returned to cereal crops for many years thereafter (Harper *et al.* 2000). In addition to the hydrological benefits, the hypothesis was that PFT may also benefit agriculture by improving soil physical, chemical and biological characters and by reducing the costs of weed and disease control. If shown to be feasible, phase farming with trees would offer land managers new income streams and a flexible method of mitigating some of the land degradation then occurring on farmland.

Tree phase

Harper *et al.* (2008) tested the tree phase of the PFT concept in a dryland cropping environment in Western Australia and were able to verify **the basic hydrological premise of the PFT system**. With the appropriate species in the suitable landscape location significant soil water depletion would enable a cropping rotation of 3 years of trees, then 11-20 years of agriculture.

However, as with lucerne, the researchers found there would be significant barriers to adoption, such as lack of cheap establishment and harvesting techniques, and lack of a profitable market for the products. Cost effective root removal may also be an issue (Campbell 2009). JVAP research has responded to these challenges and is further investigating the use of species (such as nitrogen-fixing *Acacia species*) that are amenable to lower-cost direct seeding with existing farm equipment (Carr *et al.* 2009; Giles *et al.* 2008, unpublished). If they were not harvested, the trees could provide ongoing environmental benefits including soil water depletion, grazing benefits and soil fertility improvement.

Looking to the future, the tree phase could be grown as potential feedstock for bioenergy production or manufactured wood products and extractives. Markets for biomass await the development of renewable energy targets and market scale and, in the case of biofuels, the development of enabling technologies that allow industrial-scale conversion of woody biomass to liquids.

Post-tree phase

Complementary JVAP research (Sudmeyer *et al.* 2008) detailed the findings of a five-year project examining the post-tree phase effects of PFT on adjacent agriculture. This work tested many of the claimed benefits of PFT in the first four years after a tree phase at two sites in WA with differing climatic and soil conditions.

Results indicated that, on suitable soils, the tree phase of PFT can indeed create substantial soil water deficits and so prevent groundwater recharge during an extended agricultural phase (1-2 decades). The researchers concluded however, that although PFT can have clear hydrological benefits, these may not translate to increased agricultural production immediately after the trees are harvested. **Agricultural returns on land without a tree phase were higher than returns on land with a tree phase** where it took three years for agricultural returns to revert to those from continuous agriculture, due to reduced plant available water and reduced soil fertility.

While the tree phase reduced weed burdens in subsequent crops, there was neither clear evidence of improvements in soil biological activity, structure or fertility, nor a decrease in soil-borne disease or herbicide resistance in weeds.

B1.6 Implications

JVAP has invested heavily in research to support design of agroforestry systems that integrate trees and shrubs on farms for multiple purposes, particularly salinity management in medium to low rainfall areas.

Early JVAP research into the influence of windbreaks on crops found that they would not significantly increase cereal crop yields, contrary to expectations based on Northern Hemisphere experience. This null result represents important knowledge for farmers and their advisers, helping them to avoid costly but fruitless investment on untested systems. Furthermore, cropping farmers could be confident that if they choose to plant windbreaks for other reasons, their effect on overall paddock yields will be a net gain in dry years and invaluable in severe wind events.

JVAP research into salinity management explored innovative concepts, including alley farming with trees, alley grazing with fodder shrubs, and phase farming with trees. Much of this work leveraged significant additional investment firstly through the *National Dryland Salinity Program* and subsequently the CRC for Plant-based Management of Dryland Salinity. These studies have greatly informed our knowledge of what works and the limitations of these various systems in different landscapes. For the most part, incorporating trees and shrubs into the landscape for salinity management, if done carefully, can address salinity while minimising direct impacts on crops and pastures.

Although research is continuing, results to 2009 suggest that alley grazing with fodder shrubs generates useful benefits with few downsides, and has good prospects for assisting farmers to cope with climate change. Alley cropping and grazing with woody shrubs and trees is more problematic, with several barriers to adoption, and increasing concerns about how to simultaneously optimise recharge reduction and runoff for downstream uses. In a carbon-constrained future the outlook for these systems is also bright, however, as any negative effects on crop yields may be more than offset by income from carbon sequestration.

B2. Farm forestry and biodiversity

B2.1 Sustainability of private native forests (PNF)

Management of public native forests came under increasing scrutiny by the broader community in the 1970s, when commencement of the export woodchip industry coincided with Australia's emerging environmental consciousness. 'Old growth' forests in particular, gained iconic status. As a result of increasing community awareness of the conservation values of these forests, significant areas under public management were reserved and made unavailable to the forestry sector.

Metrics as an indicator of sustainability

With the decline in availability of hardwood logs from public native forests and the lack of supplies from plantations, industry increasingly sourced native forest logs from private property. By the late 1990s, up to 50% of total timber milled was sourced from private property (Thompson and Connell 2009).

The shift in resourcing from public to private forests triggered community concern about the ecological sustainability of private native forest (PNF) operations such as harvesting and thinning. Governments responded by introducing measures to regulate PNF management, including *National Vegetation Management Framework* benchmarks in Victoria and codes of practice under consideration in New South Wales. Biodiversity surrogates and their scoring systems (metrics), such as *Habitat Hectares* in Victoria and *Biometric* in New South Wales have been used or proposed for compliance monitoring.

Box B3 What is sustainable forestry?

Lindenmayer and Recher (1998) consider ecologically sustainable forestry as perpetuating ecosystem integrity while continuing to provide wood and non-wood values; where ecosystem integrity means the maintenance of forest structure, species composition, and the rate of ecological processes and functions within the bounds of normal disturbance regimes.

PNF advocates have identified several financial and technical issues associated with governments' approaches to regulating PNF. They claim that associated measuring, monitoring and reporting adds to the cost of PNF, perpetuating the practice of 'high grading' (removal of the largest and best trees) which can mitigate against improved PNF management and be detrimental to future wood production.

Furthermore, the metrics were originally conceived to score and rank habitat and biodiversity values of remnant vegetation, and to estimate the impacts of land use change such as clearing on those values. The metrics were not designed to assess the effects of forest operations where the vegetation is managed for ongoing timber production and biodiversity conservation. Lastly, in generating their scores and rankings,

the metrics rely on surrogates such as key structural attributes of the habitat, rather than direct species surveys (Thompson and Connell 2009).

In short, the ability of metrics to show whether PNF operations were ecologically sustainable or not, was open to question.

JVAP investigations

To inform discussion on these issues, JVAP supported a suite of regional research projects (Jay 2009, Vaughan 2008, Peacock 2008) that tested the ability of the metrics *Habitat Hectares*, *Biometric*, and *Biodiversity Benefits Index* to reliably assess the impact of different PNF operations, including harvesting, on sustainability. In an overarching report, Thompson and Connell (2009) synthesised findings from these projects.

The researchers noted that the metrics generated relatively high scores for a range of PNF operations, but cautioned that these scores did not necessarily demonstrate that the operations are 'sustainable'. The researchers concluded that **the underlying logic of the metrics system – namely that maintenance of general structural attributes is sufficient to protect habitat and biodiversity – is a concern.** It may miss habitat and biodiversity issues of regional importance, and may not give sufficient credit to operations that enhance both production and ecological values. Furthermore, it imposes costly and unnecessary limitations on PNF operations; an issue addressed by Peacock (2008) demonstrating that a relatively simple measure such as a tree diameter standard deviation adds predictive capacity to the metric which can be implemented at the stand level and potentially aggregated up to the landscape scale.



Can thinning private native forests be economic while meeting public expectations for maintenance of biodiversity?

Box B4 Metrics or checklists?

Lindenmayer (2009b) argued that most commonly used indicators such as indicator species, focal species, indices of forest landscape fragmentation, and thresholds in levels of native vegetation cover, have poor scientific validity. Problems arise with these 'short cuts' because of the wide range of responses of different elements of the biota to disturbances (such as logging) which often lead to species-specific, site-specific, landscape-specific, forest-type-specific, and region-specific outcomes that are not readily generalised to other species, sites, landscapes, forest types and regions.

In view of these problems, he put forward an alternative approach, based on the major overarching theme of maintaining habitat suitability for forest biota. His approach is based on six principles:

- maintaining connectivity
- maintaining landscape heterogeneity
- maintaining stand structural complexity
- maintaining integrity of aquatic ecosystems
- using knowledge of natural disturbance in natural forests to guide off-reserve management practices
- adopting a risk-spreading strategy in which managers do not 'do the same thing' everywhere

There are three main strategies and more detailed actions to assist development of forest management plans consistent with these principles, and to act as a benchmark against which codes of practice can be assessed:

- setting aside large conservation reserves (not applicable to PNF)
- adopting landscape-level off-reserve management strategies, including:
 - protected areas within production forests
 - establishment of riparian buffers
 - appropriate location of road networks
 - spatial and temporal arrangement of harvest units
 - appropriate fire management practices
- adopting stand-level off-reserve management strategies, including:
 - retention of key elements of stand structural complexity at the time of harvest such as large trees with hollows (plus recruits), understorey thickets and large fallen logs
 - longer rotation times (coupled with structural retention at harvest)
 - altered silvicultural systems (including novel approaches to retention and the application of modified thinning regimes)
 - appropriate fire management practices

In concluding, Lindenmayer noted that it is the stand-level strategies and actions that relate most strongly to PNF, and that they must be carefully considered in relation to landscape-level factors. This requires cross-property and cross-tenure coordination involving State government agencies including catchment management authorities.

Notwithstanding these reservations, the researchers added that with the inclusion of additional components to measure the silvicultural and economic sustainability of PNF operations, and in conjunction with a checklist (such as that proposed by Lindenmayer – see Box B4) which captures broader landscape scale issues, then metrics may have a role in assessing the sustainability of PNF operations.

In addition to contributing to technical advancement of

methods to measure and monitor the sustainability of PNF operations, the JVAP studies revealed public policy issues including: anomalies between regulatory instruments and the goals of ecologically sustainable forest management; a silvicultural skills gap amongst people managing PNF; and a lack of incentives for PNF operations that yield both public and private benefits. These issues are discussed in ***Public policy, investment options, grower initiatives*** section D1.2.

Box B5 Case study #1: Biodiversity response to thinning and grazing

Most JVAP research into the sustainability of PNF operations focused on the utility of metrics to assess the ecological sustainability of harvesting and thinning for timber production. Many PNF are also used for both timber production and livestock grazing. Peacock (2008b) presented results from three 14-51 year-old studies in managed forests in northern New South Wales, East Gippsland in Victoria and southern Tasmania, where the vegetation response to thinning and grazing had been monitored. Key results were:

- Initial forest vegetation composition, thinning method and intensity, extent of soil disturbance and the timing of cattle grazing all had an effect on forest biodiversity and tree growth
- Abrupt changes in vegetation composition and structure occurred in the first 1-3 years after thinning, but the medium term (12-17 years) composition and forest structure more closely resembled that of the untreated regrowth forest
- In northern New South Wales, a lag of four years in tree growth rates in the unfenced treatment compared to the fenced treatment suggested cattle grazing led to slower growth rates for trees under 1 m tall, however the differences became less apparent over time and were negligible after 12 years
- Forest managers should consider modifying existing practices in their region, for example delaying cattle grazing until four years after thinning in northern New South Wales Spotted Gum forests

These results were from one of the few medium-term studies that examined the vegetation and plant biodiversity responses to thinning in southern Australia. They demonstrated the resilience of the vegetation to this form of intermediate disturbance, assuming soil disturbance from thinning is kept to a minimum.

Box B6 Case study #2 Timber and livestock response to thinning

Murray and Thompson (2000) found that thinning dense regrowth in north-western New South Wales could enhance timber and agricultural productivity while maintaining or enhancing habitat and conservation benefits. This JVAP research concluded:

- Selection thinning offers the most flexibility, especially for uneven-aged stands of native forest, and can create conditions for growth and regeneration which improves forest product yields. It also maintains natural patterns of species and communities resulting in improved biodiversity
- Different pruning and thinning regimes produce different final outputs (for example, sawlogs, poles, etc.)
- Tangible economic benefits from thinning trees include improved livestock stocking rates and marketing of native timbers in the region, however the economics of thinning is tempered by the lack of developed markets for thinnings
- To maintain biodiversity it is important to maintain a diversity of habitats within the forest stand. This can be best achieved by maintaining a diversity of native tree and shrub species, a range of tree ages from regenerating seedlings through to hollow trees, and maintaining other habitats such as logs, mistletoes, water, nectar and seeding grasses

Implications for PNF managers

Governments have introduced codes of practice and other regulatory measures, principally based on the metrics approach, to assure the broader community that PNF operations are ecologically sustainable. JVAP research has shown that these measures can impose additional costs on PNF managers, they may not 'prove' that PNF operations are ecologically sustainable, and furthermore they can have negative production and ecological outcomes.

There is no indication that public scrutiny of PNF management will diminish. Hence PNF managers who consider they can make a profit from their operations will need to continue efforts to demonstrate that they can meet

public expectations concerning sustainability. This effort will require ongoing awareness-raising about the unintended consequences of existing regulatory arrangements, together with continuing progress in developing better alternatives. One option is for PNF managers to consult with government agencies in jointly developing stand and landscape scale PNF plans that incorporate key principles, strategies and actions for maintaining habitat suitability for forest biota, along with metrics that establish thresholds or benchmarks for desired outcomes of the key actions. Additional measuring and monitoring would also be required.

The key challenge in developing a PNF arrangement along the above lines is to make it a viable proposition for PNF

managers. A mix of regulatory and incentive measures would be required, including some form of cost sharing or remuneration mechanism that takes account of commercial trade-offs.

B2.2 Industrial plantations and biodiversity

In the late 1990s and early 2000s, conservation of biodiversity was increasingly being recognised as a key part of managing existing plantations and establishing new ones, but there were few studies either in Australia or overseas to guide how conservation values could best be integrated into plantation management. In 1999, The Australian Government sought to promote the environmental benefits of farm forestry with significant Natural Heritage Trust funding towards several key projects to investigate and quantify the biodiversity benefits of farm forestry plantations. JVAP, along with other programs including Land & Water Australia's Native Vegetation Research and Development Program, supported significant research in this area.

Radiata Pine plantations

With JVAP support, Lindenmayer *et al.* (2002), and Lindenmayer (2009a,c) reported on a major study which sought to identify ways of enhancing the conservation value of Radiata Pine plantations in south-eastern Australia. Focusing on plantations in the Tumut region of south-east New South Wales, it found that key strategies to promote conservation in plantation landscapes could include:

- **Retaining native eucalypt forest or woodland remnants within plantation landscapes.** Even small remnants of 1-3 ha were found to have important habitat value for a wide range of species. Moreover, a landscape mosaic comprising stands of plantation trees and remnant patches will support significantly higher levels of native animals than monoculture plantation landscapes
- **Protecting native vegetation along gullies** as these areas can be valuable dispersal routes for some species (e.g. small terrestrial native mammals). These areas are also often quarantined from plantation establishment for quality reasons and they might be useful places to target for native vegetation restoration efforts
- **Controlling weed invasion** problems (e.g. by pine 'wildlings' and blackberry) within native vegetation remnants and the plantation estate

Blue Gum plantations

A JVAP report by Hobbs *et al.* (2002) on a study from south-west Western Australia, provided the first detailed information on faunal use of extensive Blue Gum plantations. The researchers found that **plantations as they are currently managed deliver a biodiversity benefit which represents a 15-25 per cent improvement over agricultural land**, based on habitat complexity scores for vertebrates. In addition, many predator and parasite insects were found in plantations

and they could be expected to contribute to the natural bio-control of pest insects both in the plantation and in surrounding agricultural enterprises.

However, the major limiting factor to biodiversity benefits appeared to be **structural simplicity**. Options proposed for increasing structural complexity without significant commercial trade-offs included: diversifying plantation age structure; providing open space habitat; providing dying and dead wood; increasing tree species richness; maintaining stands of mature trees beyond normal economic maturity; managing riparian zones sensitively; increasing resources for wildlife; adopting a landscape design approach to land use; and managing understorey vegetation sensitively.

Sub-tropical plantations

In Queensland, farm forestry has emerged as a rural industry, especially in the south east where potentially 330,000 ha is available for planting. A Queensland government farm forestry assistance scheme has encouraged farm forestry plantings on cleared farmland. Surveys of tree growers in Queensland and elsewhere had confirmed environmental benefits were an important reason for planting, however there was little published information on the contribution of farm forestry to biodiversity. In this context, JVAP supported a study in south-east Queensland and northern New South Wales to identify, quantify and compare vertebrate fauna within cleared, grazed improved pasture, various-age Gympie Messmate plantations, and selectively-logged eucalypt forests (Borsboom 2002).

The researchers found that **the highest vertebrate diversity was recorded in 38-40.5 year old plantations**, but in contrast, vertebrate density was low on pasture. Single-species eucalypt plantations of 10 ha or less with connectivity to some form of natural habitat, even without any special management to enhance biodiversity, will support more vertebrate species. They noted that the impact on vertebrate fauna of timber harvesting and subsequent replanting is unknown and requires further investigation.

The study report recommended that siting, establishment and management of **new eucalypt plantations should incorporate habitat features found in the older plantations**, including: good connectivity to native forest; retention of logs and stumps; suppression of a thick grassy groundcover; a good litter layer; encouragement of a layered understorey of shrubs and small trees; exclusion of grazing animals and hot fires.

Box B7 Trees and Biodiversity – a comprehensive guide

Trees and Biodiversity (Salt et al. 2004), published by JVAP, is a comprehensive guide to managing farm forestry to protect and enhance biodiversity in agricultural landscapes. It originated from a 2002 workshop involving scientists and extension officers experienced in farm forestry and revegetation. Following the workshop, Lindenmayer (2009a) conducted an extensive review of the scientific literature on biodiversity in commercial plantations (including small woodlots, shelterbelts and mixed-species habitat plantings) and summarised the main points and guidelines.

Trees and biodiversity examines what was known in 2003 about the biodiversity value of tree plantations, presents a case for why biodiversity conservation is a desirable outcome, and provides a basic framework of understanding for improving the biodiversity value of various forms of farm forestry. It has five themes for enhancing biodiversity, which mimic the way a plantation would usually be planned:

- Location (adjacency, connectivity, landscape context, waterway protection)
- Configuration (size and shape of plantings)
- Species composition (mixed-species plantings, local species)
- Complexity (structural complexity, time and age of plantings, patchiness)
- Ecological management (monitoring biodiversity, adaptive management, simulating natural disturbances, variability in management actions)

Practical guidelines on how to improve biodiversity at the level of a stand of trees and at the scale of the broader landscape are also outlined, together with a discussion of some of the possible trade-offs involved. A range of hypothetical farm forestry situations are discussed, with suggestions as to how their value for biodiversity may be improved.

B2.3 Mixed tree plantings and biodiversity

Declining biodiversity in agricultural landscapes has been consistently identified as a serious threat to their sustainability, and putting trees back in the landscape has been recommended part of the remedy. Well-planned farm forestry has the potential to make an important contribution, as outlined in *Trees and biodiversity*, and indeed many revegetation projects have claimed enhanced biodiversity as an outcome. However, even as that book was being published, it became apparent that actual data supporting claims concerning the biodiversity response to new plantings on previously cleared land was scarce.

JVAP supported a large-scale study (Kavanagh *et al.* 2005) in the Albury-Wodonga region in southern New South

Wales/north eastern Victoria where there had been extensive revegetation over the previous three decades. The aim of the study was to guide future planting schemes for biodiversity recovery in agricultural landscapes. Its key findings highlighted the importance of existing remnants of native forest and woodland in regional conservation planning and that these should provide the focal point for habitat restoration efforts using eucalypt plantings. Plantings of native trees and shrubs of all shapes and sizes, especially those larger than five ha, have an important role to play in providing habitat for many species and these plantings may also contribute significantly to increasing the effective size of remnants in agricultural landscapes. The researchers recommended that site preparation for eucalypt plantings could be improved by not removing old paddock trees and logs on the ground.



Native tree and shrub plantings provide habitat for many species

B2.4 Implications

Research supported by JVAP and other organisations has revealed key principles and practices that can maximise biodiversity conservation in PNF, industrial plantations, and mixed tree and shrub plantings on farms.

As a rule, these principles and practices align with the ways in which natural forests are structured and function, and centre on: maximising structural and floristic diversity; ensuring connectedness with remnant vegetation; protecting aquatic and riparian ecosystems; and managing thinning and harvesting operations so that as far as possible they resemble natural disturbances such as storms and wildfires.

Lack of knowledge about the gross biodiversity outcomes of the principles and practices is no longer an impediment to their application. The unresolved issue is that **the nature and extent of public benefits are either intuitively inadequate or cannot be valued accurately**. Thus there is an absence of markets in which their full value, or at least the value of the commercial trade-offs they entail, can be captured by the private sector interests establishing and managing the plantings.

Hence the future challenge is to design planning, regulatory and incentives frameworks so that large-scale revegetation investments are obliged and supported to take biodiversity values (and water yields, food production and landscape aesthetics) into account (Campbell 2009, unpublished). JVAP has supported research into these frameworks – see *Market-Based Instruments*, section D2.1.

B3. Farm forestry and water

B3.1 Trees for recharge control and their effects on water resources

A Murray-Darling Basin Commission report released at the time of JVAP's commencement confirmed that dryland salinity in the Basin States was rapidly expanding. At least 200,000 ha were 'grossly affected' and more than 1Mha was at risk. Tree clearing and agricultural development was considered to be the main cause, with 50% of the Basin's pre-European vegetation cover having been removed (MDBC 1993). Salinity was also widespread in Western Australia, with 1.8 Mha affected 'to some extent' in 1994 (State Salinity Council 1998).

Responding to the salinity problem, governments strengthened their investment in tree planting. The Denmark River in Western Australia was the first example of salinity trends being reversed as a result of plantation development (Campbell 2008). Agroforestry was also being recognised for its potential but there was still a low level of confidence in how to position trees in the landscape for best effect. Some catchment communities were investing their own funds and government grants in management options, for example break of slope tree planting, based on demonstration sites that bore no physical resemblance to their local conditions. Outcomes were highly uncertain. Furthermore, there was no national framework for determining catchment scale hydrological behaviour (Coram 1998).

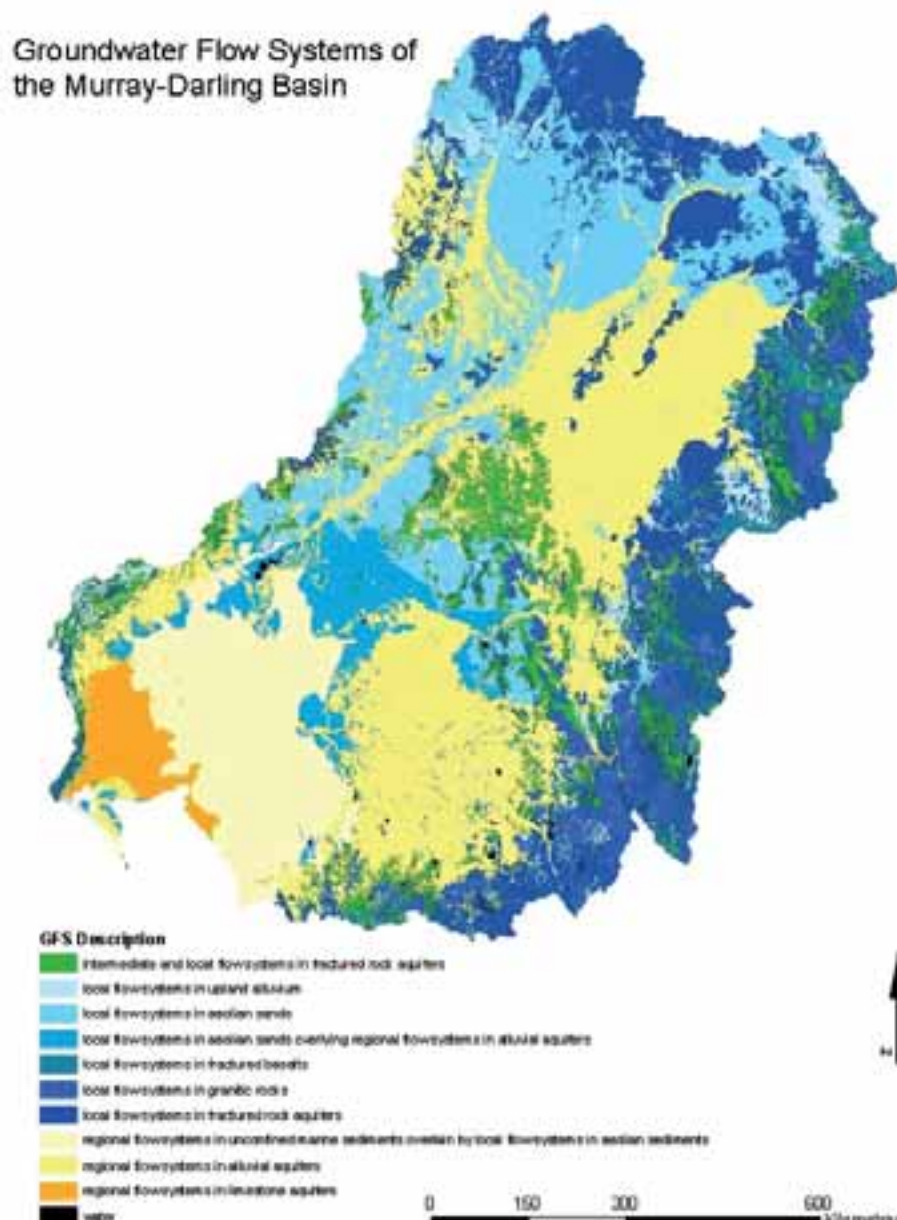


Salinised cropping land near Tammin, Western Australia

To address these issues, JVAP initiated several workshops that led to a program of high quality, targeted research. The first of these workshops, *Agroforestry and Hydrology: What do we need to know?* (Stirzaker 1996) developed the following recommendations for future research: develop a catchment classification system; establish guidelines for designing agroforestry systems to balance catchment health with tree productivity and agricultural productivity; and determine the productivity and sustainability of plantations in regions with shallow watertables (see also *Trees over shallow watertables and on saline land*, section B3.2). The recommendations were all implemented through JVAP research where they made significant contributions to our understanding of the role of trees on farms in managing dryland salinity.

Catchment Classification

The *National Classification of Catchments for Land and River Salinity Control* (Coram 1998) was the first objective, national-scale framework for guiding salinity management effort and funding allocations. It was developed by the then Australian Geological Survey Organisation with support from JVAP, CSIRO, the National Land and Water Resources Audit, and partners in the National Dryland Salinity Program including Land and Water Australia and the Murray-Darling Basin Commission.



The National Classification of Catchments for Land and River Salinity Control was a breakthrough in salinity management

The *National Classification of Catchments for Land and River Salinity Control* describes fifteen generic hydrogeological models of groundwater systems describing the broad characteristics of salinisation in different types of catchments across Australia. The models consider the different scales of processes involved in salinisation, and whether these are local, intermediate or regional groundwater flow systems (GFS). The specific settings of the models are described for each State where they are known to occur.

The GFS concept is now in common use throughout Australia as the framework for investigating and implementing salinity management options and when supported by additional local investigations, has dramatically improved confidence in the outcomes of investments in on-ground works.

Plantations and water resource management

The *Plantations for Australia – the 2020 Vision* released in 1997 (Ministerial Council on Forestry, Fisheries and Aquaculture 2002), combined with managed investment schemes, triggered significant expansion in the plantation estate in some regions. Commercial considerations, especially growth rates and proximity to markets were paramount, and hence the plantations were mostly established in higher rainfall areas¹.

There were concerns that the plantations would diminish the water available to other land uses such as irrigated agriculture (O'Loughlin and Nambiar 2001), but an opportunity for broadscale tree planting to address salinity was being missed. Responding to these concerns, JVAP, the Department of Agriculture, Fisheries and Forestry, and CSIRO convened a major workshop in July 2000 that added substantial objectivity and balance to the debate about plantations and water resources. **Nine years later, the workshop's conclusions are still considered valid, and are even more significant,** as the debate has intensified during the drought over much of south eastern Australia since 2001. Key conclusions from the workshop were:

- The impact of afforestation on stream flow will vary throughout the life of managed plantations as leaf areas change, for example through thinning and harvesting
- Planted trees that draw water directly from the watertable can achieve higher growth rates using this extra water, but can depress the level of the groundwater. The ability of trees to use groundwater in any significant amount seems strongly dependent on the depth to the watertable
- **Positive effects of afforestation can be identified in some landscapes suffering from dryland salinity.** In local groundwater flow systems, strategically-located woodlots and plantations can check or slow its spread and eventually rehabilitate damaged areas. The salt concentration of river flows can also be reduced
- **The impacts of plantations and farm forests on available surface water will be greatest in high rainfall areas,** hence if plantation expansion is mainly centred on moderate rainfall areas (600-850 mm) as it has been historically, its effect on water resources will be far less
- **Expansion of plantings into lower-rainfall areas will probably have negligible effect** on downstream water resources. However, at the local scale, new plantations on cleared land may cause unregulated rivers to revert to the flow patterns they had before the land was cleared
- **Tree plantations of all types reduce peak runoff rates during flood-producing storms** which lessen flood damage, landscape erosion and river siltation. However, river flows during smaller storms are also diminished, resulting in reduced flushing – possibly to the detriment of aquatic habitat

¹Throughout this report, 'higher' rainfall areas are described as those receiving above 600 mm/yr. Participants at the JVAP/CSIRO workshop referred to below considered these to be 'moderate' rainfall areas, inferring that they considered 'high' rainfall areas to be those receiving more than 850 mm/yr

Box B8 Trees, Water and Salt

Trees, Water and Salt: An Australian guide to using trees for healthy catchments and productive farms (Stirzaker *et al.* 2001) was published by JVAP in a period in which the salinity debate had moved from relative obscurity to the front pages of major newspapers and scientific conferences. It was the culmination of four years' research by a team of CSIRO and other scientific experts, which synthesised and added considerably to the already large body of knowledge. At the time, it was the most up to date, readable and useful book yet published on agroforestry and salinity.

The book guides its target audiences in their quest to develop the most effective approaches in their particular hydrological environment by assisting them in answering the following questions:

- How much of the catchment needs to be planted?
- What parts of the catchment should be planted?
- Which planting configurations should be used?
- How long will it take to see an effect from tree planting?
- How effective/sustainable will plantation designs be in different parts of the landscape?
- Which species should be selected and what silvicultural practices should be employed?

Harper *et al.* (2009) field tested the revegetation principles in *Trees, Water and Salt*, using a sub-catchment scale planting near Wickpin, Western Australia. As well as monitoring the hydrological effects of the planting, the researchers assessed a range of tree species for biomass production and carbon sequestration.

Although groundwater pressures declined in 19 out of 20 piezometers in the study area in the 7 years since the study commenced, it was not possible to ascertain whether this decline was due to the trees or a broader regional decline in groundwaters as a result of drought. This uncertainty confirms the need for long-term monitoring.

The research site was used as a forerunner for a broader monitoring program established in conjunction with the *Strategic Tree Farming* project, a \$64 M Australian Government and Western Australian Government initiative that is establishing 18,000 ha of trees across the medium rainfall zone (500-700 mm) of Western Australia. By mid-2009, 25 properties were expected to have hydrological monitoring systems established, building on the experience gained in this research.

B3.2 Trees over shallow watertables and on saline land

As early as 1982, irrigation-induced salinity was becoming a major problem in northern Victorian irrigation regions. By 1989 in the Shepparton Irrigation Region, there were high watertables under some 188,000 ha (36%) of the Region, and these were predicted to extend to 274,000 ha (55%) of the Region within the next 30 years. Agricultural production losses were estimated to rise from \$47 million per year in 2000 to \$120 million per year in 2025 (SPAC 1989).

In southern New South Wales, about 70,000 ha of the 716,000 ha Murrumbidgee Irrigation Area was being used for rice production, requiring about 54% of the total water allocation from the River Murray. A 1998 Groundwater Resource Management Survey report concluded that in the absence of remedial action, the proportion of land with groundwater less than two metres from the surface would increase from less than 20% to about 50% by 2020 (Polglase *et al.* 2002).

In the mid 1990s, agroforestry was being widely seen as an ideal solution to rising watertables and salinity in irrigation areas. Trees had the potential to intercept recharge and use high volumes of groundwater, lowering watertables and

generating economic returns to farmers through timber production. An early JVAP study under the Victorian *Trees for Profit* research program estimated that if 40,000 ha of plantations were established around Shepparton and other northern Victorian towns, they would deliver 'dramatic' benefits. Overall, the establishment of farm forestry in the region would increase the value of output for all industries by \$1.3 billion, or 6.1% of total output. Regional income would increase by 4.8%, or \$302 million, and 5,748 new jobs would be created (RIRDC 1998).

However, previous research had shown that when trees take up water from the watertable, groundwater flows towards the roots carrying salt with it. If there is no throughflow of groundwater, salts can build up in the root zone, limiting tree growth and threatening tree survival. Although there were modelling approaches to analyse salt dynamics and plant growth in these saline environments, few had been well documented, peer-reviewed or widely tested (Thorburn 1999).

In 1997, JVAP initiated a major workshop that brought together twenty leading researchers in this field, to compare experimental results and examine recent advances in modelling approaches, to better define the extent of current knowledge

and capabilities, and identify important information gaps. An immediate outcome of the workshop was a set of 'best bet' interim guidelines for revegetating areas with shallow, saline watertables.

Box B9 Interim guidelines for revegetating areas with shallow, saline watertables (Thorburn 1999)

A major JVAP workshop in 1997 distilled the experience and observations of 20 leading researchers and 15 years of prior research into 'best bet' interim guidelines, covering:

- Benefits of planting trees for controlling shallow watertables
- Requirements for site definition and species selection
- Where trees have the greatest potential for lowering watertables
- Sustainability of trees growing over shallow watertables
- Hydrogeological factors affecting the impact of trees
- Area of trees
- Tree performance in areas with shallow watertables

In later years, JVAP continued to support investigations into trees for managing shallow watertables in irrigation areas to address the information gaps. Priorities were to improve knowledge of groundwater uptake and salt accumulation and removal in the root zone, and to develop better models for assessing the long-term sustainability of the systems.

Early doubts about long-term sustainability

Vertessy *et al.* (2000) undertook field experiments and developed and validated a computer model (*Topog_Dynamic*) describing salt and water dynamics beneath a 21 year old Eucalypt plantation at Kyabram in Victoria. The research confirmed that hardwood plantations of salt sensitive tree species over shallow watertables could have positive short term and local effects, but their long term sustainability was not assured. Their key findings were that:

- If plantation density is sufficiently high (so that evaporative demand exceeds infiltration of rainfall into the soil), the trees will use water from a shallow watertable
- Tree water use will create a groundwater depression beneath the trees, with salt accumulating in the plantation root zone where it has been excluded by the roots
- The uptake of groundwater by the plantation along with plantation growth rates will decline as the salt accumulation increases, leading to rises in the groundwater level.
- The prospects for long-term sustainable plantation growth are poor, unless soil hydraulic properties enable processes

such as leaching and diffusion to remove salt from the root zone to balance the accumulation process

- Without these balancing processes, net tree groundwater usage will decline to zero due to salt accumulation. Nevertheless, plantations can effectively negate groundwater recharge

Vertessy *et al.* noted that the net benefits of plantation establishment over high watertables, and its potential problems, were likely to be site-specific. Site characteristics such as soil permeability, groundwater salinity, and depth to groundwater would combine with climatic conditions and tree species factors to determine how the plantation interacts with the groundwater system. These factors would affect potential growth and evapotranspiration rates, and patterns of groundwater uptake by trees. They would also affect salt accumulation beneath the trees and thus the long-term performance and sustainability of the plantation.

Confidence restored, especially for salt-tolerant hybrids

Following on from the work of Vertessy *et al.* a subsequent study of plantations over saline watertables (Dale *et al.* 2008) was based on sites in irrigation areas in the Riverina of New South Wales and northern Victoria, spanning a range of salinities. The sites were monitored for up to seven years. The researchers used *WAVES* (a hydrological and growth productivity model) to explore long-term outcomes of salt-tolerant hybrid plantations (River Red Gum x Blue Gum and River Red Gum x Flooded Gum) under a range of real and theoretical site conditions.

They found that **plantations of fast-growing, salt-tolerant trees can be sustainable (at least in the short-term)**. The study confirmed that the dynamics of salt in the root zone of trees over shallow, saline watertables is governed by a complex interaction of factors, principally soil hydraulic properties, groundwater depth and salinity, sensitivity of plantation species to salt, soil nutrient status, and plantation management. While some combinations of conditions may lead to salt accumulation in the root zone, others can maintain salt load and its distribution in the profile in equilibrium, allowing long term sustainable timber production. In certain situations, management interventions can promote salt redistribution back down the profile below the active root zone.

Furthermore, the establishment and management of such plantations on 500,000 ha of land at risk from rising watertables would require a capital investment of around \$1.5 billion, but **could potentially generate revenues of \$7.6 billion**. Timber production has a multiplier effect of around two for employment, value adding, income and output, providing a potential benefit to rural communities of over \$760 million per year.

Box B10 Trees for Saline Landscapes

Trees for Saline Landscapes (Marcar and Crawford 2003) is a major JVAP synthesis of many years of research results. It focuses on species suitable for temperate and subtropical Australia, since this is where the majority of salt-affected land is currently found and is predicted to develop in the future. Insect pests and their control are dealt with extensively.

- Chapter 1 – Setting the scene – provides an overview of the whole salinity issue, vegetation management options for recharge and discharge areas and more specific information related to salt-affected environments
- Chapter 2 – Species and management – deals with species selection and management of tree plantings, again with a focus on saline environments
- Chapter 3 – Species descriptions – provides descriptions generally sourced from books, leaflets, journal articles, other published material, unpublished reports and from CSIRO Forestry and Forest Products staff and trials
- Chapter 4 – Bibliography – is an annotated bibliography of field studies on salt-affected land with special reference to Australian species

Since there are a wide range of site conditions experienced in saline landscapes, the book includes descriptions of species which can tolerate slight to extreme salinity as well as varying waterlogging and pH conditions, and those which have commercial through to non-commercial opportunities.

Consistent with the findings by Dale *et al.* Marcar and Crawford (2003) in the JVAP synthesis publication *Trees for Saline Landscapes* (see box) conclude that opportunities to grow commercially-valuable trees fast enough for a commercial return and on a sustainable basis are greater where groundwater is not too saline (EC <5 dS/m) and not too deep (<4-5 m), and where soils allow tree roots to grow deeply.

B3.3 Implications

In comparison with initiatives such as the *National Dryland Salinity Program*, introduced in 1993, JVAP has been a minor investor in research into trees as a salinity management option.

However, there have been numerous occasions where **JVAP managers have catalysed workshops that were pivotal in reviewing existing knowledge and in setting future research priorities.** These workshops, in which JVAP brought together leading researchers and program managers, include the *Agroforestry and Hydrology: What do we need to know* workshop in 1996, the *Agroforestry Over Shallow Water Tables* workshop in 1997, and the *Plantations, Farm Forestry and Water* workshop in 2000.

The National Classification of Catchments for Land and River Salinity Control was a highlight for JVAP and the other organisations involved in its development. For the first time, the Classification and its Groundwater Flow Systems (GFS) framework allowed the use of cost-effective modelling instead of expensive site-based investigations to estimate the likely effects of salinity management options in similar types of catchments which were often large distances from each other. It dramatically improved confidence in the outcomes of tree-based plantings for salinity management. **Ten years later, the GFS concept, with local-scale variations, is still used in salinity management planning.**

JVAP has been the 'honest broker' in contributing

balanced and objective information to the debate about the effects of plantations on water resources. In the early years of JVAP, the prevailing thinking was that plantations would generate a 'win-win' outcome by providing additional timber resources while tackling dryland salinity, which was a rapidly-expanding problem. By the late 1990s, however, it was evident most plantations were being established in higher rainfall areas where salinity, if it was present, was not a significant problem. Concern began to be expressed about the negative effects of these plantations (mostly for pulpwood) on the availability of water for downstream users. These concerns intensified as the worst drought in recorded history began to impact wide areas of southern Australia, and salinity began to abate. The conclusions of the JVAP workshop in 2000 about the actual effects of plantations (and findings from much research since, particularly by CSIRO) are still valid today, and are influencing plantation policy development. The emerging issue is that this knowledge, augmented by new research, needs to be taken into account in planning carbon and biomass plantings, which potentially could cover a much wider area than pulpwood plantations.

The 'business case' for establishing hardwood plantations as part of the solution to salinity in irrigation areas is waning. There have been large reductions in water allocations due to the ongoing drought, and irrigators have either ceased irrigating or where they do have water, have adopted more efficient irrigation and drainage practices. Hence, as with dryland salinity, the salinity threat in irrigation areas has also abated. Furthermore, hardwood plantations take up valuable land and even though they may grow relatively quickly over shallow watertables, they will not be sustainable in all situations, and they suffer from the same marginal economics as similar plantations in higher rainfall areas, namely the long time before receipt of income and the lack of markets for thinning and prunings.

Similarly, with salinity abating, and with the development of more profitable saltland pasture systems (see <http://www.saltlandgenie.org.au/>) the case for establishing trees on saline land is also diminishing.

B4. Farm forestry and carbon sequestration

In the 1990s there was increasing international concern about greenhouse gases contributing to global warming, particularly carbon dioxide (CO₂). The *Kyoto Protocol*, an international agreement agreed in 1997, sought to reduce global greenhouse gas emissions by requiring developed countries to meet national targets for greenhouse gas emissions over the period from 2008 to 2012.

In the early 2000s, before Australia became a party to the *Kyoto Protocol*, revegetation advisers and farmers were contemplating offsetting tree growing expenses by engaging in carbon 'farming' (Hassall and Associates 2001), and State governments were establishing frameworks to permit carbon trading. The New South Wales *Greenhouse Gas Abatement Scheme* introduced in 2003 required electricity generators to meet specified targets for reducing their emissions, either through direct measures, or by purchasing Abatement Certificates, each of which represented one tonne of CO₂ or its equivalent (Grieve *et al.* 2008). In Western Australia, the *Carbon Rights Act 2003* enabled a carbon right to be registered on land title as a separate interest in that land, in order to facilitate trading. Importantly, the carbon right gave no guarantee as to the quantity of carbon stored in the carbon sinks on the land, whether the carbon will remain on the land, or what value the carbon may have. It was left to the market to determine what the carbon right was worth (State of Western Australia 2005).

B4.1 Carbon Farmer User Manual

Anticipating domestic and international interest in carbon markets, and the role that agroforestry could play in sequestering carbon, JVAP initiated research in 2001 to provide information critical to market operation, for example: What will trees produce in terms of usable timber and sequestered carbon? What will be the costs of establishing and maintaining a plantation and engaging in the market for sequestered carbon? What returns will there be for the timber (if it is sold) and for the sequestered carbon? They also expected that there would be a registration system for plantations, and that there would also be independent verification of the carbon sequestered (Hassall and Associates 2001).

The JVAP *Carbon Farmer User Manual* released in 2001 was an early software-based tool to assist revegetation advisers and farmers to decide whether it is worth engaging in carbon farming. It allowed them the physical and financial consequences of different assumptions about the productivity and management of plantations, the costs of cultivation and

administration, and the price for which the sequestered carbon (as well as the timber itself) may eventually be traded (Hassall and Associates 2001). The extent to which the Manual was used by its intended audience is unknown.

B4.2 Carbon pool managers

In the mid-2000s, the drought in Australia worsened, and commentary about greenhouse gas emissions, global warming and carbon trading became more main stream. In New South Wales, the possibility existed that environmental plantings established under Catchment Management Authority (CMA) revegetation programs, together with commercial tree plantations, could form a pool of carbon stocks managed under the *Greenhouse Gas Abatement Scheme (GGAS)*. Furthermore, it was thought that through the creation and sale of GGAS Abatement Certificates, CMAs may be able to access a significant income stream. Preliminary estimates suggested that gross revenue of more than \$12 million per year could become available.

A JVAP study by Grieve *et al.* (2008) with the Murrumbidgee CMA in 2006 provided background information and preliminary analysis to assist CMAs in deciding whether to apply for accreditation as a pool manager under the GGAS. It concluded that **it would be feasible for CMAs to seek accreditation as a GGAS carbon pool manager, based on environmental plantings on private land.** With only minor changes, CMA business systems could be adapted to satisfy the GGAS requirements for developing contracts, registering carbon rights and restrictions on use, developing risk management procedures, and monitoring and reporting compliance. However, the requirement to maintain the abatement for 100 years was considered to be a disincentive to landholders and would be difficult for the CMA as a pool manager to plan for.

For the small data set available, both carbon accounting methods evaluated (the *Carbon Sequestration Predictor 2003* and the *National Carbon Accounting Toolbox 2005*) were found to provide generally unbiased estimates for plantings of typical dryland eucalypt species over five years of age, however, for younger plantings the estimates were inaccurate. **Neither model provided a precise measure, hence the level of uncertainty would result in very conservative estimates of the quantum of carbon sequestration** for which for abatement certificates could be created. Nevertheless either model may be suitable for use by CMAs, subject to calibration for a wider range of species and planting types, and additional assessment of uncertainty.

A business case for the Murrumbidgee CMA showed that the returns could justify such a venture, but were dependent on the level of interest and uptake demonstrated by landholders, as well as the income sharing agreed between landholders and CMAs. Attracting existing eligible plantings into the pool would be important to provide an immediate source of revenue. A draft revegetation strategy was developed that could create a pool of over 5,000 ha of eligible plantings over

ten years. Depending on overhead costs, it may be more attractive to develop a larger pool based on several CMA areas. The study recommended a pilot project acquiring additional growth data for representative types of plantings to be included in the pool.

An alternative view to the reported findings of the JVAP study has been expressed by Campbell (2009), who suggested that even if CMAs were able to attract \$12M in revenue, most, if not all of this would be used up with the costs of meeting legal, accounting, reporting and other requirements and in negotiating binding contracts for 100 years with hundreds of individual landholders.

B4.3 Potential for carbon farming

A major JVAP study conducted recently (Polglase *et al.* 2008) synthesised spatial information on the productivity and economics of agroforestry systems in Australia and compare the outputs with market opportunities for agroforestry and inferred support from regional NRM bodies and other groups. The main findings of this study are discussed in *Market opportunities for larger-scale products*, section C1.3).

Because of its wide and multi-disciplinary scope, the Polglase *et al.* study had to make many unavoidable assumptions, particularly about growth rates and economic factors. Nevertheless, it generated new estimates of tree and shrub growth and carbon sequestration rates of different types of plantings for timber and environmental outcomes (see Box B11). Among other things, the study concluded that **carbon farming looks promising** due to the relatively low cost of production (no harvesting or transport costs) compared with a possibly high product price.

The researchers further concluded that environmental carbon plantings could be profitable while minimising their impact on water, across **9 Mha**. These plantings could achieve an

annual increment in carbon sequestration of 143 million tonnes of CO₂ equivalent per year, at an average rate per ha of 16 tonnes of CO₂ equivalent per year. The total annual increment would be equal to about 25% of Australia's net 2005 greenhouse gas emissions.

The findings of Polglase *et al.* were taken into account by the *Garnaut Climate Change Review* (Garnaut 2008) which gave added weight to the researchers' conclusions. For example, Garnaut noted that:

- Effective greenhouse gas mitigation would greatly improve the prospects for Australian agriculture, at a time when international demand growth in the Platinum Age is expanding opportunities
- The realisation of a substantial part of the bio-sequestration potential of rural Australia would greatly reduce the costs of mitigation in Australia. It would favourably transform the economic prospects of large parts of remote rural Australia
- Full utilisation of bio-sequestration could play a significant role in the global mitigation effort. This is an area where Australia has much to contribute to the international system
- Most methane abatement options are costly. The bio-sequestration options, if properly accounted and rewarded, are quantitatively much more important in the mitigation story
- The mitigation gains are potentially so large if current rangeland practices were replaced by land restoration that it is important for Australia to commence work on [the *Carbon Pollution Reduction Scheme*] design and implementation even before the issues of coverage, national and international, are fully resolved



Salt tolerant eucalypts on trial

Box B11 Growth rates and carbon sequestration rates

Polglase *et al.* (2008) generated growth data for a range of potential timber and carbon plantings. For example:

- **Blue Gum (*Eucalyptus globulus*) sawlogs** were predicted to grow at rates of 35 m³/ha/yr in 2000 mm rainfall, down to 10 m³/ha/yr in 600 mm rainfall
- **Sugar Gum (*Eucalyptus cladocalyx*) and Spotted Gum (*Corymbia maculata*) sawlogs** were predicted to grow at rates of 5 m³/ha/yr in 550 mm rainfall, down to less than 2 m³/ha/yr in 350 mm rainfall
- **Flooded Gum (*Eucalyptus grandis*) sawlogs** were predicted to grow at rates from 2 to 35 m³/ha/yr
- **Hardwood carbon plantings** were predicted to have similar growth rates to hardwood sawlogs, but their carbon sequestration rates were predicted to be 20-54% higher than hardwood sawlogs as they would be un-thinned
- Growth rates for **environmental tree and shrub plantings** were predicted to range from an average of 19 t/ha/yr at 2000 mm rainfall down to less than 5 t/ha/yr at less than 500 mm rainfall
- Compared to environmental plantings, carbon sequestration rates for hardwood carbon plantings are predicted to be much greater because environmental plantings are likely to grow more slowly (especially in areas with average temperatures higher than 25°C) and include self-thinning
- Predicted growth rates for softwoods were similar whether grown for sawlogs or carbon plantings. **Radiata Pine (*Pinus radiata*) sawlogs** were predicted to grow at rates of 39 m³/ha/yr in 2000 mm rainfall, down to 8 m³/ha/yr in 600 mm rainfall
- **Maritime Pine (*Pinus pinaster*) sawlogs** were predicted to grow at rates of 7 m³/ha/yr in 550 mm rainfall down to less than 2 m³/ha/yr in 350 mm rainfall
- **Carbon sequestration rates for softwood carbon plantings were predicted to be 130-210 % higher than for softwood sawlogs.** This percentage increase is higher than for hardwoods as more stems are removed in softwood thinning than hardwood thinning

B4.4 Implications

It appears from research to-date, Australia's ratification of the *Kyoto Protocol* in 2008, and the Australian Government's decision to introduce a Carbon Pollution Reduction Scheme, that carbon farming in Australia (particularly with short-rotation tree crops) has excellent prospects.

For the first time, it appears that **the 'perfect opportunity' of strong market demand, favourable economics, large areas of suitable land, many willing growers, and a supportive policy and regulatory environment, will finally overcome the key impediments** to large-scale revegetation and diversification in Australia's rural sector, particularly in medium to low rainfall areas.

People are moving quickly to take advantage of the opportunities. A combination of strong policy and market signals and entrepreneurship have already catalysed the establishment of new, large-scale carbon plantings. These run the risk of repeating some of the undesirable consequences associated with the rapid expansion of Blue Gum (*Eucalyptus globulus*) plantations (see *Trees for recharge control and their effects on water resources*, section B3.1, and *Industrial plantation expansion*, section E1.1).

Many challenges remain. Recent JVAP research has

generated predictions of tree and shrub growth rates and carbon sequestration rates, and one CMA has appeared satisfied with the level of confidence in the rates estimated using contemporary carbon accounting tools. However, there are many assumptions behind these. Actual historical performance data for different species in different climatic zones and soils is still limited. New predictions about the impact of climate change, for example a 60% reduction in rainfall combined with higher potential evaporation and increased extremes (Howden 2008), have added more uncertainty.

In view of the great potential but risks and uncertainties associated with carbon farming, **a priority for any future JVAP could be to generate knowledge essential for the effective operation of carbon markets.** This research would revisit predictions about tree crop growth and carbon sequestration rates under contemporary climate change scenarios, how to develop the associated regulatory and institutional arrangements, and how to avoid unintended negative consequences, particularly in relation to social issues and water.

B5. Farm forestry for bioenergy and biofuels

B5.1 JVAP-Enecon research

In 1996 JVAP published a resource kit titled *Commercial Farm Forestry in Australia, Development of a Strategy Framework* which identified a number of impediments to the widespread adoption of commercial farm forestry. Notwithstanding the environmental and social benefits of tree planting, in the absence of economic drivers, farm forestry was unlikely to expand across those large parts of Australia with relatively low rainfall or distant from coastal markets and ports. In the search for large, new industries that could utilise wood as feedstock, attention turned to renewable energies. In particular, JVAP recognised the potential opportunity in the production of renewable fuels (biofuels) as a co-product in the integrated tree processing (ITP) of oil mallees.

As part of its response to the *Kyoto Protocol*, Australia legislated that an additional 2% of renewable electricity must be sourced by wholesale purchasers and large electricity users in Australia by 2010 and held at this level until 2020. The Mandatory Renewable Energy Target (MRET), set at 9500 GWh per annum, is legislated through the Renewable Energy (Electricity) Act and the Renewable Energy (Electricity) Regulation 2001, and commenced operation from 1 April 2001.

A significant proportion of this renewable energy capacity is likely to be provided by biomass resources, including wood from plantation forests, residues from agricultural or forest production, and organic waste by-products from industry, domesticated animals, and human activities. Estimates suggest that new investment in renewable energy sources for meeting this government-mandated Target will be approximately \$3 billion (Schuck 2004).

An early study by Enecon (2001) investigated the feasibility of building a commercial-scale integrated tree processing (ITP) plant taking coppiced, chipped mallee biomass as feed and producing activated carbon, renewable energy and Eucalyptus oil as products. At the time, the pilot-scale Integrated Wood Processing Plant at Narrogin in Western Australia was under construction. The overall finding was that **a full-scale ITP plant would be financially viable**, offering commercial returns to plant investors while based on adequate prices to justify planting, harvesting and transporting mallees.

A second study by Enecon (2002) assessed the opportunity for making ethanol and methanol from wood, to be utilised as renewable liquid transport fuels. It considered the technologies and costs involved, and discussed the 'balancing' of these costs against the many potential benefits that environmentally benign fuels and increased farm forestry should deliver. The key finding was that **the benefits of producing alcohol fuels from biomass do not appear sufficient to justify a new industry** over the next 15 years. However, estimates of carbon taxes or the value of tradeable permits are key components in

the comparative analysis between energy from biomass and energy from non-renewable resources. The ongoing analytical work on global costs and benefits of reducing greenhouse gas emissions would need to be monitored.

A third study (Stuckey *et al.* 2004) comprehensively assessed the status, costs and opportunities for biomass energy for production. Bioenergy from biomass, either as electricity or as liquid fuels, was considered to represent a huge potential market for new tree plantings in the low to medium rainfall zone (400–700 mm). The main focus of the study was on biomass from forestry, particularly new forestry that may also achieve other environmental benefits in Australia's dryland regions. The key findings were that: in many cases **bioenergy alone would not be a commercial driver** for the new tree planting that JVAP was encouraging across much of Australia; and, if bioenergy production could provide a market for fuel, then **short-cycle crops would produce a much greater return to growers than long-rotation tree crops**.

However, the study found that conversion of biomass to bioenergy is complicated, involving not only conversion technology (as in wind, solar and hydro power), but the whole system. This entails gaining an understanding of: the diverse range of biomass resources; how to cost-effectively process and deliver these resources in a useful form to the conversion plant; how biomass can be transformed into heat, electricity or both in a co-generation plant; or how biofuels can be used for transport fuels.

More recent and expansive assessments of the market opportunities for bioenergy and biofuels have been completed by URS (2008), Polglase *et al.* (2008), and Hobbs *et al.* (2006). This important JVAP research highlights not only the possible opportunities but also the impact of predicted climate change on agriculture in Australia and just how rapidly market conditions are evolving. – see **Emerging market opportunities**, section C1.5)

B5.2 Bioenergy Australia

Bioenergy Australia is a government-industry forum fostering development of bioenergy as a future source of sustainable energy. It fosters and facilitates development of biomass for energy, liquid fuels, and other value-added bio-based products. It is concerned with all aspects of biomass and bioenergy, from production through to utilisation, and its work embraces technical, commercial, economic, societal, environmental, policy and marketing issues. RIRDC continues to manage Bioenergy Australia, now within a new RIRDC program – *Bioenergy, Bioproducts and Energy* – a program which had its genesis in JVAP research.

Schuck (2004) noted that Bioenergy Australia had been participating in the International Energy Agency's Bioenergy Program Task Short Rotation Crops for Bioenergy Systems. This participation had led to close collaboration with leading international experts developing short-rotation crops for energy and other value-added co-products and co-values. It had also allowed interaction and joint work on a variety

of technical and socio-economic issues concerning energy crops. A report from Australia's participation in the Task indicated that existing regulatory arrangements in Australia are impeding the use of woody crops and wood wastes for the production of renewable energy. For more detail, see *Renewable energy*, section D1.3.

RIRDC was a Principal Sponsor of its *Bioenergy Australia 2008* Conference, bringing together biomass feedstock producers and suppliers, waste management organisations, project developers, energy companies, equipment suppliers, investors, government agencies, research providers and research funding bodies.

B5.3 Bioenergy Atlas

Recognising that there was a need to improve the availability of information on bioenergy for researchers, policy, planners and potential investors, JVAP published an improved Online Bioenergy Atlas in 2007. It was developed by the University of Adelaide and the Bureau of Rural Sciences with funding from JVAP and the Australian Greenhouse Office.

The improved Bioenergy Atlas incorporates more up-to-date data than the original version and has other enhancements. It is now easier to create maps online with improved quality and to make a map for selected themes and regions. Maps can be customised and queries performed using the Geographic Information System (GIS), to incorporate a choice of data. The Atlas can be accessed at <http://www.rirdc.gov.au/reports/AFT/07-041.pdf>



Second rotation pulpwood integrated with grazing system

C. Products and markets



Highlights – where have we got to?

Higher rainfall areas

The profitability of farm forestry is currently marginal in higher rainfall areas, mainly due to a lack of developed markets for prunings, thinnings, and for the environmental benefits that farm forestry can generate. Immediate opportunities are greatest in planting tree crops on cleared farmland to add supply, especially pulpwood, to existing large-scale markets in areas where there are existing growers and processors. Carbon sequestration is an attractive future opportunity.

There are diverging views about the profitability of sawn timber, especially hardwood sawlogs. Some researchers considered that opportunities for long rotation hardwood sawlogs look promising if they are for high-value and appearance grade products, while others conclude that it is difficult to justify investment in any long-rotation sawlogs at the farm level. A new concept - short-rotation hardwood sawlogs – is considered an attractive opportunity by some. One company has produced premium structural and some high quality decorative products from 10-15 year old Shining Gum plantations.

In the tropics and sub-tropics, there appears to be good opportunities for growing cabinet woods.

Medium to low rainfall areas

There is significant potential for farm forestry in medium to low rainfall areas, but there are a number of long-standing 'deal breaking' issues preventing its realisation. These issues include lower growth rates, less-established forestry infrastructure, and, depending on product form and value, greater distances to markets.

Species selection and breeding has progressed through initiatives such as *Acaciasearch* and the Australian Low Rainfall Tree Improvement Group (ALRTIG). These have selected and developed faster growing acacias, hardwoods, pines and oil mallees that will produce higher yields of desired products. At present, the negatives outweigh the positives for long-rotation wood-based industries. Long timeframes result in adverse Net Present Values. However, short timeframe options are emerging. Pruned Spotted Gum thinnings have shown promise for sawn timber, and young Sugar Gum logs have demonstrated advantages over treated Radiata Pine as vineyard posts.

There are diverging views about opportunities for biomass industries. The *Florasearch* project concluded that many biomass industries are likely to be profitable across vast regions of southern Australia, particularly biomass for fibreboards, electricity generation, Integrated Wood Processing Plants and extractives. Although other researchers agree on the potential for extractives, they are more circumspect about opportunities for the other three industries, noting that wood raw material costs are crucial to the economic viability of production in a low rainfall environment, and it is probably not possible to produce and supply woody feedstock cheaply enough in low rainfall regions to compete with similar feedstocks grown in higher rainfall regions.

For biofuels, *Florasearch* concluded that changes in the world environment are favourable for further development of biofuels industries based on biomass grown in medium to low rainfall areas. However, other researchers have concluded that production of methanol (which can be produced at a competitive price with gasoline) is 'highly questionable' due to the prohibitive haulage costs incurred in transporting biomass from dispersed farm plantings to a viable-sized processing plant.

In the northern dry tropics, African Mahogany has proven to be a prime candidate species for plantations. In central and western Queensland, management of remnant woodlands for production of high-value hardwood products such as parquet flooring, furniture and musical instruments could potentially create a new rural industry generating substantial financial and environmental benefits.

For forage shrubs and trees, there are strong prospects for expansion with few negatives. Some have expressed the view that *Enrich*-type mixed forage systems could represent an important way forward for Australian agriculture, particularly if agriculture is included in a carbon trading scheme. These systems are resilient to climate change impacts, thus enhancing the sustainability of mixed farming and grazing systems. Furthermore, they could generate income from carbon sequestration in addition to achieving an immediate 20% improvement in farm profit even without carbon income.

C1. Higher rainfall and irrigated areas (receiving more than about 600 mm average annual rainfall)

C1.1 Overall prospects

Recent JVAP studies (URS 2008; Polglase *et al.* 2008; Fritsch and Hudson 2008; Brown and Beadle 2008; and Robins and Marcar 2007) have examined the opportunities for profitable farm forestry in higher rainfall areas. Key determinants of profitability are forest growth rates, transport distances and product price (Polglase *et al.* 2008).

The overall conclusion is that with the exception of short-rotation pulpwood, the **profitability of farm forestry in higher rainfall areas is currently marginal**, mainly due to a lack of developed markets for prunings, thinnings, and the environmental benefits that farm forestry can generate. However, **there are attractive future opportunities** as wood shortages increase and new markets emerge for carbon sequestration, biomass energy and ecosystem services.

The immediate opportunities are greatest in planting tree crops on cleared farmland to add supply to existing large-scale markets in areas where there are existing growers and processors. However, there are differing opinions about the existing and potential profitability of sawn timber in some regions, particularly long-rotation hardwood sawlogs (see Boxes C1 and C2 below). Medium to longer-term opportunities are emerging through public and private sector responses to climate change and threats to biodiversity.

C1.2 Realising the opportunities

For the opportunities to be realised, existing knowledge needs to be more effectively delivered and the implications discussed with groups that support farm forestry as a way of improving farm and landscape sustainability and contributing to regional development. Interest groups include regional NRM bodies, Private Forestry Development Committees, farm forestry networks including branches of Australian Forest Growers, forestry companies managing joint ventures and the like with farmers, Greening Australia, regional development organisations and other State and local government agencies. As greenhouse gas mitigation from livestock and cropping operations becomes more important to mainstream farming groups and organisations, they may also look to become more active in farm forestry.

In addition to these improved communication and engagement arrangements, there are numerous other issues to be addressed, such as those reported by URS (2008) in an agroforestry industry evaluation commissioned by JVAP:

- **Integrating farm forestry developments with existing larger scale growers and markets** – the scale requirements associated with markets for industrial forest products can constrain opportunities for farm forestry. The reduction in supplies from existing sawlog plantations as well as from native forests provides opportunities for farm forestry to integrate with existing larger scale industrial growers. Potential regions, for instance, for integration are the Green Triangle for softwood sawlogs and Tasmania for hardwood sawlogs

- **Private native forests (PNF)** – declining access to public native forests has already led to significant increases in harvest volumes from PNF in some regions, particularly on the north coast of NSW and in south-east Queensland. The extensive nature of PNF across Australia suggests considerable potential to expand sustainable utilisation of these resources. However, the lack of information on the nature, use and management of PNF restricts initiatives to promote their sustainable management (see also Sustainability of private native forests (PNF), section B2.1 and Private native forests, section D1.2)
- **Market-based log pricing** – the research found that in a number of regions non-market-based pricing of logs by state forest agencies was seen as a significant deterrent to farm forestry plantation development as well as PNF. There is scope to explore the relationship between market-based pricing and investment in new plantations, including farm forestry investments
- **More transparent log pricing information** – as well as the need for more market-based log pricing, increased transparency of log prices both for native forests and plantations is vital to landholders understanding and assessing the opportunity that farm forestry provides. Similarly, provision of market information, particularly at the local level, would help landholders assess farm forestry opportunities
- **New investment vehicles** – the experience of managed investment schemes (MIS) illustrates the potential for new investment vehicles to facilitate significant expansion in farm forestry. Ongoing demand for investment in plantations, limits to available land, and further development of emerging markets provides opportunities for expanding interest in farm forestry. The potential for investment vehicles that can link landowners and investors offers prospects for substantial expansion of farm forestry
- **Development of markets for environmental services** – ongoing development of markets for environmental services including carbon, water and biodiversity offers the potential for significant gain by creating additional income streams for farm forestry investments (see also *Market-based instruments* – section D2.1). There is also a need for research to develop technical understanding of the impact of forestry in these areas (for example, carbon stored in wood products and the influence of trees on water quantity and quality at the catchment level)
- **Engineered wood products** – it appears that consumption of engineered wood products will continue to grow in Australia. In particular, the development of engineered strand lumber (ESL), utilising hardwood pulpwood, could create market opportunities for farm forestry in regions where supplies from existing hardwood pulpwood are mostly allocated to export markets
- **Developing bioenergy and biofuels** – the potential size of these markets suggests that ongoing research and development could provide significant impetus to farm

Box C1 Opportunities - comments from other studies

A major JVAP study that examined regional opportunities for farm forestry (Polglase *et al.* 2008) reinforced the URS conclusions about softwood and hardwood, commenting that hardwood sawlogs and pulpwood systems look promising in several regions, particularly on the east coast and northern Australia.

On a Net Annual Equivalent Return (NAER) basis, which compared the annual equivalent returns from farm forestry compared with agriculture alone, Polglase *et al.* estimated that for hardwood sawlog systems, there were 39 million hectares of land available where the NAER was positive, equating to \$6.6 billion in profitability per year.

The values were even higher for pulpwood systems, having a potential area of 76 million ha for a total profitability of \$11 billion per year. The values for softwood sawlog systems were much lower at 1.2 Mha at a total profitability of \$0.13 billion per year.

Conclusions from case studies (Fritsch and Hudson 2008) in higher rainfall areas* encompassing regions studied by URS and Polglase *et al.* are consistent with the broad URS conclusion, that is, profitable farm forestry occurs where the participant is operating within a sphere of influence of an established forestry industry that is already growing and harvesting the same species. The case study results also supported URS and Polglase *et al.* conclusions about pulpwood, commenting that:

On a stand-alone basis, only the short-term pulpwood rotations in regional areas that have established commercial forestry operations out-performed agricultural returns on a Net Present Value (NPV) basis

The modelling predicted that short-term pulpwood rotations would be competitive with an equivalent modelled investment in the ASX 200 equity market (based on 1979 to August 2007 data).

**The six case studies were: Mixed farm enterprise, Western Australia; Private Native Forests, North Coast NSW; Blue Gum forestry lease, south-west Victoria; Grazing & shelterbelt and sawlogs, Victoria; Grazing & forestry, south-east Victoria; Mixed farm enterprise, Tasmania.*

forestry. Ongoing development of policy for carbon and renewable energy as well as the development of processing technology will assist market development in general. From a farm forestry perspective, the development of workable carbon pooling arrangements and the development of bioenergy to meet regional needs are particularly important.

C1.3 Market opportunities for larger-scale product markets

The URS report for JVAP also provided a comprehensive assessment of opportunities for existing larger-scale product markets, smaller scale and 'niche' products, and emerging markets. Overview findings and implications from that report are included below. Where relevant, comments from other studies are included in break out boxes. Figure C1 summarises URS's perspective of the opportunities.

- **Softwood sawn timber** – opportunities exist for sale into domestic markets, and will be greatest in regions where there are existing processors with constrained access to additional resources. Farm forestry could achieve price premiums for selling marginal volumes to processors
- **Hardwood sawn timber** – there are opportunities to supply the market from private native forests (PNF) and plantations. The focus will be on the production of higher value species and log qualities for production of appearance grade products. The greatest opportunities are in regions with existing hardwood sawmilling industries and those with developing hardwood sawlog plantation resources
- **Pulp and paper** – opportunities exist for farm forestry to supply existing and potential new pulpmills. While it may be possible for this to drive further leasing of farmland as

has occurred to date, it may also be difficult to compete with large scale MIS developments on purchased land. The greatest opportunities are likely to be where mills are being expanded.

- **Woodchip exports** – opportunities to lease new land to MIS companies will decline as investment becomes focussed on replanting existing areas. Regions where pulpwood plantations are at an earlier stage of development such as Central Queensland provide the best opportunities to lease additional farmland to plantation companies.
- **Plywood and laminated veneer lumber** – there may be opportunities to construct new mills to meet domestic demand. However, scale requirements for competitive mills mean that new developments may be constrained by available resources. There may be opportunities for farm forestry to supplement existing supplies or to provide resources to new mill developments.
- **Log exports** – the positive outlook for international log markets creates opportunities, however market and price volatility create risk. The greatest opportunities are in regions surrounding ports and where farm forestry supplies could complement existing log exports
- **Posts and poles** – the best opportunities exist in regions where there are established plantations or native forest operations.
- **Composite wood products** – there is some potential for hardwood pulpwood plantations in emerging markets for engineered lumber products. Opportunities for softwood will most likely stem from supplying existing processing facilities.

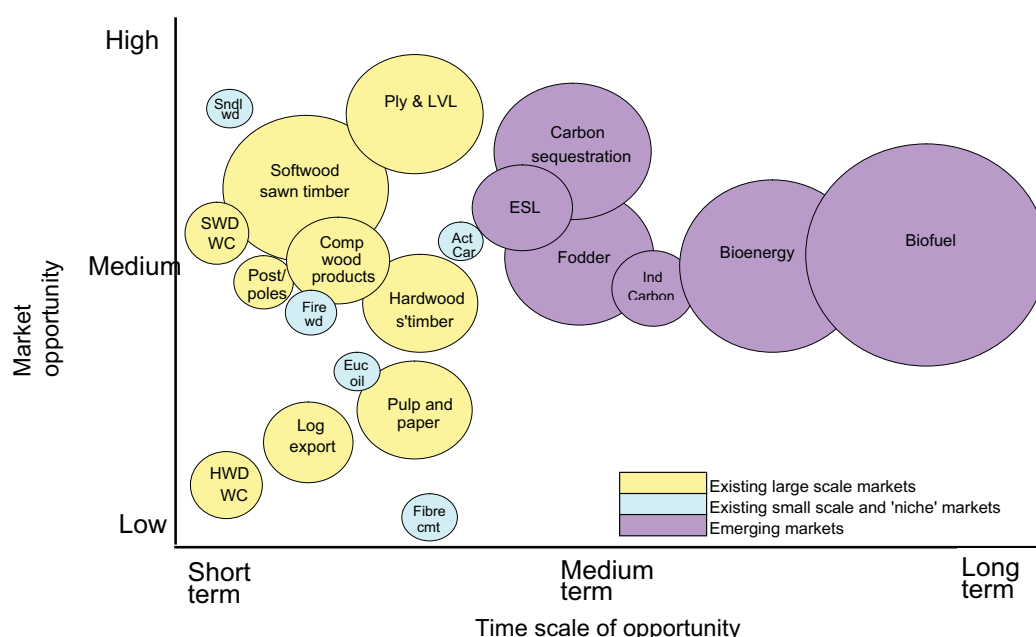


Figure C1 Opportunities for large scale, small scale, and emerging markets (URS Forestry 2008b)

Box C2 Looking to the future – sawn timber from MIS plantations and hardwood thinnings?

Time – the key reason for lack of profitability in farm-grown long rotation sawn timber

Using Net Present Value (NPV) as an investment analysis tool, the case studies in Box C1 examined by Fritsch and Hudson (2008) provided a less positive view than URS and Polglase *et al.* about prospects for farm-grown sawn timber. Some comments from the case study report are:

- Stand-alone farm forestry targeting sawlogs had longer rotation lengths and produced financial returns that did not compete with alternative agricultural enterprises on an NPV basis
- The capacity of long-term rotation sawlogs to generate lump sums competitive with alternative investments is poor
- All sawlog case studies would be substantially better off had the investment been in the equity market

Fritsch and Hudson recommended that based on their financial analysis, it is difficult to justify the promotion of investment in long-rotation sawlog regimes at the farm level, unless ways can be found to generate income earlier in the rotation to offset costs (e.g from thinnings, prunings or environmental services) or demonstrate integrated whole-farm benefits.

Overcoming time - encouraging signs for short-rotation plantations and plantation thinnings

A recent conference (Brown and Beadle 2008) considered what would need to happen to develop a viable 'plantation eucalypts for high-value timber' sector. Issues discussed included:

- if high-value sawlogs are to become a major part of the eucalypt plantation industry, will advances in harvesting and processing enable short-rotation species to fill the supply void, or will alternative species and specific regimes have to be developed?

- the rapid expansion of short-rotation hardwood pulpwood plantations has been largely due to managed investment schemes (MIS) and associated taxation incentives. Would a similar model enable a viable resource of high-value hardwood plantations to be developed?

As an example of progress being made in answering these questions, Forest Enterprises Australia (FEA) (White 2008) has developed technologies that have enabled 70% of its first MIS harvest at clearfall to meet sawlog specification at its mill instead of export woodchips – the original purpose of the plantation. The company is producing premium structural and some high quality decorative products from Shining Gum (*E. nitens*) ranging from 10-15 years of age. These are being marketed under FEA's headline brand of EcoAsh[®].

A JVAP project (Washusen 2009) showed that it was possible to produce high value sawlogs using thinnings from hardwood plantations in medium to low rainfall areas. In trials to determine the wood quality and value from pruned Spotted Gum (*Corymbia spp*) thinnings, Washusen found that a mill capable of processing 15-80 cm small end diameter logs had good potential to make the transition from using from native forest logs to either a combination of native forest logs and pruned Spotted Gum thinnings, or Spotted Gum thinnings alone.

Another JVAP project (Bush and McCarthy 2008) found that 8-12 year-old thinnings from Sugar Gum (*E. cladocalyx*) plantations in low rainfall areas were very durable with high density (greater than 600 kg/m³). Hence they would have several advantages over Copper Chrome Arsenic (CCA) – treated Radiata Pine (*Pinus radiata*) as vineyard posts. In addition, Sugar Gum is also amenable to genetic improvement, further enhancing its prospects for the vineyard post market.



Could Sugar Gums from medium to low rainfall areas replace CCA-treated Radiata Pine vineyard posts?

C1.4 Market opportunities for smaller scale and niche products

- **Firewood** – there are opportunities for on-farm returns for landowners who use firewood for domestic heating. The opportunity for PNF and as a by-product from higher value sawlog plantations is ranked in the URS report as **‘medium’**
- **Sandalwood** – the opportunity is ranked as **‘medium’**, with the greatest opportunity in south-west Western Australia where sandalwood plantations and industry expertise are developing. Opportunities beyond existing developments may be limited by market size
- **Activated carbon** – the market opportunity is ranked as **‘medium’**. There are indications of strong market opportunities. However, there are some uncertainties relating to technology and competitiveness
- **Eucalyptus oil** – the market opportunity is ranked as **‘low’**. There are small markets, international competition and uncertainty over development of integrated wood processing
- **Fibre cement** – there is little opportunity at present for Australian wood to supply this market, due to strong import competition. The opportunity is ranked as **‘low’**

C1.5 Emerging market opportunities

Emerging markets analysed and ranked by URS generally apply across all regions or beyond traditional forestry regions into medium and low rainfall areas. The opportunities, as summarised by URS, are:

Carbon sequestration – markets are developing rapidly but are still in their early stages. They are expected to develop significantly in Australia with the introduction of a national emissions trading scheme. Opportunities for carbon sequestration in farm forestry are rated as **‘high’**

- **Industrial carbon** – not yet well developed as a market, but reports on its commercial applications at this stage appear positive. Market development will be assisted by the development of emissions trading. However, substantial research and development in the steel making industry is also focussed on alternative manufacturing processes. Opportunities for industrial carbon are consequently ranked as **‘medium’** for farm forestry

- **Engineered strand lumber (ESL)** or laminated strand lumber (LSL) – is an engineered wood product manufactured from lower grade wood. LignorR is an ESL product being developed in Australia that would compete with solid timber used in high strength and appearance applications. If successful, LignorR could create significant potential for farm forestry investment. However, existing supplies of hardwood pulpwood in Australia and the large scale required suggest that it is a **‘medium’** opportunity for farm forestry
- **Bioenergy production** – is creating significant enthusiasm internationally and government renewable energy frameworks are developing. Wood based bioenergy appears to have cost advantages over other renewable energy sources. However, other technologies are developing rapidly. Uncertainty over the competitiveness of wood based bioenergy and the potential to utilise existing residues means that this opportunity is ranked **‘medium’** from the perspective of farm forestry
- **Biofuels** – these represent a similar opportunity to bioenergy. The long term potential of lignocellulosic bio-ethanol appears strong and commercial development may only be a matter of years away. However, there are significant uncertainties with future development and so the overall market opportunity of biofuels for farm forestry is ranked **‘medium’**
- **Markets for other environmental services** – these are developing, particularly for water and salinity. While markets for some services such as biodiversity are at earlier stages of development, there have been few transactions or payments to date and government policies are less certain than those for carbon. Market opportunities for farm forestry are rated as **‘medium’**
- **Woody fodder** – production utilising woody perennial species which is being adopted across a wide range of agricultural regions is rated as a **‘medium’** opportunity for farm forestry. This ranking largely reflects the situation that most fodder production is for on-farm use, and the potential for woody fodder species to compete with existing fodder species in off-farm markets is uncertain. The development of markets for environmental services may increase investment attractiveness

Box C3 Supporting comments

Polglase *et al.* (2008) found that carbon farming looks promising due to the relatively low cost of production (no harvesting or transport) relative to a possibly high product price. New forests could be grown in many locations and for multiple environmental outcomes. For example:

- environmental carbon plantings could be profitable and minimise the impact on water across 9 Mha. The annual rate of carbon sequestration was predicted to be 143 million tonnes of carbon dioxide equivalent per year, which equals about 25% of Australia's net 2005 greenhouse gas emissions
- the profitability of long-rotation sawlog systems can be significantly improved if carbon is included as an additional, saleable product

Box C4 Supporting comments

The Polglase *et al.* (2008) study reported that dedicated bioenergy and Integrated Tree Processing systems are not profitable at present unless they are very close to processing facilities. This is due to the high cost of production (harvesting and transport) relative to low product prices at present for wood energy.

Box C5 What species will grow where, for what products and markets – an update

A recent JVAP publication (Clarke *et al.* 2009) synthesises knowledge about the profiles of 22 primarily native species that are not only bio-physically suited to various planting sites, but are also capable of delivering the right products and services for available markets. The book also includes general notes on silviculture, including site preparation, weed control, fertiliser, spacing and protection.

C1.6 Best regional prospects

In addition to analysing market opportunities on a product-by-product basis, the URS study also ranked the opportunities on a regional basis. A 'high' ranking represented a product that has a favourable market outlook and where there is generally an existing processor or readily identifiable market in the region for farm forestry resources.

The Polglase *et al.* study completed more detailed regional assessments than the URS study for softwood sawlogs, hardwood sawlogs, and woodchips exports or pulpwood. This study considered various farm forestry systems, opportunity costs, market opportunities, regional conditions such as distances to processing mills, environmental impacts, and possible changes in economic conditions such as new processing plants and emerging markets. A 'high' rating by the Polglase *et al.* study meant that a region ranked by URS as high could still be rated high when the growing opportunity (suitability of site conditions for particular species) was taken into account.

Regions and products rated as 'high' by the Polglase *et al.* study were: **central and north Queensland, south east Queensland, and north coast New South Wales** – 'high' for hardwood sawlogs, with **south east Queensland** and

north coast New South Wales also rated 'high' for woodchip exports or pulpwood; **Murray Valley, southern New South Wales** and **north east Victoria** – 'high' for woodchip exports or pulpwood; **Southern Tablelands New South Wales** – 'high' for woodchip exports or pulpwood; **South east New South Wales coast** – 'high' for hardwood sawlogs; **central and western Victoria** – 'high' for hardwood sawlogs; **Gippsland, Victoria** – 'high' for hardwood sawlogs and woodchip exports or pulpwood; **south west Western Australia and Tasmania** – 'high' for hardwood sawlogs and woodchip exports or pulpwood.

There were no regions rated 'high' for softwood sawlogs.

C1.7 Tropical and sub-tropical Queensland

JVAP research relevant to northern Australia has been less prolific than that for southern Australia. To-date it has focused largely on species-by-site studies to enhance confidence in 'what will grow where'. This lag is largely because the availability of farm forestry research funding has been driven by the geographic spread of existing forest industries and the increasing prominence of salinity and other natural resource management issues especially in the Murray-Darling Basin and south-west Western Australia.

Box C6 South-west Western Australia - sustaining pulpwood plantation productivity over second and subsequent rotations (Grove *et al.* 2001)

In south-west WA in the early 2000s, there were about 150,000 ha of first-rotation Blue Gum pulpwood plantations established on land previously used for agriculture. The land had a history of phosphate fertiliser applications together with nitrogen-rich organic residues from legume pastures.

Past agricultural research had shown that where fertiliser applications cease or become less frequent, soil fertility and plant productivity declines within several years. Furthermore, past research into declining productivity in second-rotation Radiata Pine had shown that retention of logging residues and litter, together with fertiliser application and other silvicultural practices, were the most appropriate methods to avoid a productivity decline in the second and subsequent rotations.

The Grove *et al.* study investigated the soil fertility effects of 6-11 year-old Blue Gum pulpwood plantations established on land previously used for agriculture in south-west WA, and recommended strategies to maintain soil fertility and sustain the long-term productivity of the plantations.

The study found that nitrogen and phosphorus concentrations were lower in plantation soils that had reduced fertiliser inputs compared with similar soils that continued to be used for agriculture. Potassium levels were higher in plantation soils. The researchers concluded that plantation management practices that conserve organic matter and nutrients (such as retention of harvest residues) and correct nutrient deficiencies are important to sustain the productivity of future rotations.

However, there has been some investment in farm forestry research for tropical and sub-tropical Queensland, and for the dry tropics in Queensland and the Northern Territory (for the dry tropics, see below under **Medium to low rainfall areas**). In part, this investment has been driven by the cessation of logging in Queensland's wet tropics in 1988, causing a substantial decline in the supply of high-quality rainforest timbers (Lamb and Borschmann 1998).

Climate change predictions suggest the future will be wetter in northern Australia and dryer in southern Australia (Garnaut 2008). These predictions, combined with market opportunities, particularly for specialty hardwood sawlogs, could justify a higher level of farm forestry research investment in northern Australia than in the past.

Species and plantation designs

There appears to be good potential for growing cabinet woods in plantations in tropical and sub-tropical Queensland and New South Wales. At present however, there is a lack of critical resource mass and market prospects and profitability appear uncertain.

A 2008 JVAP report (Dickinson *et al.* 2008), based on measurements on more than 110 Queensland Department of Primary Industries and Fisheries growth plots and additional growth plots in private plantations in southern Queensland, identified the following 'best bet' cabinet woods and eucalypts² for different rainfall zones:

- In north Queensland regions with >1500 mm rainfall, cabinet species with potential include: Blue Quandong; Hickory Wattle; Queensland Maple; Silky Oak; Leichhardt Tree; Burmese Teak and Blackbean
- In north Queensland regions with <1500 mm rainfall, mainly eucalypt species performed best: Gympie Messmate; Red Mahogany; River Red Gum and Narrow Leafed Ironbark
- Indian Sandalwood plantations and their hosts may also have potential in northern Australia
- In central Queensland with lower annual rainfall (1000-2000 mm), the cabinet woods Hickory Wattle, River Oak, Silky Oak and Peach Cedar all performed well. A number of eucalypts also performed well: Red Mahogany; Gympie Messmate; and White Mahogany. Less drought-tolerant species such as Blue Quandong and Queensland Maple often performed poorly
- In southern Queensland and northern New South Wales, a number of cabinet woods performed very well: Blue Quandong, Candle Nut; Silky Oak; and White Cedar. The *Flindersias* are very popular in mixed species plantations and Queensland Maple, Cudgerie or Silver Ash, and Yellow Wood have also performed well on certain sites. Good growth rates of Gympie Messmate,

Lemon Scented Gum, Blackbutt and Flooded Gum were observed in numerous mixed species plantations in this region

Notwithstanding the positive conclusions from species by site studies and progress with plantation designs, other research (see more detail in *Motives for adopting farm forestry*, section E1.2) found that the small number of Queensland landholders who have mature timber ready to harvest are experiencing great difficulty in obtaining stumpage prices that justify harvesting. In addition, there is at present a lack of critical mass of farm-sawn and dried timber for sale into niche markets for high-quality furniture (Maczkowiack *et al.* 2008).

Box C7 Designs for mixed-species tropical and sub-tropical plantations

The following guide summarises best-bet mixed-species configurations (Dickinson *et al.* 2008).

Design of mixed-species plantations is driven by two factors: inter-specific competition and harvesting access.

There are two main groups of species: fast-growing species such as Blue Quandong, Hickory Wattle, Candle Nut, Peach Cedar and most eucalypts; and slower-growing species including many cabinet woods such as Cudgerie or Silver Ash, Blackbean, and White Beech. A few species such as Hoop Pine, Queensland Maple, White Cedar and Silky Oak can be quite fast-growing on particular sites, but tend to be less competitive.

The ability to harvest the larger trees without damaging slower-growing trees is a major objective when designing mixed-species plantations. A simple mixed species design often includes a small selection of best-bet species (usually 2-4), with each individual species established in rows.

A typical more complex design which produces a more natural forest appearance is to plant alternate rows of fast-growing and slow-growing species of similar growth rates at an initial spacing of 3 m x 3 m. Early plantation growth needs to be carefully monitored and some strategic non-commercial thinning will be required to manage inter-tree competition. Generally the fastest-growing row may then be completely or partially-harvested between ages of 8-15 years, freeing site resources to allow the slower-growing species to grow on to merchantable size.

² For species names, see Appendix 2

C1.8 Irrigation regions

In the mid-1990s, the *Trees for Profit* Program established eight trials in northern Victoria (in the vicinity of Shepparton and other northern Victorian towns) to demonstrate and test the benefits of tree-growing for multiple benefits – particularly wood production and salinity control. JVAP funded development of an integrated economic model for the region to assist local councils and regional development organisations to develop policies related to plantation development.

The modelling delivered some predictions that in hindsight³ could be considered optimistic – for example, it predicted that establishment of farm forestry in the region would increase the value of output for all industries by \$1.3 billion, or 6.1 per cent of total output. Regional income would increase by 4.8% or \$302M, and 5748 new jobs would be created (see <http://www.rirdc.gov.au/pub/shortreps/sr21.html>).

C2. Medium to low rainfall areas

(receiving less than about 600 mm average annual rainfall)

C2.1 Overall prospects

From the mid 1990s, JVAP had a greater focus on researching farm forestry for medium to low rainfall areas to assist in managing dryland salinity and in diversifying agricultural returns. The potential of farm forestry to sequester carbon and contribute to regional economic development was also recognised. In 2009, the overall conclusion is that there is **significant potential for farm forestry in medium to low rainfall areas to benefit farm income and regional development (AGO and MDBC 2001), but several ‘deal breaking’ issues** are preventing its realisation.

For example, wood raw material costs are crucial to the economic viability of production in a low rainfall environment, and it is probably not possible to produce and supply woody feedstock cheaply enough in low rainfall regions to compete with similar feedstocks grown in higher rainfall regions (Hague *et al.* 2007). Hence traditional farm forestry industries in medium to low rainfall areas are unlikely to be as profitable as in higher rainfall areas due to lower growth rates, less-established forestry infrastructure, and, depending on product form and value, greater distances to markets (Zorzetto and Chudleigh 1999).

Notwithstanding some positive assessments (for example Hobbs *et al.* 2006), there are doubts about the viability of new and emerging industries based on energy and chemical products. The cost of electricity production from biomass cannot at present compete with that of coal, and haulage costs alone from dispersed farm plantings could prevent production of methanol as an alternative to gasoline in medium to low rainfall areas (Hague *et al.* 2007). Furthermore, the costs to farmers of re-skilling and re-equipping (and the lack of compatibility with farmers’ values and goals) means that widespread farm forestry will occur only if it is much more profitable than existing agricultural land uses (Robins and Marcar 2007).

Key research topics to address these issues include: improving the germplasm and silviculture of selected, promising woody perennials, and developing novel harvesting approaches, in order to improve the quality and yield of feedstocks and significantly reduce the delivered cost of raw materials to a competitive and attractive level (Hague *et al.* 2007). Although salinity as a driver for investment in research into these issues looks like decreasing in the light of climate change predictions (Howden 2008), shifts in public policy and commercial activities in relation to energy, climate change and other environmental matters are becoming more powerful drivers.

C2.2 Potential industries and markets

Long rotation wood-based industries

Although many native hardwoods and pines growing naturally in medium to low rainfall areas have positive attributes for long-rotation wood-based industries (for example, exceptional durability in the case of eucalypts, or equal or better performance than exotic timbers in the case of cypress pine flooring), **it appears the negatives outweigh the positives at present.** Numerous studies support this conclusion.

In the most positive example, 29–44 year-old plantations of Swamp Yate (*Eucalyptus occidentalis*), Sugar Gum (*Eucalyptus cladocalyx*), Brown Mallett (*Eucalyptus astringens*), and Yellow Gum (*Eucalyptus leucoxylon*) in the southern Murray-Darling Basin were assessed for their potential to provide ‘high-value’ solid wood products to compensate for the anticipated slow growth rates and high establishment, management, harvesting, transport and processing costs for sawlog production in the medium to low rainfall zone (Blakemore *et al.* 2003). Its key findings were:

- There was very poor recovery of green appearance-grade products (0.9–8.1%), at least partially attributable to the small diameter logs sampled. Sugar Gum achieved only 1.0% recovery. Older and larger Sugar Gum trees in a previous study yielded 20.6%. A minimum Diameter at Breast Height of 40 cm would be required to maximise the volume of clear outer heartwood
- Despite the poor recovery of appearance products in this study, growth rates and the good appearance product recovery rates in the previous study suggest that **Sugar Gum has the best potential for producing high-value solid wood products in the lower rainfall zones. Swamp Yate and Brown Mallett followed closely behind**, provided poor form and branching could be improved. Yellow Gum showed little potential
- Using conservative air-drying, and in the absence of other defects, 85% of the dried boards would have made select grade or better, however because of the high densities of species grown in the lower rainfall zone, careful drying would be required to minimise surface checking in back-sawn boards
-

³The modelling was apparently done at a time when water leakage and salt mobilisation in irrigated and dryland areas was worsening and trees were being widely promoted as a major part of the solution. It appears not to have taken account of the importance of lost surface water yield and its value for irrigated agriculture in the Shepparton Irrigation Region. It was completed prior to the extended dry period commencing in 2001, the increasing community concern about the impacts of plantations in reducing surface water yield, the predicted effects of climate change on catchment water yields, and the severe impacts of reduced flows on the Murray River being experienced in the late 2000s.

- These results highlight the critical importance of the Australian Low Rainfall Tree Improvement Group's (ALRTIG)⁴ work (see *Species selection and improvement*, section C2.3) in improving genetic stock and of appropriate silviculture to achieve green recoveries of appearance products of at least 30-35%

In another example, a report on the growth potential, products and characteristics of native and exotic conifers concluded that selectively-bred Radiata Pine (*Pinus radiata*) established with the best silvicultural practices on good cropping country in south-west New South Wales in a 500 mm rainfall zone and growing at 12 m³/ha would be profitable, but unselected trees growing at 10 m³/ha would be unprofitable. Furthermore, the report concluded that most tools used to determine economic viability indicate that **the return on investment in conifers in low rainfall (~500 mm) areas is marginal** (Spencer 2001).

In a third example, the objective was to assess the potential of 13 eucalypts proposed for use in farm forestry production systems for kraft pulping and papermaking, relative to existing commercial pulpwood resources. The species assessed included were Spotted Gum from Gympie in Queensland, Swamp Yate from Timmering in north-central Victoria, Dunn's White Gum (*Eucalyptus dunii*) from Coffs Harbour in New South Wales and Araluen Gum (*Eucalyptus kartzoffiana*).

Only Swamp Yate, Araluen Gum and Spotted Gum had any potential for low rainfall sites. Furthermore, as the trees sampled were sourced from high rainfall or irrigated stands, **questions remain about the likely wood quality of these**

species grown on drier sites. There was a strong association between low rainfall (450-500 mm) and poor pulpwood quality. This suggests that farmers planning to grow trees in drier regions (<600 mm) may experience not only reduced growth rates but also poorer quality and hence less marketable pulpwood (Hicks and Clark 2001).

The final example cited here investigated Cypress Pine (*Callitris* spp) forest management and utilisation in order to promote its retention and management for high-value timber production. The hypothesis was that increasing international demand for feature-quality white cypress flooring, panelling, componentry and mouldings had created a demand for better quality logs and that millers would pay better prices for logs from managed stands.

However, the project concluded that although there is great opportunity for landholders to manage regrowth forests towards dual purpose grazing and timber production, they choose not to manage the resource because of lack of management information, poor economics and lack of resource security (Taylor *et al.* 2005).

Notwithstanding these poor prospects for long-rotation industries, **there are signs that sawn timber from pruned hardwood thinnings grown in medium to low rainfall areas may be a viable option** (for example from Sugar Gum), given recent advances in drying and sawing techniques (see Box C2).



Long-rotation wood-based industries in medium to low rainfall areas are unlikely to be profitable in their own right

⁴ALRTIG is a cooperative of State and Commonwealth researchers drawing on pre-existing biological and scientific resources belonging to the Partners, and pooling them to maximise impact through nationally-coordinated research and development.

Box C8 Case studies – profitability of medium to low rainfall farm forestry

Conclusions about good prospects but lower profitability for traditional industries are supported by case studies. These studies include several from WA and NSW (Abadi *et al.* 2006), which compared the relative profitability of agricultural systems incorporating tree crops with conventional agriculture. Key findings were:

- In the WA cropping zone, Oil Mallees have the greatest potential for further development, however Oil Mallee systems did not break even with conventional agriculture until year 20 after planting
- For Maritime Pine plantations established and managed by the landowner, the establishment costs combined with a wait of 15 years until first income make them unattractive from a cash flow perspective
- A conceptual system of woody phase crops did not break even with conventional agriculture
- In NSW, Jojoba was the most profitable case study, generating an Annual Equivalent Return 12 times that of conventional agriculture. To achieve this reward, the landowner must be able to endure a peak debt of \$6400 /ha in year six and has to wait 11 years for a positive cash flow
- Blue Mallee has the lowest peak debt and shortest break-even period of all the NSW systems investigated, breaking even with the conventional cereal-pasture rotation in year six. River Red Gum grown in plantations for firewood, posts and several grades of sawlogs were not viable under the assumptions used, making a loss of \$181/ha
- For both WA and NSW, the most attractive projects offset the costs of establishment (e.g. through share-farming or integrating the trees with conventional agriculture) and regularly harvest for biomass or use grazing by livestock (e.g. alley farming)

Biomass industries

The *FloraSearch* project initiated in 2002 (Hobbs *et al.* 2006) was a large JVAP project in partnership with the then CRC Salinity. Following on from its predecessor the *Search* project (Donaldson, J pers. comm.), it sought to answer the question: given Australia's relatively harsh natural environments, and future scenarios of hotter and drier weather, water scarcity, carbon sequestration, and bioenergy, what are the prospects for biomass-related industries based on native plants?

The overall conclusion of *FloraSearch* is that **many biomass-related industries are likely to be profitable across vast regions of southern Australia**, and economic returns from several industries are likely to be competitive with existing land uses. This is a more optimistic view than another benchmark study conducted between 2001 and 2003 (Hague *et al.* 2007 – see Box C10)

Existing high priority biomass industries identified by *FloraSearch* include wood fibre industries, bioenergy (electricity generation), eucalyptus oil, and integrated wood processing (oil/charcoal/bioenergy). Positive factors for these industries are: the paper and paperboards, fibreboards and particleboards markets provide opportunities for new industry development; there is potential to substitute hardwood biomass for coal in electricity generation; the market potential and price of many biomass extractives in local and international sectors has improved; and plants such as the Integrated wood processing plant at Narrogin in Western Australia will be able to derive additional benefits from greenhouse gas abatement schemes.

Box C9 Some FloraSearch case studies

The *FloraSearch* case study *Bioenergy Crops for Lower Rainfall Regions of Southern Australia* concluded that there is 'immense potential' to develop new woody bioenergy crops in southern Australia. In a similar vein, the case study *Woody Crop Potential in the Upper South-East Region of South Australia* concluded that new bioenergy industries and carbon sequestration offer opportunities for landholders in the region. Furthermore, they are likely to provide significant 'symbiotic' (and perhaps competitive) economic returns to cereal and grazing enterprises (Hobbs *et al.* 2009a,b; Hobbs 2009).



Box C10 Markets and prospects for six products from woody biomass in low rainfall areas (Hague et al. 2007)*

A benchmark JVAP study reviewed the potential market size and prospects for six selected products that may come from low rainfall grown woody biomass. Along with product use and processing technology, the study estimated the planted resource required to service viable processing plants in the region.

Appearance grade timber

A potentially sizeable market for appearance grade products exists in Japan, but significant expansion in hardwood plantation resources and associated processing industries is anticipated in other parts of Asia. This expansion, and the expansion of hardwood plantations in higher rainfall regions across Australia, will also be a determinant of the future for low rainfall hardwoods. The key drawback to establishing an economically viable appearance grade products industry in low rainfall areas is that growth rates are too low.

Dry formed fibreboard

A substantial future potential export market exists for Australian-produced medium density fibreboard (MDF) in the Asia-Pacific region. However, strong competition from New Zealand and South-East Asia, based on resources grown in low-cost, high-rainfall areas, and possibly recycled wood and agri-residues, will severely limit potential market sizes for resources from low rainfall areas. Radical new approaches that generate low-cost woody biomass with the appropriate properties would be required.

Wood-plastic composites

Potentially sizeable domestic and export markets exist for wood-plastic composites (WPCs). A market size of 50,000 t/yr valued at AU\$200M could exist in 2010. Relatively small scale of production units, modest investment costs, and the likely suitability of residues from low rainfall sawmilling operations are attractive features for WPCs.

Electricity from biomass

With revisions to remove an anomaly that currently excludes plantations for bioenergy production, the Australian Governments' Mandatory Renewable Energy Target (MRET) could catalyse a biomass-based electricity industry, particularly where biomass has cost advantages over other forms of renewable energy such as wind and solar. However, biomass-based electricity generation is likely to come from lower-cost waste streams from forestry and agriculture rather than biomass energy plantings in low rainfall areas.

Alcohols – ethanol and methanol

Ethanol and methanol produced from woody biomass can be used as substitute fuels for gasoline. Hence the domestic and export markets are potentially very large. Processing limitations mean that ethanol is not cost-competitive with gasoline. Methanol can be cost competitive (at AU22 cents per litre), but the viable-sized processing plant would require more than 1 Mha of woody biomass to service its feedstock requirements. As haulage costs alone could be prohibitive if planted areas were widely dispersed, its suitability for low rainfall areas must be highly questionable.

Pyrolytic bio-oil

Bio-oil can be used for fuel for electricity generation, transport fuels, and a source of value-added compounds such as specialty chemicals, food flavourings, pharmaceuticals, adhesives and wood preservation industries. It is largely at the pilot scale of its development process. It has less than half the fuel energy content of petrochemical fuels, and it is too expensive to be competitive with petrochemically-derived diesel.

*The study was conducted between 2001 and 2003

Emerging biomass industries favoured by *FloraSearch* include carbon sequestration, industrial carbon (carbonised wood and charcoal), liquid fuels from woody biomass, and other extractives. Positive factors for these industries are:

- The potential for carbon trading has become a significant factor in the economics of using long-term perennial vegetation as permanent sinks, and there is increasing interest in carbon storage in harvested tree crops such as traditional farm forestry and short rotation woody crops
- The current European carbon price suggests that carbon sequestration alone may be economically viable for revegetation in some landscapes and regions. Additionally, commercial woody crops may also include their average standing biomass as a carbon sequestration value, or even the long-term carbon stored in their roots and accumulated soil carbon, as a contributor to the economic value of these perennial farming systems
- The metallurgical industry faces increasing pressure to reduce greenhouse gas emissions from metal production. The substitution of fossil carbon by renewable carbon from biomass has the potential to radically reduce the net carbon emissions from metallurgical processes
- The world market for activated carbon is around 700,000 t/yr and is currently increasing by about 4-5% per year
- In 2004, *FloraSearch* identified ethanol and biodiesel as two potential industries, but at that time two factors downgraded their priority: the relatively low price of mineral oil-based fuels; and the infant stage of the technology to convert woody biomass to ethanol or biodiesel. In the last two years there have been changes in both of these areas which are favourable for further development of the industries
- There are potentially many chemicals that might be commercially extracted from large volume biomass feedstocks, and *FloraSearch* recognised the potential economic importance of additional revenue that might

accrue from being able to extract an additional product

Forage shrubs and trees

There are around 400,000-500,000 ha planted with woody forage species on farms across Australia. Western Australia has 200,000-300,000 ha of forage crops and Queensland has almost 150,000 ha. The five key species are Tagasaste, Old Man Saltbush, Leucaena, Orange Wattle (*Acacia saligna*), and Rhagodia (URS 2008).

Key investigations into the use and potential for forage shrubs and trees (Lefroy *et al.* 2002; de Koning and Milthorpe 1998; Revell 2008, unpublished) have concluded that **there are strong prospects for expansion in the use of forage shrubs and trees in low rainfall mixed-farming systems**. The main economic advantage of forage shrubs is in providing high-protein green feed in dry periods, enabling producers to maintain liveweight in animals for breeding or market heavier livestock when those annual pastures are losing condition (de Koning and Milthorpe 2008).

The economics of forage shrubs have been assisted by strong red meat markets in recent years and higher livestock prices. In case studies, Tagasaste for cattle production in alley farming or plantations proved more profitable than cattle production from conventional annual pastures. The ability of Tagasaste to provide a valuable feed source from year two after planting was a key factor in its profitability (Abadi *et al.* 2006).

Enrich

The *Enrich* project, which is investigating (in 2009) the merits of mixed forage systems for livestock, is a joint venture between JVAP and the Future Farm Industries Cooperative Research Centre. The benefits of *Enrich*-type systems for livestock producers have been discussed in *Alley grazing with fodder shrubs*, section B1.4).

Enrich has another dimension: modelling for carbon dioxide (CO₂) sequestration. Preliminary modelling indicates that the profit-maximising area of shrubs on some farms increases

Box C11 Extractives

A project reported in 2004 (Foley and Lassak 2004) sought to identify sources of new bioactive products that might provide another income stream from plantings of low rainfall eucalypts.

It focused on recently-described compounds that show potency as anti-fouling agents (e.g. sideroxylonals), tumour suppression, and have antibacterial and antiviral properties. Sideroxylonals are the most potent natural anti-fouling agent known and are being sought to replace toxic tin compounds in Australian waterways.

Thirty nine eucalypts and four paperbarks (*Melaleucas*) were surveyed. Several rich sources of formylated phloroglucinol compounds (FPCs) were identified, particularly amongst some Western Australian oil mallees. Most notable was York Gum, with sideroxylonal concentrations as high as 9% of the dry leaf mass – the richest source of sideroxylonal recorded. The genetic correlation with cineole (*Eucalyptus* oil) is strong and so programs to improve the concentration and yield of cineole in oil mallee plantations will coincidentally also select for greater concentrations of sideroxylonals (Foley 2009).

There is no doubt that there are rich sources of bioactive products available in existing low rainfall tree plantings. However, better ways of preparing enriched and purified extracts must be found before enough of these products can be isolated for research into their use with a view to eventually marketing.

markedly as the carbon price increases. At a price of \$50 per tonne of CO₂ equivalent, the optimal shrub area would be four times higher than without a value for carbon. Even without a value on carbon, incorporating perennial shrubs into 10% of the area of mixed farming enterprises could boost profit by up to 20%. This means that producers can confidently start plantings now and be ahead, regardless of carbon pricing (Campbell 2008).

C2.3 Species selection and improvement

Realising the potential for existing and emerging farm forestry industries in the medium to low rainfall zone depends on the availability of trees and shrubs that will deliver satisfactory growth rates and yields in highly-variable climates while making a worthwhile contribution to farm viability. Hence over many years, JVAP and other organisations have made significant investments in identifying and breeding trees and shrubs with inherent capacity to contribute to mixed farming systems in medium to low rainfall environments. Acacias and eucalypts have been the focus of this investment.

Acacias

The *Acaciasearch* project (Maslin and McDonald 2003) identified three types of commercial tree crops for the medium to low rainfall zone: **long-cycle crops** – trees of erect form selected and managed over a growth period of 10-100 years; **coppice crops** – long-lived species that readily re-sprout from the cut stump after harvest. These crops could be harvested every 2-5 years. They are usually grown in narrow belts within agricultural crops; and **phase crops** – short-lived woody species used as a de-watering phase within the crop rotation, harvested at 3-6 years after which the land reverts back to annual crops or pasture. They are usually planted in large blocks.

Coppice and phase crops produce material suitable for reconstituted wood products, chemical extracts and bioenergy. These two types of crops appear to have good prospects, even in the absence of breeding programs. As indicated by the Blakemore *et al.* project reported above, long-cycle woody crops require extensive selection and breeding programs to have any chance of achieving reliable profitability.

Acaciasearch assessed 35 Acacias with crop potential, and ranked Orange Wattle (*Acacia saligna*) and Northern Silver Wattle (*A. leucoclada*) as the most prospective (Maslin and McDonald 2003). These acacias can be expected to show fast or moderately-fast growth rates and produce high or moderately-high volumes of wood biomass. They have the potential to be cultivated over a wide geographic area. Stringybark Wattle (*A. linearifolia*) and Swamp Wattle (*A. retinodes*) were less prospective. While they possess acceptable growth characteristics, they display attributes that tend to reduce their potential for crop development (e.g. poor growth form, reduced wood biomass production, or relatively slow growth rates).

Of the 35 prospective acacias, 31 have some potential as phase crops, 13 have prospects as long-cycle crops, while only 8 appear to have any prospects as coppice crops. Orange Wattle appeared to have the best potential as a coppice crop.

Oil Mallees

Oil Mallees (for example, York Gums and Blue Mallees – *Eucalyptus loxophleba* and *E. polybractea*) are used mainly for producing eucalyptus oil, and are also being considered for other products including electricity generation and carbon sequestration. A pilot Integrated Wood Processing Plant at Narrogin in Western Australia has achieved 'proof of concept' for the production of energy, eucalyptus oil and activated carbon (AFG 2006) from oil mallees. About 13,000 ha of oil mallees have been established in Western Australia, with an estimated additional 10,000 ha to be established in 2009 (Bartle, J. pers. comm 2009).

Large-scale plantings of Oil Mallees began to be established on farms in Western Australia from the early 1990s, mainly as a salinity control measure. The Oil Mallee Association and the Oil Mallee Company have played a pivotal role in developing the industry, working with partners and achieving advances in many areas including silviculture, establishment techniques and tree survival rates, productivity, and harvester development (Oil Mallee Company 2007).

As large-scale plantings of Oil Mallees were being established on farms in Western Australia, JVAP was supporting breeding and nutritional studies, including a Mallee genotype by environment trial by the Australian Low Rainfall Tree Improvement Group (ALRTIG) (Bartle and Brennan 2002). Preliminary breeding results (Bush *et al.* 2007) have shown that *E. polybractea* has clearly outgrown *E. horistes*. However there were no statistically significant differences within families or other groupings (such as orchard versus wild) of seedlots for either *E. polybractea* or *E. horistes*.

An assessment of the oil yields and analysis (i.e. composition of certain valuable compounds such as cineole) from the trial series was undertaken by the Department of Conservation and Land Management Western Australia during 2005. This assessment analysed the variation between families, as much of the selection in orchard lots is for oil yield and quality traits. Results of these analyses are unpublished.

Nutrition trials have shown that biomass removal over several harvesting cycles will significantly deplete total site stores of some nutrients unless replacement strategies (return of ash, or fertiliser application) are implemented (Grove *et al.* 2007).

Hardwoods and pines

The largest investment in breeding hardwoods and pines for medium to low rainfall areas has been through the Australian Low Rainfall Tree Improvement Group (ALRTIG), which established 33 progeny trials of Sugar Gum (*Eucalyptus cladocalyx*); Swamp Yate (*E. occidentalis*); Red Ironbarks (*E. sideroxylon*); Spotted Gums (*Corymbia spp*); River Red Gum

(*E. camaldulensis*); Brutian Pine (*Pinus brutia*); Maritime Pine (*P. pinaster*); Blue Mallee (*E. polybractea*); and Oil Mallee (*E. loxophebla*) from 2000 to 2002.

Results for the hardwoods (Bush *et al.* 2009) are: **Sugar Gum** – survival to 5-6 years of age exceeded 80% at five out of eight sites and exceeded 60% at the others; **Swamp Yate** – overall survival exceeded 80% for four out of six provenance-progeny trials, but was only 50-60% in the others which experienced severe drought after planting; **Spotted Gum** – survival in four provenance-progeny trials in western Victoria was excellent, except at a dry frosty site at Brynerton Victoria, where it was only 51%.

The researchers concluded that the significant differences in survival, growth and stem form among provenances and other seed sources for all three species confirm the potential for ongoing genetic improvement in the ALRTIG breeding programs. **The progeny trials and other investigations by ALRTIG have delivered improved germplasm of hardwoods and pines with significant commercial value.** Seed from the orchards could underpin establishment of a sizeable plantation estate. In 2009, it is envisaged that the ALRTIG Partners will market this seed to nurseries and growers. The sale of 'interim' improved seed has commenced from some Partners' stands.

C2.4 Regional opportunities in the temperate zone

A 'prospects statement' (Robins and Marcar 2007) by the CRC Salinity examined the potential for farm forestry for salinity management in six medium to low rainfall regions

in southern Australia with significant salinity hazard or risk. Drawing on JVAP research along with other sources, its conclusions concerning farm forestry in the medium to low rainfall parts (400-600 mm) of those regions are summarised below. Although the immediate threat from salinity in these regions has declined since the report was prepared, the conclusions concerning limited prospects for profitable farm forestry still hold.

In *south-west Western Australia*, farm forestry is still developmental. The areas are distant from existing infrastructure and markets, less profitable than traditional agriculture and unlikely to deliver large off-site salinity benefits.

In *south-west Victoria and south-east South Australia*, farm forestry can play a role in managing dryland salinity in the upper south-east of South Australia, but rainfall is only 400-600 mm, limiting growth rates and profitability. In south-west Victoria, the close proximity of existing infrastructure is highly beneficial, and local ground water flow systems that characterise the region mean that farm forestry would deliver more rapid salinity benefits. However, large-scale farm forestry is dependent on incentive payments and careful management of water yield impacts and social concerns is needed.

In *north-west New South Wales*, the current prospects for extensive uptake of farm forestry are limited. Although species and product options are being investigated, achieving widespread plantings will necessitate moderate to high incentive payments to compete with more profitable options and to offset risks.



The Australian Low Rainfall Tree Improvement Group has established hardwood progeny trials

In *central-west New South Wales*, current prospects are limited. Farm forestry is a potentially effective salinity management option, but it is a significant threat to water yield if not well targeted. Market development, infrastructure and incentive payments are required for extensive adoption of farm forestry.

In the *Murray western slopes/Murrumbidgee New South Wales and northern Victoria*, farm forestry is a potentially effective salinity management option, but it needs to be carefully targeted for stream yield impacts not to outweigh salinity benefits. The best prospects for farm forestry are plantings on agricultural land close to adjacent higher rainfall forest industries.

In the *Hunter region of New South Wales*, well-targeted tree planting is needed for salinity management. If targeted to recharge sites, farm forestry has good prospects for contributing to salinity management while providing a visual buffer for mining and power station operations.

C2.5 Opportunities in the northern dry tropics

The tropical savannahs of northern Australia are characterised by poor soils, high evapo-transpiration, medium to low rainfall distributed in a distinct wet season, followed by a variable but often-extended dry season (Bristow 2004). These conditions are very different from temperate areas, and there is little history of forestry in the 'Top End' for people contemplating farm forestry to draw on. To provide more certainty about farm forestry potential, JVAP invested in projects (for example Bristow 2004; Armstrong *et al.* 2007; and Venn *et al.* 2004) that completed initial assessments of tree species by sites and of wood properties and utilisation potential.

African Mahogany

JVAP addressed the scarcity of information on plantation grown African Mahogany (*Kaya senegalensis*) with concise and accurate assessment of log qualities and wood properties, and its potential to produce high value timber in northern Australia (Armstrong *et al.* 2007). African Mahogany emerged from this study as a prime candidate species for the dry northern tropics. Thirty-two year-old plantation trees from unimproved seed stock and with little silvicultural management produced good quality attractive timber that was judged equal to or better than the African Mahogany currently imported into Australia.

Industry assessors considered there would be good prospects for plantation-grown African Mahogany on the domestic market in the future, which would conservatively retail for between \$3000 and \$5000/m³ for dried, dressed Medium feature to Select grade timber. Green off-saw recovery from the plantation trees studied was 39% and although it was unstable during sawing, it was relatively easy to dry with little drying degrade. These results could be significantly improved with better seed stock and silviculture (Armstrong *et al.* 2007).

A JVAP review of agroforestry in tropical savannah systems in northern Australia also concluded that older material from African Mahogany is promising, although early growth rates in young trees are poor compared with Eucalypts and Acacias (Bristow 2004).

Sandalwood

High-value non-timber products from a plantation resource such as Sandalwood are attracting a lot of interest. With irrigation, a large area of the tropical savannahs could be suitable for integrated plantations of Indian Sandalwood (*Santalum album*). Western Australian studies have shown that early silvicultural testing can lead to substantial improvement in survival and early growth of this high-value species (Bristow 2004).

Other species

The Bristow study also recorded promising early growth rates of potentially high-value timber and non-timber species. Suitable species are River Red Gum on drier sites and Red Mahogany on wetter sites, and also their hybrids. New, readily-available hybrids, such as Flooded Gum x River Red Gum clones, or *Corymbia* (Spotted Gum) complex, are showing good survival and early growth rates over a broad range of soils and rainfall zones. Hickory Wattle and Thick Podded Salwood have also shown good performance in the savannah's higher rainfall areas.

C2.6 Central Queensland

JVAP supported a study (Venn *et al.* 2004) into the potential for landholders in the South West Strategy and Desert Upland regions to generate alternative income from managing their remnant woodlands for wood production.

The main conclusion was that management of remnant western Queensland woodlands for hardwood production could potentially create a new rural industry generating substantial financial and environmental benefits. This conclusion was based on surveys of Australian and international wood product manufacturers and discussions with several current and potential consumers of western Queensland hardwoods, who expressed great interest in stocking or experimenting with these timbers. Feedback highlighted opportunities for exporting western Queensland hardwoods, especially to North America and Europe.

Parquet flooring manufacturers, small-scale furniture manufacturers, musical instrument manufacturers and timber merchants were found to be the most likely purchasers of western Queensland hardwoods.

D. Public policy, investment options and grower initiatives



Highlights – where have we got to?

Public policy

As interest in farm forestry gained traction in the early 1990s, its advocates became frustrated with impediments created by public policies that had historically been framed around public native forest management. Key policy issues identified by JVAP research were: the monopolistic characteristics of State forest agencies; lack of harvest rights for farm-grown timber; lack of differentiation between farm-grown and public native forest timber; lack of markets for environmental services; and inconsistent local government planning and rating policies. These issues and others were addressed in the JVAP-funded *Strategy Framework* for commercial farm forestry in Australia (1996), and in the *Plantations for Australia: The 2020 Vision* introduced in 1997 and revised in 2002.

With the decline in availability of hardwood logs from public native forests and the lack of supplies from plantations established to-date, industry has increasingly sourced native forest logs from private property. In some regions, up to 50% of total timber milled is sourced from private property. This shift has attracted increased community (and hence public policy) attention to the sustainability of private native forest (PNF) operations. Codes of practice intended to protect habitat and biodiversity within PNF may not achieve ecological sustainability and may have negative impacts on future wood supply.

Renewable energy Regulations are impeding the establishment of short-rotation woody crops for the production of bioenergy and biofuels from biomass.

Investment options

Farm forestry in higher rainfall areas has better prospects for being commercial in its own right than in medium to low rainfall areas. However, it is in the latter areas that farm forestry has the best prospects for addressing land degradation and providing environmental services such as carbon sequestration, fresh water supply, and biodiversity enhancement. Traditional initiatives to support farm forestry for environmental services such as regulations, tax concessions and grants

programs have their drawbacks. More flexible market-based approaches, in which sellers and buyers have an informed negotiation about outcomes to be supplied and their value are more appealing, because they offer the potential to achieve the desired changes in priority locations at least cost. Auctions are an example of a market-based approach.

JVAP and other organisations have supported a significant research effort in evaluating Market-Based Instruments (MBIs) and other investment options to support farm forestry, all of which still present challenges. It is critical that suppliers and buyers have confidence in the 'metric' underpinning estimates of the outcomes from actions, because the metric score strongly influences who should pay and the quantum of payment. The science required to provide the necessary level of confidence can be significant. Furthermore, it can be difficult to define landholders' legislative obligations which set a baseline from which an MBI could leverage change. Hence, designing, implementing and administering MBIs can be more expensive than other options and might exceed the marginal benefits of an MBI.

Notwithstanding the challenges involved in establishing MBIs, successful auctions for environmental services have commenced. These include the *Bush Tender* program in Victoria and the more recent *Box Gum Grassy Woodland Project* introduced by the Australian Government in 2008 and managed by the Lachlan and Murrumbidgee Catchment Management Authorities in New South Wales.

Grower initiatives

JVAP research has investigated the merits of cooperative marketing arrangements and on-farm processing which seek to provide grower groups with improved bargaining power and higher prices for high quality products. For both cooperative marketing arrangements evaluated (*Farmwood Tasmania* and *SMARTtimbers*), the conclusions were positive. Portable sawmills have shown that they can produce high quality timber but they are more labour-intensive than industrial-scale mills. Although JVAP investigations into on-farm sawmilling in Victoria noted that occupational health and safety fell short of standards achieved in industrial-scale operations, this may not be representative of the wider industry due to initiatives by portable sawmill manufacturers.

D1. Public policy

D1.1 Multiple issues

In the mid 1990s, JVAP identified several major public policy issues impeding farm forestry and stimulated extensive policy debate and action. For example, with JVAP funding support, RIRDC (1996) reported that:

- Public forest agencies were regional selling monopolies, they did not determine log prices in **competitive markets**, and hence prevented clear price signals for investment in farm forestry
- **Rights to harvest** or export timber grown in farm forests were unclear as farm forests had not been **differentiated** from public native forests
- There was a lack of effective income tax averaging for forestry; there were no **markets for environmental services**
- Integration of farm forestry support programs was poor; and local government **planning and rating policies** were inconsistent

In a similar vein, Alexandra and Hall (1998), reporting from a series of seven consultative workshops held through regional centres and capital cities in 1996 suggested that among other things:

- A systematic approach to reporting and third-party

auditing of State forest agencies' accounts and accounting practices is required to give confidence that their management is sound and that **competition policies** are being implemented

- All State governments should introduce tree-tenure legislation and systems that guarantee **rights to harvest** farm forests, and must ensure their policies **differentiate** between industrial plantations, public native forest management, and farm forestry
- A wide range of **farm forestry financing options** need to be developed to the point of being commercially accepted by financial advisers and investment managers
- All State governments should review the impact of local government **planning regimes** on farm forestry developments. If necessary, they should introduce State-wide planning policies that overcome the current uncertainty created by the possibility of local governments changing land use planning policies within the life of a farm forest

Further impetus for action to address the public policy issues was provided by a third JVAP project (FORTECH 1999), which found among other things that: independent advisory services should be provided to landholders, as **forest agencies may compete** with private growers for markets; private native forests should have the same **harvest security** status as public forests; and there should be recognition by policy bodies of the environmental benefits of sustainable forest management through appropriate **cost sharing**.

The *Strategy Framework* for commercial farm forestry in Australia (RIRDC 1996) proposed the following actions to develop an enabling public policy environment:

- minimise sovereign and tenure risk from farm forestry investments
- tax farm forestry investments consistently
- ensure consistent and fair codes of practice
- integrate public programs through regional projects
- invest in R&D to solve priority problems
- develop markets for environmental services

The *Strategy Framework* also identified the development of cooperatives, providing information on price, cost and current optimal procedures for developing farm forestry, and educating financial markets of the opportunities as priority actions.

Over the last decade or so, governments have progressed in addressing these matters. Regulatory and policy actions in *The Plantations for Australia: The 2020 Vision* (Ministerial Council on Forestry, Fisheries and Aquaculture 2002) introduced in 1997 and revised in 2002 include: legislation covering rights to plant, harvest and trade plantations and their products; appropriate plantation investment structures; plantation guidelines and codes of practice; transparent and competitive markets; and regional planning for plantation expansion.

This progress has been largely due to the strong links and enduring working relationships between the farm forestry sector and relevant Australian Government and State agencies. Retention of corporate memory in key personnel within agencies has also helped.

D1.2 Private native forests

Principal objectives of the 1992 *National Forest Policy Statement* were maintenance of an extensive and permanent native forest estate and the protection of nature conservation values (Council of Australian Governments 1992). Commonwealth and State processes such as Regional Forest Agreements and the Interim Assessment Process gave effect to the *Policy Statement*, accelerating the reduction in wood supply from public native forests that had been occurring since the 1980s.

Although the *2020 Vision* created a policy framework in support of the Commonwealth and States' aim of offsetting reduced supply from native forests with increasing supply from plantations, most new plantations established since release of the *2020 Vision* are being managed for short-rotation pulpwood. Plantations that are being managed for sawlogs will take years to mature.

With the decline in availability of hardwood logs from public native forests and the lack of alternative supplies from plantations, industry has increasingly sourced native forest

logs from private property. In some regions, up to 50% of total timber milled is sourced from private property. With this shift in resource availability, public policy attention concerning the sustainability of private native forests (PNF) has increased, with a particular focus on habitat and biodiversity (Thompson and Connell 2009).

The Thompson and Connell research report synthesised findings from a suite of JVAP projects that examined the utility of metrics for assessing the sustainability of PNF operations such as harvesting and thinning (Jay 2006; Vaughan 2008; Peacock 2008). Among other things, the synthesis report revealed that existing and proposed public policy initiatives such as PNF codes of practice and their associated metrics (habitat scoring tests) can perpetuate 'high grading' – removal of the largest and best trees. Although high grading may pass the metric tests or benchmarks incorporated in PNF codes of practice, the practice may not be ecologically sustainable, and furthermore its effects on future wood production may be significantly negative.

Hence there appear to be anomalies between regulatory instruments for PNF and the goals of ecologically sustainable forest management, which includes future productive values. ***Sustainability of private native forests (PNF)*** (section B2.1) has more detail about the technical aspects of metrics for assessing the sustainability of PNF management.

Another JVAP report (Parsons and Pritchard 2009) draws together information from many published and unpublished studies that provide information on the role, values and uses of PNF. It focuses on PNF where wood production is one of the management objectives.

Implications

The researchers suggest that policy makers consider alternative checklists (Lindenmayer 2009b) and systems (Thompson and Connell 2009) for addressing habitat and biodiversity issues in PNF. The alternative systems should recognise scale issues through a regional mosaic of timber production and conservation goals on private land, and incorporate landholder incentive systems which cater for regional habitat priorities.

From the Parsons and Pritchard report, Government agencies can identify those regions where there is a dearth of information on the sustainability of current harvesting regimes. Private Forestry Development Committees and relevant State and regional authorities can use the report to target extension activities and management tools to PNF managers.

D1.3 Renewable energy

A JVAP report by Schuck (2004) noted that *Bioenergy Australia* had been participating in the International Energy Agency's Bioenergy Program Task: *Short Rotation Crops for Bioenergy Systems*.

A report from Australia's participation in the Task indicated that existing regulatory arrangements in Australia are

impeding the use of woody crops and wood wastes for the production of renewable energy. For example:

- The Commonwealth's *Renewable Energy (Electricity) Act 2000* and Regulations, which set mandatory targets for generation of electricity from renewable resources, preclude the use of woody crops from being eligible and restrict the use of wood wastes substantially
- For plantations, the *Regulations* require that wood wastes must be the product of a harvesting operation for which no product of a higher financial value than biomass for energy generation production could be produced at the time of harvesting. This introduces uncertainty for potential investors in biomass plantings and energy generation plants as there is a risk that wood biomass may cease to be eligible as a renewable energy resource at some time during a project
- The *Regulations* also preclude the growing of tree crops for energy, which has a direct impact on the potential use of woody short-rotation crops to address environmental problems such as dryland salinity

D2. Investment options

JVAP's 1999-2004 *Research and Development Plan* (RIRDC 1999) put greater emphasis on developing farm forestry systems for medium to low rainfall areas because it was in these areas where land degradation was greatest and adoption

of farm forestry had been slow (van Bueren *et al.* 2002). One of the reasons for the slow adoption of farm forestry was its relatively low profitability compared with other land uses (Zorretto and Chudleigh 1999).

A decade later, this situation looks like changing dramatically. The salinity threat has abated in some medium to low rainfall regions, and in a carbon constrained environment, many biomass industries are likely to be profitable across large parts of southern Australia (Hobbs *et al.* 2006). Payments for environmental services from farm forestry such as carbon sequestration, fresh water supply or biodiversity enhancement, will be important (Robins and Marcar 2007). Environmental carbon plantings could be profitable (Polglase *et al.* 2008).

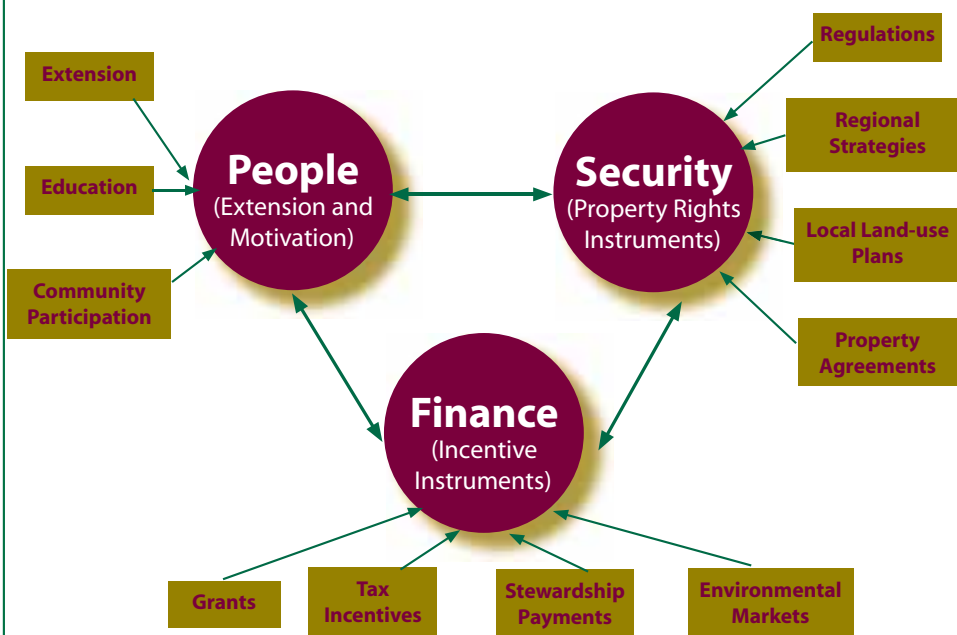
Hence in addition to investing in research to identify biomass-based industries that may be profitable in their own right (see **Potential industries and markets** section C2.2), JVAP has also invested in research supporting development of markets for environmental services. This investment includes Market-Based Instrument (MBI) research, and development of tools to underpin effective operation of MBIs, for example metrics to quantify the environmental services of different forest management regimes (see **Sustainability of private native forests (PNF)**, section B2.1).

Consistent with its focus on multi-purpose farm forestry, JVAP has not invested in research into investment instruments for industrial plantations, such as managed investment schemes (MIS).



Getting the policy mix right

The diagram below provides an overview of the range of policy tools that can be used to promote farm forestry.



The tools are divided into the following broad categories:

- those that can be used to motivate and retain land-holders' support for farm forestry programs (**People** tools);
- those that can be provided to share the costs of managing farm forestry and act as financial incentives (**Finance** tools);
- the regulatory, legal and voluntary property right instruments that can be used to provide secure management of farm forestry (**Security** tools).

These categories provide a useful framework for evaluating policy instruments. Research has shown that policy mixes which harness the synergies between educational (people), regulatory (security) and economic (finance) incentives are likely to be more effective (both in terms of cost and environmental outcomes) than those which use only single instruments.

Getting the policy mix right Source: van Bueren et al. (2002)

Historically, governments in Australia have relied on regulations, tax concessions and grants along with associated awareness-raising, to achieve improvements in natural resources management. Each of these initiatives has disadvantages. Regulations may enjoy broad community support but not from their target markets, tax concessions can be cost-effective to administer but difficult to target to priority locations, and grants programs can be more easily targeted but are usually administratively expensive.

Market-Based Instruments (MBIs) have the potential to overcome these disadvantages by providing market signals such as trading mechanisms (e.g. auctions), brokerage opportunities, and incentives for innovation and profit. **Well-designed MBI's are supported by their target markets and achieve desired changes in priority locations at least cost.**

MBIs in various forms have been operating in Australia since the introduction of transferable water entitlements in the Murray-Darling Basin in the early 1980s (van Bueren et al. 2002).

The Australian Government introduced the *Market-Based Instrument Pilot Program* in 2003 to address key knowledge gaps in MBIs for conservation purposes - see <http://www.napswg.gov.au/publications/books/mbi/round1-evaluation.html>. JVAP joined this initiative, co-sponsoring a two-day symposium, organised by the Australian Agricultural and Resource Economics Society. This brought together national experts to present a series of papers of the highest quality which were subsequently published by JVAP (<http://www.rirdc.gov.au/reports/AFT/04-142.pdf>).

Box D1 Agroforestry purchaser-provider as an example of the Buffier Three I's Framework

The government acts as a purchaser of environmental services that stem from agroforestry activities.

Information

- The public sector purchaser provides information about the broad environmental outcomes that it wishes to advance and the structural aspects of the proposed purchase—for example, the duration of purchase or funding
- Information concentrates on specific areas where it has been assessed that agroforestry will deliver environmental benefits - basically, tree 'hot spots' are put on a map
- In order to stimulate interest in initial offerings where much is uncertain, the purchaser also provides information about the public sector value of agroforestry activities in specific areas
- There may be a need to educate and inform farmers and foresters about how the scheme works and develop their capacity to participate in it. The greater the

pool of potential participants, the higher the level of competition

Institutions

- A public sector entity is required to act as purchaser of environmental services
- A separate regulator is introduced to verify that environmental services are delivered
- A brokerage role for innovative farmers, environmental interests and community and forestry business interests is left open

Incentives

- The winners of the competitive process are paid by government for the environmental services they provide
- All stakeholders have better information about tree 'hot spots'. Altruistic investors may invest in agroforestry options in these areas - even if they miss out on competitive support - if they can clearly point to the fact that they are doing 'the right thing'

JVAP has played an important role in supporting CSIRO to develop its research capacity in MBIs for environmental services, starting with investment in research examining ways to make farm forestry pay (van Bueren *et al.* 2002), and following that by investing in development of regional markets for ecosystem services (Coggan *et al.* 2008; Reeson *et al.* 2008; Whitten *et al.* 2008). Knowledge generated by JVAP-supported research is summarised below.

Market Based-Instruments within the policy mix

MBIs fit within one of three types of policy instruments that can be used to encourage environmental services. The three policy instruments need to act in concert to be effective, and have been referred to in varying terminology by JVAP researchers.

For example, van Bueren *et al.* (2002) note that there can be three categories of policy tools: **People** (Extension and Motivation); **Finance** (Incentive Instruments); and **Security** (Property Rights) – see Figure D1.

Another report (Buffier *et al.* 2002) proposes a Three I's Framework, which has **Information** covering extension, **Incentives**, and **Institutions** covering regulations (see Box D1).

A third, more contemporary report (Whitten *et al.* 2008), notes that policy interventions can be in three categories: **Facilitative** measures, improving information flow; **Incentive** measures; and **Regulatory** measures (Box D2).

Box D2 Whitten *et al.* - Examples of potential NRM instruments

Facilitation

- Creation, clarification or allocation of property rights (e.g. water markets)
- Provision of information (including technical advice, measurement advice or requirements and certification schemes)
- Voluntary agreements (such as voluntary covenanting programs)

Incentives

- Output taxes and charges (e.g. carbon tax)

- Input taxes and charges (e.g. fertiliser tax)

- Input subsidies such as grants

Regulation

- Compulsory purchase (e.g. some national parks)
- Prohibition of resource uses (e.g. clearing laws)
- Specified management actions or specified best management practices that are imposed
- Duty of care performance standard that is imposed

Developing effective MBIs – lessons learned

Researchers investigating MBIs have extensively reviewed MBI experiences in the USA and Australia. Three MBI options are available: price-based (for example auctions); quantity-based (for example tree clearing offsets); and market friction instruments (for example removing impediments to existing markets). Selecting a preferred option is a pragmatic trade-off involving transaction costs and other factors (Whitten *et al.* 2008). Several **key principles** for good MBI design have emerged from research to-date:

- **Designing, implementing and administering MBIs can be more expensive** than other options and the marginal benefits of an MBI may not exceed the additional costs
- **MBIs could outperform other instruments** where there are a large number of potential participants, there is a large variation in their ability to provide the desired outcome, and where there is flexibility in the range of actions that will deliver the outcome
- **MBIs should be designed from ‘scratch’**, in consultation with specialists to ensure they are appropriate to local goals and objectives
- Multiple outcome MBIs should be considered only where there are many sites that could produce multiple outcomes and the available management actions can deliver multiple outcomes
- It is critical to ensure that suppliers and buyers have confidence in the science or ‘metric’ underpinning estimates of the outcomes from actions. For environmental services, the metric may be based on the estimated improvements in biodiversity from tree planting or private native forest management (see *Sustainability of private native forests*, section B2.1)
- MBIs **should be designed to integrate or ‘nest’ within existing regulatory or incentive measures** to reduce the costs of implementation and administration, as well as costs to landholders (Whitten *et al.* 2008; van Bueren *et al.* 2002)

Are they worth the effort? – MBIs in practice

Both the van Bueren *et al.* and Buffier reports incorporated **practical ideas** for implementing their suggested MBI arrangements. Buffier suggested using the then *National Action Plan for Water Quality and Salinity (NAP)* as the preferred ‘pathway’ for delivery of the Three I’s framework, as it was already understood and resourced.

Key challenges – Property rights and metrics

Coggan *et al.* (2008) reported on a comprehensive JVAP project that used **actual case studies** to assess regional impediments to establishing MBIs for ecosystem services. The case studies included: incentives for tree planting to reduce salt damage to roads; local government requirements for development offsets associated with peri-urban subdivision;

saline land management in the Wimmera region of Victoria; and vegetation corridors in central Queensland.

At the start of their project, Coggan *et al.* envisaged that a number of pilot applications of MBIs would be well underway to completion, but this was not their experience. They found that MBI design and implementation is a complex and time-consuming process. Only one case study (the Wimmera) was operational. Key difficulties included incomplete **definition of existing property rights** (for example the duty of care imposed on landowners through regulation), and **defining a metric** to quantify the new property right attributes (for example the environmental service).

Some progress has been made on these two issues by other organisations. For example, an unpublished report for Australian Wool Innovation Limited by the author of this report (Powell *et al.* 2003) defined graziers’ existing responsibilities (property ‘rights’) under native vegetation protection legislation, identified actions that should be taken by graziers at their own cost to comply with the legislation, and then identified additional actions and their ‘public conservation service’ outcomes (the metric). They proposed that the public conservation services could be sold to public sector buyers at a negotiated price.

D2.2 Public-private partnerships, revolving loans

In addition to supporting research into MBIs as an option for enhancing investment in farm forestry, JVAP has also supported research into alternatives. These include Public-Private Partnerships summarised below, and a *Landcare Revolving Loan Fund* (see Box D3).

Alexandra *et al.* (2007) examined the feasibility of using Public-Private Partnerships⁵ as an option for financing multi-purpose farm forestry delivering public good benefits such as carbon sequestration and other environmental services. They argued that as Public-Private Partnerships are commonly used by State Governments for maintaining or renewing built infrastructure, then they should be considered for maintaining or renewing natural infrastructure such as catchments and landscapes.

The researchers found that although there are no examples in the world where Public-Private Partnerships support broad-scale environmental repair, the existing financial, legal and policy mechanisms appear suitable. Their findings indicate that Public-Private Partnerships could have advantages similar to MBIs in encouraging multi-purpose reforestation.

In a similar way to Buffier, Alexandra *et al.* also put forward **practical recommendations** for advancing Public-Private Partnerships for reforestation, including: establishing a flexible framework for Public-Private Partnerships development; exploring a range of options for structuring deals; segmenting long-term deals with shorter-term renegotiation periods; determining the liability for specific risks; establishing a carbon register; underwriting long-term contracts; funding

⁵ Public-Private Partnerships are contractual agreements between public agencies and private companies. The parties share skills and assets in delivering a service or facility, and each party may share in the potential risks and rewards

learn-by-negotiation processes as well as on-ground projects; reducing transaction costs of dealing with multiple agencies; involving all stakeholders from the outset; and establishing clear negotiation processes.

Notwithstanding practical suggestions from the JVAP-supported research cited here and other suggestions, there appears to have been limited interest within State and regional natural resources management organisations to progress development of MBI.

D2.3 Implications

Notwithstanding the challenges involved in establishing MBIs, successful auctions for 'environmental services' have commenced. These include the *Bush Tender* program which the Victorian Government piloted in the early 2000s and extended State-wide in 2006 - see <http://www.dse.vic.gov.au/ourenvironment-ourfuture/regional.htm>, and the more recent *Box Gum Grassy Woodland Project* introduced by the Australian Government in 2008 and managed by the Lachlan and Murrumbidgee Catchment Management Authorities in New South Wales - see <http://www.nrm.gov.au/stewardship/box-gum/index.html>

Other than auctions, development and implementation of options for financing farm forestry appears to be problematic. Defining landholders' obligations to set a baseline from which an MBI could leverage change, and developing cost-effective and robust metrics to quantify the outcomes that will result from various actions, remain key issues. Implementing the investment options discussed here depend on resolving these issues to the satisfaction of potential MBI managers and participants.

D3. Grower initiatives

The fundamental issues for farm foresters are to provide consistent, secure and reliable supplies of wood of known

quantity, quality and cost and to construct mutually agreeable commercial partnerships amongst themselves and with buyers of their products. To this end, grower groups have trialled cooperative marketing and value adding through on-farm processing. On-farm processing, which can assist in overcoming marketing difficulties such as small discontinuous supply, remote location, and unsuitable resource (Stewart and Hanson 1998) is becoming more commonplace as portable sawmill designs improve and operators gain more experience. JVAP research has examined the merits of these initiatives.

D3.1 Cooperative marketing

Wettenhall and Henderson (2002) reviewed the *Farmwood Tasmania single desk export* model. They found that it has potential to help farmers obtain a fair share of timber profits by overcoming impediments associated with fragmented, small-scale forestry; as well as those of long-term, cyclical, and sporadic harvesting of timber. Through aggregation of resources, the 'single desk' model overcomes the problem of delivering timber of variable quantity and quality - ensuring consistency of supply of products of guaranteed quality - two attributes sought by timber product buyers. It also ensures that marketing experience is developed, resources to fund promotion are pooled, and economies of scale are provided, which enables effective servicing of export markets.

JVAP also supported investigations into the *SMARTtimbers single desk domestic marketing* model (Wettenhall 2008). *SMARTtimbers* seeks to deliver higher returns for growers producing sustainable, high-value products such as Sugar Gum (*Eucalyptus cladocalyx*), through direct marketing to architectural firms at the 'top end' of the building market. Among other things, this study found that small-medium scale architectural firms do provide a good fit for marketing from grower groups, and they do look for evidence in support of the groups' claims about specialty timbers. However, the firms' clients are more interested in the 'look' of a product than its sustainability, and builders can act as a barrier to

Box D3 The Landcare Revolving Loan Fund

Mortimer *et al.* (2003) reported on an innovative investment option trialled in Victoria called the *Landcare Revolving Loan Fund*. The *Fund* was owned by landcare groups within the Broken Catchment Landcare Network and was operated by volunteers. It offered low interest loans for farm forestry and landcare works, as an alternative to government grants. The researchers found that:

- A company to operate the *Fund* had been created. However, it had not attracted sufficient capital for the *Fund* to be viable in the long term. It was very difficult to secure corporate sponsorship for a relatively small fund (\$75,000 is the minimum capital required to cover costs)
- Revolving loan funds could be a cost-effective investment in landcare. For example, an initial \$180,000 grant could result in \$600,000 in landcare loans being disbursed over ten years
- Revolving loan funds could offer a cost-effective means of exposure for corporate brands. A one-off grant from a corporation will be used year after year to provide loans into the community. A no interest loan by a corporate to a revolving loan fund could be negotiated for requisite exposure
- The revolving loan fund is a means to address the Australian Landcare Council's highest priority, viz the securing of long-term funding for landcare works

specifying sustainable products, as price is the major criterion on which they base their purchasing decisions.

D3.2 On-farm processing

Several JVAP projects have investigated the merits of portable sawmills, including sawmilling techniques, sawn timber drying and marketing, and occupational health and safety issues. The consensus is that **portable sawmilling is technically and financially feasible** – recoveries are comparable to industrial scale mills, but they are more labour-intensive and hence the mills have lower productivity (Stewart and Hanson 1998). Furthermore, portable sawmills can produce high quality timber. In sawing trials, Brown Mallett (*Eucalyptus astringens*), Sugar Gum (*E. cladocaylx*), Yellow Gum (*E. leucoxydon*) and Swamp Yate (*E. occidentalis*) produced dimensionally consistent 150 mm-wide boards that could be used for furniture manufacture and other high-value products (Blackwell and Stewart 2003).

In common with occupational health and safety issues on farms generally, the situation with regard to on-farm sawmilling may be highly variable. A JVAP study of six small-scale harvesting operations in Victoria (two by contractors and four by owners) were found to be 'pioneering', using improvised equipment, limited skills, and short-term marketing arrangements. Harvesting costs, operational impacts and occupational health and safety fell short of standards achieved in industrial-scale operations. The contractors did not perform better than the owners (McCormack *et al.* 2000).

On a more positive note, portable sawmills manufactured by Lucas Mills at Wooragee in Victoria incorporate many safety features, and the company has donated five sawmills to training institutions in Australia. Over 8000 Lucas Mills have been sold over the 11 years to 2006, and no fatalities or major amputations have occurred with these mills (Noble 2006).



Portable sawmilling is feasible, but labour intensive

E. Socio-economic issues, training and extension



Highlights – where have we got to?

Socio-economics

JVAP and associated investment in socio-economic research has mostly been directed to enhancing knowledge of community impacts of industrial plantation expansion in higher rainfall areas, and to understanding what motivates landholders to adopt 'integrated' farm forestry.

At regional and local government scales, industrial plantation expansion is not the 'root cause' of any rural population decline and loss of service. Instead, it accelerates changes that have been occurring for decades. The magnitude of change is usually limited because where landholders move away, new landholders move in. However, at the local scale, plantation expansion can have negative outcomes for communities that have a narrow economic base and few diversification opportunities. It can also cause land values to rise, which is an advantage for some and a disadvantage for others.

There are general principles for addressing conflicts associated with industrial plantation expansion, including empathising with affected communities, interacting with them on social occasions, and forming working relationships based on trust and mutual acceptance. Regional consultative and planning processes are also important. These principles and processes may also be relevant to medium to low rainfall areas if there is rapid expansion of short rotation woody crops for carbon sequestration and other products and services.

'Integrated' farm forestry is at present characterised by landholders concerned about landscape, lifestyle and leaving a legacy for future generations. While they do mention economic returns, profit is not the key driver. The key message for policy makers, regulators and farm forestry program managers is that there should be continued investment in research to elicit the key drivers and barriers that influence their target market segments, and in initiatives tailored to those factors.

Training and extension

JVAP has delivered research outcomes through: face-to-face contact between researchers, educators and intermediaries and end users via the Australian Master TreeGrower Program (AMTG); production of ANU market reports, major synthesis publications, manuals and guides, and research reports; and through JVAP and RIRDC sponsorship of conferences, workshops and meetings. The AMTG has proven to be an ideal conduit for communication and extension of research

and policy, and instrumental in providing guidance and encouragement to farm foresters across Australia. By 2009, it had reached 1500 participants and 30 partner organisations through 77 AMTG courses.

A survey of farm forestry stakeholders' needs found that a 'very high proportion' of people who were aware of JVAP and had accessed JVAP information had found the information useful. Personal advice, along with trials and demonstrations were 'highly preferred' ways of accessing information. Written forms of information (for example, research reports, newsletters and fact sheets) also rated 'very highly'.

Sixteen editions of the quarterly ANU market report were published between September 1997 and June 2001. Topics covered included: structural timber prices; pulp log prices; log and agricultural prices beyond 2000; the cost of tree seedlings and cuttings; stumpage; log exports; the cost of log transport; woodchip markets and prices; trends in sawn wood market; market for forest products in South Korea; market trends in the 1990s; carbon credit markets; rents for plantation land leases; Japanese woodchip import market; stumpage trends in South Australia; firewood market.

Major synthesis publications fully funded or supported by JVAP include: Design principles for Farm Forestry: A guide to assist farmers to decide where to place trees and farm plantations on farms (Abel et al. 1997); Trees, water and salt: An Australian guide to using trees for healthy catchments and productive farms (Stirzaker et al. 2001); Plantations, Farm Forestry and Water: A Discussion Paper (O'Loughlin and Nambiar 2001); The Farmers Forest: Multipurpose Forestry for Australian Farmers, (Reid and Stephen 2001); Trees for Shelter (Cleugh 2003); Trees and biodiversity (Salt et al. 2003); and Trees for Saline Landscapes (Marcar and Crawford 2003). These publications are available from RIRDC in Canberra. In addition numerous JVAP research reports are available as internet downloads and hard copies. More are 'in press'.

Notwithstanding JVAP's training and extension initiatives, the overall impact of JVAP's research, extension and training activities on penetrating farm forestry research user markets and influencing farm forestry expansion is unknown.

E1. Socio-economics

In recent decades, farmers have become more productive, manage larger areas of land, and their households are more likely to rely on both farm and off-farm income, compared to two or three decades ago. 'Seachangers' and 'treechangers' have also substantially changed the culture and community of many rural areas. Even among the rural landholder population, a large number of people do not identify themselves as farmers (Schirmer 2006).

These changes have had many flow-on effects, with increasing concern being expressed about declining rural populations and rural services, isolation of farming families who have seen their neighbours leave farming, and a loss of a sense of community and identity in some rural areas. In higher rainfall areas (greater than 600 mm rainfall) experiencing rapid expansion of industrial-scale plantations, these concerns have intensified.

JVAP investment in socio-economic research has mostly been directed to enhancing knowledge of the community impacts of industrial plantation expansion, and to understanding what motivates landholders to adopt 'integrated' farm forestry, which is seen to have minimal impacts.

E1.1 Industrial plantation expansion

Issues

There are contrasting perceptions about the social effects of industrial plantation expansion in south-west Western Australia, the Green Triangle of south-east South Australia and south-west Victoria, and in southern New South Wales and north-east Victoria:

- on the one hand, new jobs and increased economic activity generated by industrial plantation forestry and associated processing facilities can benefit rural communities by halting or even reversing population decline, however
- industrial plantation forestry can disadvantage rural communities by exacerbating population decline, leading to loss of social capital, withdrawal of banking services, closure of health services, and declining enrolments in small schools, and
- farmers wishing to expand their holdings to remain viable cannot compete with higher prices being offered by companies wishing to expand plantations

Current knowledge

A number of studies (for example Tonts *et al.* 2001; Schirmer 2006; Schirmer 2008) have investigated the extent to which these perceptions are supported by reality. With regard to employment and economic activity:

- Industrial plantations do offer important employment and economic benefits at regional scale, initially from growing and other servicing activities and in the longer term, from harvesting and downstream processing
- With softwood plantations, around one-third of employment is generated through growing and harvesting, and two-thirds by downstream processing. Hence the total employment impact is highly dependent on location of processing facilities
- There has been significant generation of employment, population increase and economic growth in some towns where softwood processing facilities have been established

near plantations (e.g. Tumut, Tumbarumba and Holbrook on the south-west slopes of New South Wales)

On the issue of plantation expansion causing population decline and subsequent loss of services etc, the studies have found that at the regional and local government area scales:

- **Plantation expansion is not the 'root cause' of any rural population decline and loss of services** that may occur. Instead, it accelerates restructuring and changes to services that have been occurring for decades due to volatile commodity prices, falling farm incomes, farm amalgamation, and associated farm family out-migration (Tonts *et al.* 2001)
- In south-west Western Australia where 10-25% of agricultural land was converted to plantations, the higher-than-average decline in school enrolments began before plantation expansion occurred, suggesting that **the main cause of declining enrolments was declining population of rural landholders**, and that plantation expansion was a response to increased land availability as the number of rural landholders dwindled (Schirmer 2006).
- Where plantation expansion has triggered some population decline, **the magnitude of change is not as high as some suggest**, because in many cases where landholders move away, new residents move in (Schirmer 2008)

However **plantation expansion can have negative outcomes at the local scale** (see Box E1), if it occurs within small communities that have a narrow economic base, few alternative prospects for diversification (including construction of downstream processing facilities), and are already experiencing adverse consequences of structural adjustment (Tonts *et al.* 2001). In these circumstances, some businesses and residents find it difficult to adjust to both the nature and pace of change, and out-migration accelerates, making it increasingly difficult to maintain services.

Investigations into land values in Western Australia during a period of rapid expansion of Blue Gum plantations (1988-2004) have confirmed that plantation expansion can cause land values to rise. Outside of coastal areas experiencing high demand for rural residential blocks, the highest rate of land price growth in the Great Southern region occurred in areas suitable for plantation establishment. At Bombala in southern New South Wales, land sold for plantation establishment also sold for a higher price than land sold for other purposes. An upturn in farming has since led to rapid growth in prices of land for broadacre cropping and grazing, but not for plantation establishment (Schirmer 2006).

Rising land values are generally seen as positive by landholders wishing to exit farming, but as negative by landholders wishing to expand.

Resolving concerns

At regional scale, there appear to be net benefits of plantation expansion, mainly due to increased employment and economic activity. Plantation expansion and its associated processing facilities can halt or even reverse rural population decline. Rural land prices can increase, benefiting landholders wishing to retire but disadvantaging those who wish to expand their holdings. However, the regional scale benefits can come at the expense of social capital or loss of services in smaller, more local communities that are already suffering due to ongoing structural adjustment in the rural sector.

General principles for preventing or resolving conflict between the industrial plantation sector and local to regional communities include:

- Having a solid understanding and empathy with the communities – their environmental and social history, values, and future aspirations all provide insights into the likely concerns and issues surrounding plantation management

Box E1 Local community concerns – a case study

Plantations North East Inc (PNE) in Victoria wants to have an additional 25,000 ha of plantations established in the Victorian side of the Murray Valley by 2020. The Towong Shire in the Upper Murray in Victoria has about 132,000 ha of suitable land, but most of the recent expansion in plantations has occurred over the border in New South Wales.

Stewart *et al.* (2008) investigated the reasons for this. Several factors favoured plantation expansion in the Towong Shire. These included support from PNE, the market price of land was more closely related to agricultural value than 'lifestyle' value, three managed investment schemes made offers to develop plantations, and the Towong Shire population was declining (8% from 1991-2001) and ageing due to ongoing structural adjustment in the rural sector.

However, other factors look like preventing PNE from achieving its 2020 target. Firstly, even if the target is achieved, the scale of resource would be too small to justify construction of new processing facilities – any additional resource would be hauled to processing centres in Victoria and New South Wales. Hence there is no prospect of increased employment and economic activity associated with the processing of plantation resources within the Towong Shire.

Secondly, there is an over-riding concern from local communities about the impact of plantation expansion. They consider that if only a few [more] farm families moved away, it will have a significant effect on the social capital of the community.

Lastly (most likely due to the community concerns) the Towong Shire has discouraged plantation forestry from prime agricultural land in the Farming Zone and further restricted plantations in areas covered by planning overlays.

- Interacting with the communities during social occasions to better understand the people involved, their concerns and beliefs, and to verify the information sources that the communities trust
- Forming working relationships based on trust and mutual acceptance of contrasting personal values (Dare *et al.* 2008)
- the profitability of farm forestry in higher rainfall areas is currently marginal, mainly due to the lack of income during long rotations, but there are attractive future opportunities
- there is significant potential for farm forestry in medium to low rainfall areas, but there are a number of 'deal breaking' issues, including low growth rates (and hence even longer times with little or no income)

More specific processes have been suggested by Tonts *et al.* (2001) and Stewart *et al.* (2008). These centre on regional consultative and planning forums that bring together private forestry development committees, catchment management authorities, and regional development organisations including local government. These forums would: collaboratively maintain regional databases; organise regular community workshops that outline trends and proposed developments; develop locally-specific guidelines/protocols for issues affecting farm management and neighbour relations; and devise a set of standard planning provisions, tied to existing Codes of Practice.

Could history repeat itself?

To-date, rapid expansion of plantation forestry and its associated social effects have occurred only in regions where forestry is profitable in its own right, that is, in the higher rainfall areas. In medium to low rainfall areas, long rotation times coupled with slower growth rates and long haulage distances to markets have precluded establishment of 'wall-to-wall' plantation forests. Integrated farm forestry for multiple purposes, including some economic (but not necessarily profitable) return has been the norm.

This situation in medium to low rainfall areas could change dramatically if species and products with good prospects (for example from direct wood production to carbon sequestration and environmental services) make farm forestry economically viable as suggested by Hobbs *et al.* (2006). These areas could experience economic and social impacts similar to those that have occurred in some high rainfall regions (Tonts *et al.* 2001).

Application of the principles and processes for consultation and planning suggested above are highly relevant to consideration of proposals for large scale plantings in medium to low rainfall areas.

E1.2 Motives for adopting farm forestry

It is often claimed (for example Robins and Marcar 2007) that farm forestry would be more widely adopted if it can be shown to be at least as profitable, and preferably more profitable than, existing agricultural enterprises. Over its 15-year history, numerous JVAP studies have investigated profitable opportunities and prospects (see *Higher rainfall and irrigated areas*, section C1, and *Medium to low rainfall areas*, section C2). In summary, those studies have shown that:

How important is profitability?

The weight of evidence suggests that with some exceptions, farm forestry is not profitable at present, and that the long waiting time for income is the key factor. Although this situation could change dramatically in a carbon-constrained future involving shorter times to income generation, why, when managed investment scheme plantations are excluded, has the area of farm forestry plantations already increased by around 33,000 ha compared to areas reported in the *National Farm Forestry Inventory?* (URS 2008).

One explanation is that **for many farm foresters, profitability is not the only (or even the most important) motivating factor**. Several JVAP and other studies support this proposition.

Campbell White and Associates Pty Ltd and Alan Black (1999) examined the profitability and other outcomes from ten case studies across southern Australia. One property was in a low rainfall zone (275 mm), while the remainder were in medium to high rainfall zones (600 mm-1735 mm). All case study farmers considered the long-term viability (both economic and environmental) of their farming business to be the key motivating force for adoption of farm forestry.

The researchers found that eight of the ten farms could expect direct positive returns of varying significance. However, two cases yielded negative economic results, suffering from an inability of the trees to generate a large enough income at the end of the rotation to compensate for the loss of agricultural income over the length of the rotation. This 'cost of waiting' is often the 'Achilles heel' of long-rotation farm forestry and has been discussed in detail by Reid (2008) – see below.

Perhaps surprisingly, the researchers found that **for all properties, there was a positive social impact** at the personal and family level, **even those where farm forestry was not profitable**. This finding is consistent with that of the Maczkowiack *et al.* (2008) study in Queensland (see Box E2).

Box E2 The Queensland experience

The Maczkowiack *et al.* (2008) study provided insights into the motivations and decision processes for landholders who have adopted in farm forestry. In total, 22 cases from far-north Queensland and south-east Queensland were investigated. Key findings were:

- Most 'farm' forestry currently in far-north and south-east Queensland is by landholders who do not rely on the land for their primary source of income
- About 80 per cent of landholders in the sample were older than 45 years and several were above 65 years of age, and respondents were in most cases new to the community in which they owned land
- Sixteen respondents were moderately satisfied to enthusiastic with the growth of the trees and the way their other objectives are being met. **The pleasure from growing the trees and the improvement in visual appeal of the landscape were primary motivations** for undertaking the project
- **Main motivational themes** that drove involvement in small-scale forestry were (in ranked order): had a **personal interest** in trees; **environmental concerns**; wanted their own **rural lifestyle** or retreat without the hassles of caring for livestock; **expectation of lump-sum capital gain** from either timber or **enhanced appreciation of real estate**; became **personally involved** in establishment or management of the plantation; wanted to **influence their children** during their formative years, or to **leave a legacy** for the next generation; wanted to **derive income** from the project before retirement
- Prior vocation or lifestyle was also important – for all but three of the respondents, either their lifetime career had previously been in rural industry, or they had deliberately adopted rural living as a lifestyle
- Although the landholders were motivated towards tree planting, many required an external trigger to translate their aspirations into action. For some, it was the offer of a joint venture arrangement, or the advent of the Community Rainforest Reforestation Program. For others, it was the encouragement of groups such as Queensland DPIF, Landcare or Greening Australia
- Three of the 22 landholders were quite disenchanted by their forestry experience and would not repeat the adventure. Another three would avoid joint venture arrangements and identify better species prior to planting
- **Optimistic views about future timber prices tend to be held by landholders who have immature plantations.** In stark contrast, there is a small number of landholders who have mature timber ready to harvest that are experiencing great difficulty in obtaining prices that justify harvesting, let alone 'making a killing'

Other perspectives

Another ten case studies involving surveys between 1999 and 2002 measured attitudes to farm forestry among landholders in the eastern Darling Downs of southern Queensland and the Northern Tablelands of New South Wales (Harrison and Herbohn 2008). It found that:

- There was unlikely to be any large-scale increase in the rate of plantation establishment by existing landholders in broadacre agricultural landscapes. Any expansion at all would be largely confined to smallholder activity, especially those with higher incomes, professional backgrounds and off-farm income and with some pre-existing interest in, or experience with, trees
- Both plantation and native timber production were seen by landholders, especially those with a commercial focus, as providing relatively minor land and habitat protection and in any event would be best placed on the poorest soils. Anecdotal evidence suggests that these findings would have been fairly typical of cropping zones right across Australia

Romantics and pragmatists

There is much commonality between the positive social impact identified by Campbell White and Associates Pty Ltd and Alan Black, the factors that motivated the Queensland landholders surveyed by Maczkowiack *et al.* and positive comments attributed to leading farm foresters in a keynote address to the Australian Forest Growers (AFG) 2008 National Conference (Reid 2008). The comments at AFG included:

- "We, as tree growers, invest some of ourselves in our forests, write a history on the landscape with trees and leave a legacy for our children and the community" (Dr Jim Finley, Pennsylvania)
- "Farm forestry is more than growing wood for money and it's OK to be emotionally involved with your forest – to care" (David Jenkins, Western Australia)
- "Long-term rotations of up to 30 years don't really present a problem to me the next generation, they'll gain the benefit of harvesting those trees" (Andrew Stewart, Victoria)

- “It gives us a great feeling every time we come up here. It’s a beautiful landscape and it’s improving every year. How do you value that? Improving the landscape gives you a better feeling about where you live. It’s not something that you can value with money, it’s just a feeling. It’s where you live, and if it improves your quality of life it’s a great thing” (Noel Passalacqua, New South Wales)
- “*Time* is not just a cost, it is also an *opportunity*: An opportunity which gives purpose and meaning to our own lives now and also provides the real prospect of generating a cash return and leaving a legacy” (Rowan Reid, Victoria)

These positive comments about farm forestry display the hallmarks of *romantics*, defined in *The Concise Oxford Dictionary* as ‘.....imaginative, emotional, visionary, passionate...’. Drawing on the book *Zen and the Art of Motorcycle Maintenance*, Reid himself notes that quality [of life] embodies the romantic (aesthetics and emotion), as well as the classic (technology and economics).

Giving voice to the classic as opposed to the romantic, Reid notes that for many farmers ‘an investment in growing timber is akin to making a large fixed-term cash deposit in a government bank of a small politically unstable island nation facing hyper inflation and inundation by rising sea levels.’ This more hard-nosed perspective, concerned mainly about risk and economic return, also appeared to be held by the broadacre landholders surveyed by Harrison and Herbohn. It characterises *pragmatists*, defined in the *Dictionary* as ‘... doctrine that evaluates any assertion solely by its practical consequences...’

Implications

It appears that farm forestry, as with the landcare movement, is dominated by visionary and passionate landholders, who are concerned about issues such as landscape, lifestyle and leaving a legacy for future generations. While they do mention economic returns, their farm forestry activities are not strictly about profitability. This industry makeup may well change in a carbon-constrained future, which could see a significant increase in the number of people adopting farm forestry on its economic credentials alone.

The key message from the JVAP work and the AFG address cited here for policy makers, regulators and farm forestry program managers is that their **time, resources and effort in assisting development of the farm forestry sector will continue to be maximised by investing in research to elicit the key drivers and barriers that influence behaviour by their target audiences**, and by matching their initiatives to these factors.

E2. Training and extension

E2.1 Australian Master TreeGrower Program

The *Australian Master TreeGrower Program* (AMTG) is a national outreach and extension project led by Rowan Reid from the University of Melbourne. Its overall aims are to increase the area of farm forestry and increase landholder participation in designing, managing and evaluating farm forestry systems. AMTG has served as the major avenue for adoption of key JVAP research findings.

Commencing in 1996 with financial support from the Myer Foundation, the AMTG Program has been funded by JVAP, with support from the Natural Heritage Trust and the Murray-Darling Basin Commission in some years (Reid and Stephen 2006). The emphasis placed by JVAP on the development of design principles for farm forestry has been fundamental in supporting the diagnosis, design and evaluation approach adopted by the MTG Program. The JVAP publication *Design principles for Farm Forestry: A guide to assist farmers to decide where to place trees and farm plantations on farms* is provided to all MTG participants.

The AMTG is considered to be the leading farm forestry education program in Australia. It seeks to:

- Facilitate farmers’ involvement in the development of farm forestry systems, provide them with simple and practical approaches to prepare and implement their own farm forestry plans, and encourage them to be more active in regional grower groups and programs
- Help farmers to recognise that governments, industry and community groups have an interest in farmers’ revegetation and forest management activities, and encourage mutually beneficial partnerships that encourage open, strong and sympathetic communication
- Establish regional and national groups of ‘Master Tree Growers’ that provide ongoing support for farmers involved in farm forestry and contribute to regional extension and development programs

In addition to providing regional education courses, AMTG supports farm forestry newsletters, publications, websites, community groups, marketing cooperatives, field days, seminars, and major farm forestry events (Reid and Stephen 2001).

Box E3 Extension case study #1 – Mixed species plantations in Queensland

Dickinson *et al.* (2008) reported on a JVAP project that used field days, seminars, workshops and hard-copy and electronic publications to communicate generic recommendations on species selection and silvicultural management to stakeholders throughout this diverse region.

Thirteen project workshops were conducted in eastern Queensland and northern New South Wales, attended by a total of approximately 400 people. The project culminated in a final workshop (attended by 45 people) where project outcomes and latest mixed-species plantation techniques were presented.

An important role of the workshops was to provide contact details for local extension support and consulting services, so that participants could continue to find information. Over the project duration, the momentum generated was highly-successful in building, maintaining and re-establishing important communication networks.

The project report noted that provision of permanent records in the form of advisory manuals and research publications is the only way to ensure that valuable knowledge and technologies gained by years of experience are not lost. As new technologies are identified, they should be made widely-available through electronic web-based reports, manuals and scientific papers.

AMTG achievements

The 10-year performance of AMTG was reviewed in 2006. The report of the review (Reid and Stephen 2007) notes that the **Program has proven to be an ideal conduit for communication and extension of research and policy, and instrumental in providing guidance and encouragement to farm foresters across Australia.** Other conclusions of the review report were that:

- The program has had an impact on the perceptions, enthusiasm and activity of participants. Farmers believe they are making better farm forestry management decisions and are making a greater commitment to farm forestry as a result of participating in the program. They are also making a greater contribution to farm forestry research, development and extension within their regions, particularly through their participation in regional farm forestry networks supported by the program
- Extension agencies, professionals and industry organisations also appear to be benefiting from their participation in the program as sponsors, partners or specialist presenters. As a result the AMTG Program has been incorporated into the research and development programs of State agencies and non-government organisations promoting development of farm forestry

By 2009, AMTG had reached 1500 participants and 30 partner organisations through 77 regional courses.

In the future, the AMTG Program is expected to have an ongoing role in delivering courses and other activities, extending research and technical information, and facilitating social learning. Recognised needs for the future are for the AMTG Program to provide training and support for regional extension agents, engaging farmers as extension agents in their own communities, and enhanced farmer and stakeholder participation in research and development.

E2.2 Improving communication and extension

JVAP's target audiences are diverse. They have different motives for adopting farm forestry, they have varying levels of understanding about how to go about it, and they prefer to access information in different ways. The challenge for JVAP is to design and deliver its communication and extension activities so that its target audiences make the right farm forestry decisions.

Roth and Molony (2008) reported on a survey to answer the following questions: Who needs information? What type of information do they need and in what form? How aware are they of existing information? How do they currently obtain information? How would they prefer to receive information in the future?

The survey found that a 'very high proportion' of people who were aware of JVAP and had accessed JVAP information had found the information useful. Personal advice, along with trials and demonstrations were 'highly preferred' ways of accessing information. Written forms of information (for example, research reports, newsletters and fact sheets) also rated 'very highly'. Discussion groups were thought to be potentially helpful. Overall though, training courses did not rate very highly, but some were 'still popular'.

The key information needs related to: financial, legal and policy aspects; environmental products, services, credits and training; forestry products and markets; and farming systems including integrating farm forestry for environmental outcomes.

Box E4 Extension case study #2 – Using and managing acacias: adding value

A report by Brown *et al.* (2007) summarised a JVAP-supported workshop in 2006 to maximise the value of research on acacias by collating and disseminating existing information. The workshop included an assessment of progress against research priorities identified in 2002 at the third BIG (Blackwood Industry Group) workshop in New Zealand in 2002 in cooperation with AMIGO (NZ *Acacia Melanoxylon* Interest Group Organisation).

The workshop noted that in the intervening four years, new markets were developed for blackwood and progress had been made in measuring wood-quality variables. Little progress had been made with tree improvement, and progress towards understanding of the expression of colour was minimal. There was a better appreciation of how research can better serve markets for blackwood and other *Acacia* species.

BIG is an attempt to ensure the coordination of existing and new knowledge so that it can best serve what is a small though valuable industry serving niche markets. JVAP has assisted dissemination of this knowledge since 1996 through four workshops, publication of three proceedings, and internet access to them.

BIG is an example of a network in action and might serve as a model for the challenges confronting small sectors that can together make a difference to the sustainability and beneficial use of Australia's resources.

E2.3 Market reports

In the mid-1990s, a lack of independent market information was considered a major impediment to farm forestry in Australia. Farm foresters had complained that the lack of reliable information on log prices diminished the chance of them obtaining a fair price for their products. Prospective growers were asking 'how can I invest in farm forestry when I don't know what the prices are now, let alone in 20 years' time?

In the 1997 *2020 Vision*, the first goal to improve information flows was to provide growers with log specifications and anticipated prices. The Department of Forestry at the Australian National University (ANU) established a regular national market report for farm forestry in 1997, with JVAP funding support. The objective was to contribute towards creating more informed and transparent forest products and input markets in Australia, particularly for small-scale growers.

The *Market Reports* compiled information from the Australian Bureau of Statistics (ABS), the Australian Bureau of Agricultural and Resource Economics (ABARE), State and Territory forest agencies, industry organisations, consultants, a network of informed farm foresters and advisers, and international organisations.

Sixteen editions of the *Market Report* were published between September 1997 and June 2001. In chronological order, topics covered included: structural timber prices; pulp log prices; log and agricultural prices beyond 2000; the cost of tree seedlings and cuttings; stumpage; log exports; the cost of log transport; woodchip markets and prices; trends in sawn wood market; market for forest products in South Korea; market trends in the 1990s; carbon credit markets; rents for plantation land leases; Japanese woodchip import market; stumpage trends in South Australia; firewood market. The *Market Reports* were published quarterly and were included as inserts to publications such as *Australian Forest Grower*, *Agroforestry News* and the *Australian Farm Journal*. They were also available on the internet.

Log specifications

Interpretation of the *Market Reports* was hampered by lack of understanding among potential forest owners as to how logs are defined in the marketplace and the principles which drive these definitions of quality.

A report by James (2001) explained that logs form a hierarchy of quality classes and values based on intended use. From best to worst these were veneer logs, sawlogs and pulplogs. The report added target log specifications for new growers wishing to develop silvicultural regimes to maximise income. For example, native forest sawlogs should be at least 2.4 m long and of at least 25 cm in small end diameter. The logs must be substantially straight, properly 'manufactured' and all branches and large limbs trimmed. Plantation-grown pine sawlogs should be at least 2.4 m long and of at least 15 cm in small end diameter. They should be substantially straight with a minimum deviation of 25% of the small end diameter under bark measured over a 2.4 m length.

An appendix to the James report listed, for each State and for export logs, the main grades and their descriptions applied throughout Australia.

E2.4 Synthesis publications

JVAP has either fully funded or contributed to the production of key publications that were excellent syntheses of research knowledge generated by hundreds of projects managed by JVAP and other organisations. At the time of their release they were 'trailblazers'. Some of these books, that have significantly enhanced extension of farm forestry research outcomes, include:

- ***Design principles for Farm Forestry: A guide to assist farmers to decide where to place trees and farm plantations on farms*** (Abel *et al.* 1997) is an easy-to-read publication synthesising knowledge about key elements of agroforestry systems, and how they could be integrated on-farm to achieve multiple objectives. At the time of its release, *Design Principles* also fulfilled other

important roles, including identification of knowledge gaps requiring further JVAP investment (actioned in the *JVAP R&D Plan 1999-2004*), and as a manual for the *Australian Master TreeGrower Program*

- ***Trees, water and salt: An Australian guide to using trees for healthy catchments and productive farms*** (Stirzaker *et al.* 2001) was written in a period in which the salinity debate had moved from relative obscurity to the front pages of major newspapers. It was the culmination of four years' research by a team of CSIRO and other scientific experts, which brought together and added considerably to the already large body of knowledge. At the time, it was the most up to date, readable and useful book yet published on agroforestry and salinity
- The book guides its target audiences in their quest to develop the most effective approaches in their particular hydrological environment by assisting them in answering: How much of the catchment needs to be planted? What parts of the catchment should be planted? Which planting configurations should be used? How long will it take to see an effect from tree planting? How effective and/or sustainable will different plantation designs be in different parts of the landscape? Which species should be selected and what silvicultural practices should be employed?
- ***Plantations, Farm Forestry and Water: A Discussion Paper*** (O'Loughlin and Nambiar 2001) was a landmark publication that added substantial objectivity and balance to the debate about plantations and water resources, which had intensified during the drought that commenced in south eastern Australia in 2001
- Key conclusions of the paper are: The impacts of plantations, farm forests and water will be greatest in high-rainfall areas; Many recently-established plantations are in areas of moderate rainfall (600-850 mm) where their effects on water flows will be considerably less than those of plantations established in high-rainfall areas; If plantation expansion is mainly centred on moderate rainfall zones (600-850 mm) as it has been historically, its effect on water resources will be far less than that of plantings in higher-rainfall zones; Expansion of plantings into lower-rainfall areas will probably have negligible effect on downstream water resources, but at the local scale, new plantations on cleared land may cause unregulated rivers to revert to the flow patterns they had before the land was cleared
- ***The Farmers Forest: Multipurpose Forestry for Australian Farmers***, (Reid and Stephen 2001) combines the authors' personal experience with knowledge drawn from their work with hundreds of farmers, foresters, researchers, and advisers from across Australia. The book arose out of the *Australian Master TreeGrowers Program* experience that had conducted 38 regional programs over its first five years. Part of what the farmers learn in the AMTG Program is included in the book. The book has three case studies and has chapters on integration, markets,

silviculture, quantity assessment, and economics

- ***Trees for Shelter*** (Cleugh 2003) summarises findings from JVAP's 5-year National Windbreaks Program, and 3-years' subsequent research into the role of wind damage. JVAP launched the National Windbreaks Program in 1993, involving researchers from State Governments, universities and CSIRO. At the time, the Program was considered the most comprehensive study in the world of the effects of windbreaks on crops. Results indicated the benefits of windbreaks in Australia were less than suggested by overseas research, and hence may have disappointed their advocates. Nevertheless the research played a critical role in developing realistic expectations for optimal windbreak designs
- ***Trees and biodiversity*** (Salt *et al.* 2003) is a comprehensive guide, focusing on how farm forestry might be applied to protect and enhance biodiversity in agricultural landscapes. The book originated from a 2002 workshop involving a wide range of scientists and extension officers with experience of farm forestry and revegetation. In contributing to the book, Lindenmayer carried out an extensive review of the scientific literature on biodiversity in commercial plantations (including small woodlots, shelterbelts and mixed-species habitat plantings) and summarised the main points and guidelines. This work is elaborated in Lindenmayer (2009a,c)
- *Trees and biodiversity* examines what was known in 2003 about the biodiversity value of tree plantations, presents a case for why biodiversity conservation is a desirable outcome, and provides a basic framework of understanding for improving the biodiversity value of various forms of farm forestry
- ***Trees for Saline Landscapes*** (Marcar and Crawford 2003) synthesises many years of research results. It focuses on species suitable for temperate and subtropical Australia, since this is where the majority of salt-affected land is currently found and is predicted to develop in the future. Insect pests and their control are dealt with extensively

E2.5 Manuals and guides

JVAP's numerous manuals can assist farmers in deciding whether farm forestry will be worthwhile for them. As a rule, the manuals incorporate, or provide for insertion of, relevant tree growth and financial information. Selected examples are briefly summarised below, and more detail is provided in **Appendix 1**:

Agroforestry Calculator: User Manual (RIRDC Publication 99/154) was an early decision support tool that could be used by farmers to estimate the profitability of best-bet farm forestry projects

The Carbon Farmer Model User Manual (RIRDC Publication 01/060) preceded later carbon accounting tools (e.g. *Carbon Sequestration Predictor*, and the *National Carbon*

Accounting Toolbox) to explore the physical and financial consequences of different assumptions about the productivity and management of plantations, the costs of cultivation and administration, and the price for which the sequestered carbon (as well as for the timber itself) may eventually be traded

Growing Rainforest Timber Trees: A farm forestry manual for north Queensland (RIRDC Publication 03/101) outlines the steps required to successfully establish rainforest timber species, particularly in plantation situations, in the Wet Tropics of north Queensland

Farm Forestry Toolbox Version 5.0: helps growers to manage their trees (RIRDC Publication 07/135) with a computer package enables them to model tree growth and integrate financial and tree products information. *Farm Forestry Toolbox Version 5.1* (unpublished) updates Version 5

Silvicultural Design Support for Farm Forestry (RIRDC Publication 08/094) describes a new model called *AGGRO*, specifically designed for farm forestry applications. It aims to remove some of the uncertainty impeding the adoption of farm forestry, and make it possible for land managers to consider tree growing as an economic part of the farm enterprise

Agroforestry and farm forestry: Support systems to assess the viability of whole-farm and regional agroforestry enterprises (RIRDC Publication 08/097) provides farmers and policy makers with a multi-purpose decision support system that allows comprehensive assessment of the suitability, sustainability and profitability of alternative forestry options in relation to agricultural enterprises

E2.6 Web-based research reports

The majority of JVAP research reports, particularly from projects completed since 2001, are available from RIRDC as internet downloads (<http://www.rirc.gov.au/fullreports/index.html>). These and hard copy reports from earlier projects are also available direct from RIRDC at 15 National Circuit, BARTON ACT 2600, Ph (02) 6271 4100. Over 200 JVAP research reports are now available and more are 'in press'.

E2.7 Conference support

In addition to producing hard copy and web-based books, market reports, manuals and guides and research reports, **JVAP takes a leadership role in farm forestry research through sponsorship and presence at conferences, workshops and meetings.** It also supported some overseas travel that broadens Australia's research base and experience.

E3. Implications

The *Australian Master TreeGrowers Program* (AMTG) has been the major mechanism for face-to-face delivery of JVAP research outcomes. Wider delivery has occurred through production of ANU *Market Reports*, major synthesis

publications, manuals and guides, and research reports, and through sponsorship of conferences, workshops and meetings. JVAP research reports and publications are also available as downloads from the internet and from the JVAP library in Canberra.

However, while JVAP has reached at least 1500 people through the AMTG, and possibly many more, **the overall impact of JVAP's research, extension and training activities on penetrating farm forestry research user markets and influencing farm forestry expansion is unknown.** In hindsight, evaluations that involved baseline surveys of JVAP stakeholders' Knowledge, Attitudes, Skills and Aspirations at the commencement of each 5-year R&D plan, and follow-up surveys on completion of each 5-year period with analyses that discern JVAP's impact, would have been valuable inputs to evolution of the Program. A recent review (Ewing 2009a) has found that there is limited awareness of JVAP amongst many farm forestry stakeholders.

It appears that for people who have adopted farm forestry to-date, it does not have to be profitable in its own right. They are more concerned about landscape, quality of life, and leaving a legacy for future generations, than profit. It is possible (but unproven) that existing JVAP extension and training initiatives are meeting the information and learning needs of this market segment. The establishment of an additional 33,000 ha of farm forests in recent years, excluding managed investment scheme plantations, supports this view. Other landholders who take a more pragmatic approach to on-farm investment, particularly those in broadacre cropping areas, are unlikely to adopt farm forestry in its current forms.

Questions about social issues and training and extension remain, for example:

- how large are JVAP's different user market segments, and what are key factors in their adoption decisions? For example, would demonstrating less risk with higher profits from farm forestry convince the more 'hard-nosed' pragmatists to adopt, or will they never see themselves as farm foresters, just as some cropping specialists will not consider adopting 'less risk – higher return' mixed cropping and livestock systems (Grain and Graze 2008)
- to what extent are proposed short rotation-early return tree crops for carbon sequestration and bio-energy more consistent than traditional farm forestry with cropping specialists' and mixed farmers' values and aspirations? In the event short rotation woody crops become the new 'industrial' plantations, what social issues are likely to arise and how can they be addressed?
- would earlier and more direct engagement of users in research planning and operation result in generation of more highly-adoptable knowledge? How can delivery to and adoption by wider user networks be improved?

F. Future research opportunities



F1 Where have we come from?

When JVAP commenced in 1993, there were two key drivers for its vision of trees and shrubs integrated into agricultural landscapes for multiple purposes. In higher rainfall areas, the key driver was for agroforestry to augment wood supplies from public native forests, many of which were becoming unavailable to the forest industries. In medium to low rainfall areas, the driver was to address salinity, which was rapidly expanding and causing large on-farm and off-farm impacts. However, little was known about which trees would grow where, for what products and benefits, and how best to integrate trees into agricultural systems. Even less had been published. There was little coordination of national research with a farm forestry focus.

F2 Where have we got to?

Over the ensuing 15 years, JVAP covered a lot of territory for a Program with a modest core budget of about \$1M/yr. For much of its life, the emphasis was on addressing impediments to commercial agroforestry and on researching species, products and markets. In its middle and third phases it had a greater focus on addressing salinity in medium to low rainfall areas, and on collating results from multi-disciplinary research into optimal designs for salinity management. It continued its emphasis on the need for commercial products from

agroforestry systems to drive greater adoption. In addition to water management, other issues such as environmental services, carbon sequestration and bioenergy became priorities.

As JVAP progressed, the benefits of agroforestry proved more difficult to demonstrate than first envisaged. There were few obvious win-win situations that favoured integrated farm forestry over industrial plantation forestry. Nevertheless, the community of interest in agroforestry is imaginative, emotional, visionary and passionate. When managed investment scheme plantations are excluded, the area of farm forestry plantations has increased by around 33,000 ha. While not proven, it is highly likely that JVAP, along with its participating partners such as the *Australian Master Tree Grower Program*, the *Australian Low Rainfall Tree Improvement Group*, *SMARTtimbers* and Australian and State government farm forestry programs, has had a large bearing on this result.

F2.1 Ten key messages

JVAP has assembled a vast amount of knowledge synthesised in this report. Ten key messages concerning farm forestry emerged:

1. Except for short-rotation pulpwood, the profitability of 'traditional' farm forestry, including thinning private native forest (PNF), is marginal in higher rainfall areas.

This is mainly due to a lack of early financial returns, for example from prunings, thinnings and markets for environmental services*. In medium to low rainfall areas, 'traditional' farm forestry is for the most part unprofitable. In these areas, there is not only a lack of early financial returns, but also lower growth rates, a lack of processing infrastructure, and greater distances to markets

2. Emerging markets (in carbon sequestration, bioenergy and biofuels⁶) have the potential to profoundly change the profitability of farm forestry. Subject to provisos, carbon 'farming' (through either 'tree crops' dedicated to carbon sequestration or through multi-purpose woody crops), appears to offer significant potential for 'mainstream' farmers to add to and diversify their income streams, and/or mitigate emissions from their livestock and cropping operations. Hence the scale of adoption could be very high. Lessons learned about the social and water impacts of existing industrial plantations in higher rainfall areas need to be applied to future large-scale plantings. Impacts on Australia's food and fibre export markets also need to be considered

3. In addition to the anticipated effects on the profitability of farm forestry from emerging carbon sequestration, bioenergy and biofuels markets, there are encouraging signs that the lack of early financial returns for 'traditional' farm forestry are being overcome by innovative processing technologies that enable high-value products such as appearance grade timber to be produced from short-rotation pulpwood grown in higher rainfall areas and pruned sawlogs grown in medium to low rainfall areas. Hence there is potential for farm foresters to have several income streams from timber, carbon sequestration and biomass production

4. The 38 Mha of private native forests (PNF), especially in higher rainfall areas, have significant potential to augment diminishing hardwood sawlog supplies from public native forests, but good PNF management for production and conservation is being hampered by lack of profitability as well as regulatory arrangements. Enhancing research into the biodiversity outcomes of good silvicultural management, combined with development of metrics to underpin markets in environmental services from PNF (and hence some early returns), will assist in realising their potential

5. JVAP and other programs have greatly enhanced our understanding of the water and salinity management effects of various designs of tree and shrub plantings on farms. Although the research was driven by the paradigm of managing excess water in the landscape, the knowledge has much to offer the new, more complex challenge – how to achieve an optimal balance between recharge control and runoff in landscapes and communities that offer the best prospects for carbon sequestration and biomass plantings

6. There are considerable costs associated with developing workable Market-Based Instruments (MBIs) for farm forestry. MBIs appear to have particular value in three contexts: for PNF management where there are commercial trade-offs associated with meeting community expectations and standards for biodiversity conservation; where off-farm salinity impacts are severe and farm forestry can deliver net benefits in terms of reducing the salt concentration of streams while maintaining desired runoff volumes; and for remnant native vegetation managed primarily for biodiversity conservation outcomes

7. With increasing rainfall predicted for northern Australia in the future, there appears to be significant potential for good returns on investment from research into farm forestry in the wet and dry tropics. Research to-date for cabinet woods, African Mahogany and Sandalwood has provided an encouraging start

8. Although JVAP has supported excellent and influential extension and training initiatives including synthesis publications, grower manuals, decision tools and the *Australian Master TreeGrower Program* (AMTG), the actual effect of these on the expansion of farm forestry is largely unknown. Apart from AMTG course participants, there is limited understanding of the farm forestry-related knowledge, skills, attitudes and aspirations (KASA) of JVAP's target audiences

9. The time, resources and effort of policy makers will continue to be maximised by investing in research to elicit the key drivers and barriers that influence behaviour by their target audiences, and by matching their initiatives to these factors

10. It is critically important to engage key regional interests in consultation and planning for R, D & E and on-ground action, particularly where large scale plantings are proposed. These interests include private forestry committees, agroforestry and farm forestry networks, landcare and other farming groups, regional natural resources management organisations, and local governments

⁶ Environmental services are natural resources management outcomes that are likely to have mainly public sector buyers. They are limited to the domestic context, and notwithstanding many attempts to-date, have not attracted corporate sector interest. Examples are biodiversity conservation and off-farm water quality outcomes from salinity management. On the other hand, carbon sequestration, bioenergy and biofuels have moved beyond the realm of environmental services – they are becoming saleable products, similar to wood, meat and fibre, that have mainly private and corporate sector buyers operating in global markets

F3 Where should we go next?

F3.1 Macro influences

Ewing *et al.* (2009a) identified key developments and changes anticipated for the next five years – and beyond. Briefly summarised, these include:

- **The changing face of agriculture**, with larger holdings but declining profits and extensive drought impacts coupled with a public policy shift from drought assistance to drought preparedness
- **The changing view of the role of reforestation** towards a more diverse range of public perspectives, with its value being weighed against other, sometimes diametrically opposed, resource considerations such as food production capacity and water availability
- **Societal changes**, based on increased awareness of climate change impacts and governments' willingness to take significant action to address them. The proposed carbon pollution reduction scheme (CPRS) provides solid grounds for woody crops to be an important part in Australia's climate change response. However, there are also negative perceptions of reforestation, principally in response to the rapid expansion in industrial plantations over the past decade
- **The emergence of new markets**, which allow woody crops to generate income without incurring costs of harvesting and transport. These markets fundamentally change the traditional 'framework' for evaluating the profitability of forest products and business models. Similarly, the introduction of the CPRS, and complementary instruments such as the Mandatory Renewable Energy Target (MRET), will foster bioenergy projects at least partially reliant on woody feedstock. New markets for sequestered carbon and woody feedstock for bioenergy will attract new corporate investors that will increasingly influence rural landscape transformation

F3.2 Key organisations in farm forestry-related R, D & E

In addition to considering the macro environment, a future woody crop-focused program also needs to consider the agendas of other forestry-related Research, Development and Extension (R, D, & E) organisations and initiatives. These include: the CRC for Forestry; Future Farm Industries CRC; eWater CRC; forestry research by CSIRO, State forest agencies, universities; forestry and wood products research by industry; greenhouse gas and carbon sequestration research, bioenergy research, and oils and extractives research.

Furthermore, a future woody crops R, D & E program should embrace the traditional agricultural industries, which are likely to have an increasing interest in mitigating greenhouse gas emissions from their livestock and cropping enterprises and selling any net surplus carbon credits. Rural

Research and Development Corporations such as Meat & Livestock Australia, Australian Wool Innovation Limited, Grains Research and Development Corporation, and Dairy Australia should be given the opportunity to become partners in a future program.

It appears unlikely that any of the above organisations will take on the role of national sectoral champion for R, D & E to pursue the vision developed by Ewing *et al.* and which this report supports, namely 'Tree crop products and services positioned in agricultural landscapes and systems, optimising economic, social and ecosystem benefits'. Hence the key question in determining research priorities for a future woody crops program, is:

'given the key messages generated by JVAP to-date, their implications for future research, the likely future macro environment, and research agendas under consideration by other organisations, which tree crop issues should JVAP take the lead on?'

F3.3 Priority issues

Taking all these matters into account, this synthesis of JVAP research, the evolution of farm forestry issues, and the likely trajectory of agricultural and natural resource conditions, the priority issues are:

- Tree crops for **carbon sequestration and biomass-related industries**
- **High-value, farm-grown, wood-based industries**, such as short-rotation sawlogs, cabinet timbers in the wet tropics, and timber products in the dry tropics
- The **social trajectories, and relevant knowledge, attitudes, skills and aspirations** of farming and regional communities who may become involved in growing the tree crops in 1 and 2
- **Integrating knowledge** from 1, 2 and 3 in holistic assessments of the social, economic, water, biodiversity and agricultural export outcomes of various carbon sequestration, biomass-related and high-value wood-based industry scenarios and designs
- Unlocking the potential of **private native forests** (PNF) through improved metrics and Market-Based Instruments
- **Knowledge sharing** between research program investors and managers, researchers, and research users, to improve the direction and operation of research projects, and maximise adoption of outcomes.

As a successful extension and adoption initiative, the AMTG brand and logo should be retained as the trusted and credible deliverer of woody crops knowledge through face-to-face learning activities. The program could be enhanced by augmenting existing training courses with less formal learning opportunities and products.

Ewing *et al.* (2009b) have prepared a draft *Five-Year R&D Plan for a Woody Crops on Farms Program*, which proposes three strands or themes:

- **Growing the resource base**
- **Delivery of innovative production and ecosystem benefits**
- **Communicating the knowledge base**

Although the terminology is slightly different, their proposed themes do provide for action to address the priorities listed above. In addition, a draft *Business Case for 2010-2015* has been produced, seeking in-principle support from potential investors in a new program.

Although at the time of writing this report (February 2009) a successor to JVAP had not been decided, there is strong evidence in support of such a program, from many quarters. It is envisaged that this report, the draft *Business Proposal*, and the draft *Woody Crops on Farm Program*, will be valuable contributions to informing that decision.



Appendix 1

Decision support tools and resource inventories (In chronological order of publication)

Agroforestry Calculator: User Manual

RIRDC Publication No. 99/154

The Agroforestry Calculator is a user-friendly spreadsheet-based tool for farmers to estimate the profitability of best-bet agroforestry projects. Users select a redefined forestry enterprise that already has production, cost and management information associated with it. They then enter: paddock name and area; start year; discount rate; gross margin per hectare for agriculture at the project site; area to be revegetated; and the length and unit cost of fencing.

The software allows comparisons between do-it-yourself agroforestry, annuity arrangements, and cropshare joint venture schemes. There is also an option to include expected benefits from reduced land degradation, calculated as a change in productive area within the paddock over time (*Shaping the Future with Farm Forestry*, Issue 5, September 1999)

A Bibliography of Plantation Hardwood and Farm Forestry Silviculture Research Trials in Australia

RIRDC Publication No. 01/101

The Bibliography, an output from the National Farm Forestry Silviculture project, was devised to address the information needs of silviculture researchers and farm foresters. The project targeted silvicultural experiments on native species in plantations and species grown in farm forestry situations (e.g. wide-spaced trees, low rainfall pine).

The Bibliography targets publications which report on silviculture research with native tree species in Australian plantations. It includes eucalypts, native pines, rainforest cabinet species, and native species used in saline site rehabilitation. Trials with *Pinus* species are not generally included in the Bibliography.

Silviculture is defined as field management of trees, including: site preparation; tree protection; fertilisation; weed control; herbicide susceptibility; thinning and pruning.

A silviculture experiment intentionally compares at least two different management treatments in a controlled, replicated and pre-determined manner. The bibliography targets papers and reports which describe experimental design, site, and/or growth data from trials. It also presents some reports with growth data from farm forestry plantings with the potential to be grown for wood and other production values.

Bioenergy Atlas of Australia

RIRDC Publication No. 02/137

The online Bioenergy Atlas of Australia (http://www.brs.gov.au/bioenergy_atlas/) is a tool to assist in planning an emerging bioenergy industry. It brings together the best available data and information – on existing and potential resources, industry and infrastructure – and presents this using state-of-the-art online Geographical Information System (GIS) technology.

The Atlas provides availability and accessibility of information on existing and potential bioenergy resources in Australia. It has two main components: a geographic information system (GIS) that provides online mapping and query capability; and a decision support system (DSS) to perform pre-determined analyses.

A user can identify the location and extent of bioenergy resources that meet specified criteria using the DSS, for example processing residues within 50 km of major roads and population centres. In addition to the national GIS and DSS, more detailed information (where available) is provided for the Lachlan and Goulburn-Broken catchments of south-eastern Australia.

Growing Rainforest Timber Trees: A farm forestry manual for north Queensland

RIRDC Publication No. 03/101

This manual is one in a series which aims to provide practical guidance for people wishing to establish farm forestry projects. It outlines the steps to successfully establish rainforest timber species, particularly in plantation situations, in the Wet Tropics of north Queensland. It was written for land managers (including farmers) and intermediaries such as farm forestry or agribusiness advisers.

The manual discusses what is known about growing native rainforest species on farms, the planning issues that growers need to address, and the trees' requirements for successful establishment and early plantation management.

The manual is general in nature because the environment of north Queensland varies from one region to another. However it describes general principles that can be applied to different sites and illustrates the management decisions involved, using case studies based on north Queensland research. A case study on a north Queensland mixed species plantation demonstrates site-specific issues and the management decisions adopted to suit the site.

The manual also has a list of publications with additional information.

Useful Databases and Websites on Agroforestry and Farm Forestry

RIRDC Publication No. 04/061

This publication provides a list of useful databases and online indexes of publications, Australian websites, and international websites with research and research-related information on agroforestry and farm forestry.

This list, together with the *Farm Forestry and Agroforestry Reference Library (FFARL)* database, provides farm forestry practitioners, extension officers and researchers with a good starting point for location information relevant to agroforestry and farm forestry, and identifying the research that has been completed.

Guide to using the Farm Forestry and Agroforestry Reference Library Database

RIRDC Publication No. 04/062

The Guide outlines the contents of the database, database user instructions, and keywords used in the database.

The *FFARL* database contains references to publications, non-published reports, and research projects on farm forestry and agroforestry in Australia. The database contains over 5000 citations of publications and research projects on agroforestry and farm forestry in Australia. It provides reference details, where to obtain the publication, keywords, and sometimes the text of abstracts or summaries of publications.

A wide range of farm forestry and agroforestry topics is covered, including social, economic, silvicultural and other research, but generally not non-commercial tree planting or industrial-scale plantations, or farm forestry and agroforestry outside Australia.

Information Availability and Needs in Agroforestry

RIRDC Publication No. 04/063

This publication discusses development and content of the *Farm Forestry and Agroforestry Reference Library (FFARL)* database. Much of the existing research and research-related information was reported in conference papers, and non-refereed journal articles and reports, but these papers and articles were often not included in existing databases, which included refereed journal papers. It was therefore decided that the *FFARL* database should include conference papers, non-refereed journal articles and reports, providing a complementary resource to existing databases.

Modelling the Potential Productivity of Commercial Farm Forestry Species

RIRDC Publication No. 05/175

This report outlines the prediction of productivity of several key farm forestry species, using available data and three modelling approaches. Generalised growth of five species

in response to climate and soils was modelled, and mapped for three species. The models have since been used for other projects.

Tree growth, climate and soils data was collected from a wide range of farm forestry sites across south-eastern mainland Australia. Over 200 plots growing Spotted Gum, Blue Gum, Flooded Gum, Sydney Blue Gum and River Red Gum at more than 80 locations were assessed, including both irrigated and rainfed sites.

Analyses extended assessments of plantation potential into low rainfall areas which are a high priority for farm forestry development. The analyses successfully indicated broad patterns of productivity for the three target species. More maps were prepared for particular regions, such as the Lachlan catchment, for use by extension staff.

An Improved Online Bioenergy Atlas of Australia

RIRDC Publication No. 07/041

There are opportunities for bioenergy in Australia, and a need to improve the availability of information for researchers, policy, planners and potential investors. The new and improved Bioenergy Atlas incorporates more up-to-date data and has other enhancements. It is now easier to create maps online with improved quality and to make a map for selected themes and regions. Maps can be customised and queries performed using the Geographic Information System (GIS), to incorporate a choice of data.

New data compiled for inclusion in the Atlas includes the extent and type of forest, existing plantations, and the potential distribution on plantations of selected tree species. Data on the location of renewable energy plants and biomass database sample sites was added, along with updated data for wood processing facilities.

Suggestions on how to improve the Atlas were sought from industry, researchers, government and other users through newsletters, an online survey and face-to-face discussions or phone interviews.

Biofuel Database: A database of energy-related characteristics for Australian biomass

RIRDC Publication No. 07/064

There is increasing interest in renewable energy supplies with a lower carbon footprint, to address global warming and new industry development.

The database covers important fuel characteristics of 118 Australian biomass types sampled, including a number of low rainfall species. In collecting samples, particular relevance was placed on harvesting operations as close as possible to the processing site.

The database contains relatively simple-to-use information such as calorific value to enable project proponents to draw

conclusions as to likely plant capacity and annual output. The information also provides a guide to growers of energy crops as to the particular characteristics to be enhanced, or avoided, under growing conditions.

It also contains much more detailed information for engineers and designers concerning possible fouling, slagging and corrosion propensity, and devolatilisation and char burn-off characteristics under gasification conditions.

It is noted that prior to any plant proceeding, project developers must carry out additional testing on the proposed fuel, as fuel properties do tend to vary from season to season, region to region, and due to sampling irregularities.

Native Vegetation Data Sets on Freehold Lands within NSW: An audit

RIRDC Publication No. 07/083

Regional NRM organisations, planners and forest managers use maps and other vegetation information to understand and manage forest resources for a range of purposes. The vegetation information is prepared by a range of organisations, often with varying vegetation measures and descriptors. Metadata statements describing these data are the key to searching for available maps and data.

A vegetation metadata statement is a brief description or summary of the vegetation data and maps that can be accessed at a particular source. This summary information should be provided for all data sets, but is generally not presented consistently between agencies, making it hard to search.

This report (07/083) lists and describes fifty-five data sets, using 13 data fields and outlines public access to them. The mapped regions span much of New South Wales.

The report also recommends key data fields to include in future vegetation metadata statements to assist public search and access. The project also catalogued all the data sets and stored them for access via the NSW Natural Resource Atlas web site.

Farm Forestry Toolbox Version 5.0: Helping Australian growers to manage their trees

RIRDC Publication No. 07/135

A wide range of eucalypts and conifers provide commercial wood products in Australia. Taper and growth models for these species are important in evaluating regional options for species, regime and products, and can be used to analyse site-specific tree measurement data to aid in silvicultural management. However, farm foresters have had very limited access to these models, and many models also require integration into a decision support system to be of practical and widespread use.

The Farm Forestry Toolbox is a computer package containing user-friendly tools that help forest growers to better handle

the wide range of issues in growing trees successfully. Version 5 of the Toolbox provides simple conversion tools, as well as more sophisticated tools that now incorporate newly-available regional tree growth models. These will assist the grower to model tree growth and integrate financial and tree products information. The Toolbox also includes assistance with area surveying and mapping and identifying tree pest and disease problems.

TREDAT: A database for tree growth in Australia

TREDAT was developed by the Australian Tree Seed Centre of CSIRO in collaboration with the Queensland Forestry Research Institute to link farm forestry trial results for mainly Australian tree species with site characteristics (climate and soil) and management factors (such as tree spacing and use of fertilisers).

In the mid 1990s, JVAP supported projects to identify important tree growth trials in south-eastern Australia, compile species/provenance performance data, and incorporate the data into the CSIRO Multi-Purpose Tree Database and TREDAT (RIRDC Research Compendium 1997).

A search of the TREDAT database for Australian trials with a minimum age of three years resulted in an extract of about 3000 lines of data covering some 100 sites and 180 tree species. These sites covered an annual rainfall range of 350-1800 mm. Measurement age ranged from 3 to 14 years. The Commercial Environmental Forestry project enhanced TREDAT by including annual average climatic information for each site, as well as the interpolated actual climate for the growth period.

Guidelines for Regional Private Native Forest Inventory

RIRDC Publication No. 07/072

Privately-owned native forests represent the largest category of native forests in Australia. Information on the extent, composition, management and condition of these forests is important to assist planning and management at local, regional and national levels. Adoption of more consistent methods between organisations that undertake regional mapping and inventory of private native forests will lead to better data for assessment of the area of private native forest, regional wood supply, conservation issues, and reporting on sustainability criteria and other benefits.

These guidelines describe:

- Principles, general procedures and minimum standards
- The outputs required, for example maps and reports showing forest location, age classes or stand structure, harvestable and restricted sites, timber and non-timber values, roads and other infrastructure

Silvicultural Design Support for Farm Forestry
RIRDC Publication No. 08/094

Silviculture models currently used in industrial forestry are not very helpful in agroforestry because many of the inherent assumptions do not apply to common situations.

This report describes a new model called AGGRO, specifically designed for farm forestry applications. It provides indicative yields for a range of farm forestry scenarios. It is informed by the many valuable silvicultural experiments conducted in Australia, and passes this wealth of information on to small growers. It aims to remove some of the uncertainty impeding the adoption of farm forestry, and make it possible for land managers to consider tree growing as an economic part of the farm enterprise.

Agroforestry and Farm Forestry: Support systems to assess the viability of whole-farm and regional agroforestry enterprises

RIRDC Publication No. 08/097

This report discusses research in the eastern Darling Downs and the northern tablelands of NSW to provide farmers and policy makers with a multi-purpose decision support system for comprehensive assessment of the suitability, sustainability and profitability of alternative forestry options in relation to agricultural enterprises. The report covers:

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

Farm Forestry Area and Resources in Australia

RIRDC Publication No. 08/104

The area of farm forestry continues to grow, however information to support and inform decision makers on progress has not kept up. This report updates information on the extent and nature of farm forestry and agroforestry across Australia. Farm forestry is defined to include plantations on farms (including agroforestry plantations such as mallees), private native forests (PNF), and woody fodder crops.

The key finding of the report is that there is an estimated 155,000 ha of farm forestry plantations in Australia which has expanded from an estimated 67,000 ha when last assessed in 2001. Areas of PNF are more difficult to estimate due to a lack of information but PNF provides scope for further development of farm forestry. Areas of woody fodder crops are estimated to be around 400,000-500,000 ha.

Management Guidelines for Private Native Forests

RIRDC Publication No. 08/160

These guidelines consider the planning, implementation and marketing decisions – recommended and required – to sustainably manage PNF either at property level or as part of the regional network of timber production and conservation.

Specific case studies for (a) foothill mixed species forests of the south-east of Victoria and New South Wales, and (b) for dry eucalypt forest of south-east Queensland, are presented as examples of more intensively-managed forests and the biological, economic and legislative factors which affect their successful and sustainable utilisation for wood products.

The guidelines cover: property management planning; silviculture to improve forest condition and value; case studies – illustrating the use of silvicultural strategies to increase wood production – particularly of sawlogs; protecting soil and water, biodiversity and aesthetics; product recognition; forest inventory – collecting the appropriate forest information; the market place; harvesting and transport; and detailed forest management planning.

Appendix 2

Tree and shrub species

Eucalypts

Araluen Gum	<i>Eucalyptus kartzoffiana</i>
Bimble Box	<i>Eucalyptus populnea</i>
Blackbutt	<i>Eucalyptus patens</i>
Blue Gum	<i>Eucalyptus globulus</i>
Blue Mallee	<i>Eucalyptus polybractea</i>
Brown Mallett	<i>Eucalyptus astringens</i>
Dunns White Gum	<i>Eucalyptus dunii</i>
Flooded Gum	<i>Eucalyptus grandis</i>
Gympie Messmate	<i>Eucalyptus cloeziana</i>
Jarra	<i>Eucalyptus marginata</i>
Lemon Scented Gum	<i>Eucalyptus citriodora</i>
Manna Gum	<i>Eucalyptus viminalis</i>
Narrow Leafed Ironbark	<i>Eucalyptus drepanophylla</i>
Oil Mallee	<i>Eucalyptus loxophleba</i>
Queensland Yellow jacket	<i>Eucalyptus similis</i>
Red Ironbark	<i>Eucalyptus sideroxylon</i>
Red Mahogany	<i>Eucalyptus resinifera</i> , <i>E. pellita</i>
River Red Gum	<i>Eucalyptus camaldulensis</i>
Sugar Gum	<i>Eucalyptus cladocalyx</i>
Swamp Yate	<i>Eucalyptus occidentalis</i>
Sydney Blue Gum	<i>Eucalyptus saligna</i>
White Mahogany	<i>Eucalyptus acmenoides</i> , <i>E. umbra</i>
White Mountain Ash	<i>Eucalyptus oreades</i>
White Stringybark	<i>Eucalyptus eugenoides</i>
Yellow Gum	<i>Eucalyptus leucoxylon</i>
York Gum	<i>Eucalyptus loxophleba</i>

Pines

Aleppo Pine	<i>Pinus halapensis</i>
Brutian Pine	<i>Pinus brutia</i>
Canary Island Pine	<i>Pinus canaryensis</i>
Hoop Pine	<i>Araucaria cunninghamii</i>
Maritime Pine	<i>Pinus pinaster</i>
Radiata Pine	<i>Pinus radiata</i>
White Cypress Pine	<i>Callitris glauca</i>

Acacias

Black Wattle	<i>Acacia mearnsii</i> , <i>Acacia decurrens</i>
Blackwood	<i>Acacia melanoxylon</i>
Brown Salwood	<i>Acacia aulacocarpa</i>
Gidgee	<i>Acacia cambegei</i>
Hickory Wattle	<i>Acacia implexa</i>
Lancewood	<i>Acacia shirleyi</i>
Mulga	<i>Acacia aneura</i>
Northern Silver Wattle	<i>Acacia leucoclada</i>

Orange Wattle	<i>Acacia saligna</i>
Prickly Acacia	<i>Acacia nilotica</i>
Soft Wattle	<i>Acacia fulva</i>
Stringybark Wattle	<i>Acacia linearifolia</i>
Swamp Wattle	<i>Acacia retinodes</i>
Thick Podded Salwood	<i>Acacia crassicarpa</i>

Tropical and sub-tropical species (other than eucalypts, pines and acacias)

African mahogany	<i>Khaya senegalensis</i>
Albizzia	<i>Albizzia lebbek</i>
Blackbean	<i>Castanospermum australe</i>
Blue Quandong	<i>Alaocarpus grandis</i>
Burmese Teak	<i>Tectona grandis</i>
Candle Nut	<i>Aleurites moluccana</i>
Cudgerie	<i>Flindersia schottiana</i>
Indian Sandalwood	<i>Santalum album</i>
Kakadu Plum	<i>Terminalia ferdinandiana</i>
Leichhardt Tree	<i>Nauclea orientalis</i>
Leucaena	<i>Leucaena leucocephala</i>
Lotus Lily	<i>Nelumbo nucifera</i>
Peach Cedar	<i>Trema orientalis</i>
Queensland maple	<i>Flindersia brayleyana</i>
River Oak	<i>Casuarina cunninghamiana</i>
Sandalwood	<i>Santalum spp</i>
Silk Cotton Tree	<i>Bombax ceiba</i>
Silky Oak	<i>Grevillea robusta</i>
Silver Ash	<i>Flindersia schottiana</i>
White Beech	<i>Gmelina fasciculiflora</i> , <i>G. leichhardtii</i> , <i>G. dalrympleana</i>
White Cedar	<i>Melia azedarach</i>
Yellow Wood	<i>Flindersia xanthoxyla</i>

Other

Beefwood	<i>Grevillea striata</i>
Carob	<i>Ceratonia siliqua</i>
Desert Oak	<i>Casuarina decaisneana</i>
Indian Sandalwood	<i>Santalum album</i>
Jojoba	<i>Simmondsia chinensis</i>
Paperbark	<i>Melaleuca spp</i>
Red Lancewood	<i>Archidendropsis basaltica</i>
Sandalbox	<i>Eremophila mitchellii</i>
Saltbush	<i>Atriplex spp</i> , <i>Rhagodia spp</i>
Spotted Gum	<i>Corymbia maculata</i>
Swamp Oak	<i>Casuarina obesa</i> , <i>C. glauca</i>
Tagasaste	<i>Chamaecytisus proliferus</i>

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Fifteen Years of the Joint Venture Agroforestry Program

Foundation research for Australia's tree crop revolution

by John Powell

RIRDC Pub. No. 09/063

This report was commissioned by JVAP to increase public awareness of the role, value and potential of farm forestry, and to highlight the significance of JVAP's research achievements over the past 15 years

The report synthesises the knowledge generated by 15 years and about \$29 million dollars in investment in farm forestry research, development and extension. The report covers four main agroforestry topics: *Farm forestry for multiple benefits; Products and markets; Public policy, investment options, and grower initiatives; and Socio-economic issues, training and extension.* Importantly, this report interprets the relevance of the knowledge for today's issues and identifies future woody crop research, development and extension priorities.

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Contact RIRDC:

Level 2

15 National Circuit

Barton ACT 2600

PO Box 4776

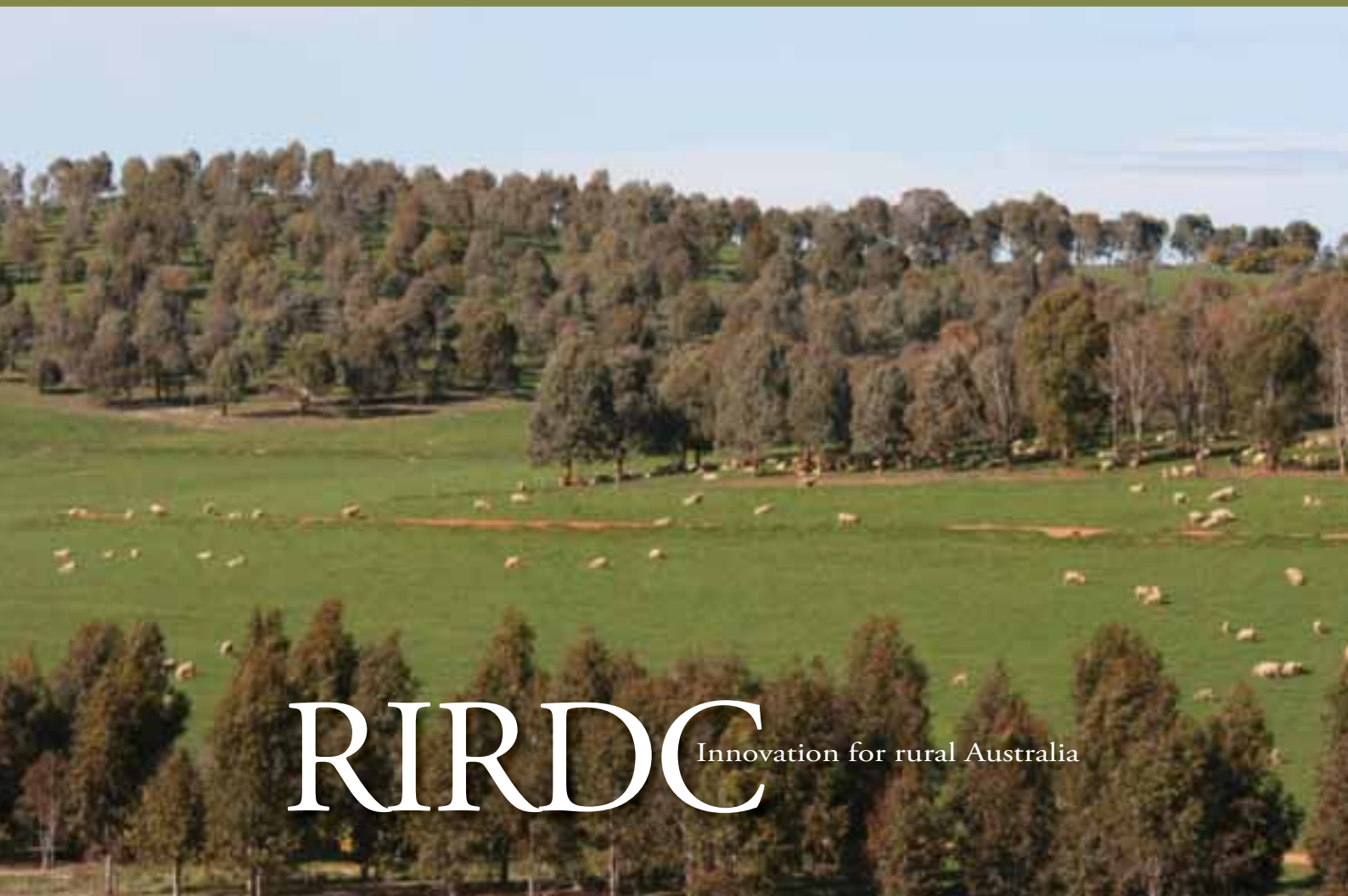
Kingston ACT 2604

Ph: 02 6271 4100

Fax: 02 6271 4199

Email: rirdc@rirdc.gov.au

web: www.rirdc.gov.au



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