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Bioenergy from Native Agroforestry

— An assessment of its potential in the NSW Central Tablelands —

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An assessment of its potential in the NSW Central Tablelands

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Foreword

This research was undertaken to assess whether farm-based agroforestry has the potential to generate the critical volume of biomass needed for a regional bioenergy industry in the Central Tablelands of New South Wales (NSW). The focus was on the attitudes of different types of landholders to the opportunities and risks of this new industry.

This research will better inform government, industry groups, and rural communities when considering the potential of bioenergy as both a new source of low-carbon power generation and as a transport fuel. By understanding the concerns and interests of landholders (the potential producers of the biomass), appropriate incentives and regulatory frameworks could be established that will encourage the long-term investment needed to develop a sustainable bioenergy industry – one that will also improve the economic, social and environmental conditions of rural Australia.

One of the key findings of this research is that, while farm-based agroforestry linked to a regional bioenergy industry has clear economic potential, there is considerable mistrust of government policy in this area and the stability of market returns from biomass production is uncertain. Biomass production is considered risky given the long-term nature of the investment, in terms of establishing forestry plantations and changing land use.

A second significant finding is the different approaches that can be anticipated by the various landholding groups across the region. The traditional landholders with large properties, mostly involved in grazing and dependent solely on farm-based income, have significantly different attitudes compared to the smaller 'blockies' and hobby farmers who make up an equally significant group. There were also subregional groups that exhibited differences in attitude and priorities in terms of the amount and quality of land they were prepared to allocate to agroforestry, and hence the anticipated output in terms of biomass production.

Given the requirement that a regional bioenergy industry must have a stable feedstock of biomass supplied within a suitable radius of any electricity or biofuel production centre, it is essential that the biomass production capacity of any region is critically reviewed in conjunction with local farming communities. Also, government policies to support such an industry should consider a wide range of economic, social and environmental factors affecting both farmers and rural communities. It was made clear from this research that, given the complexity of factors involved in bioenergy production, market demand alone would not be sufficient to drive the establishment of a sustainable bioenergy industry in the Central Tablelands of NSW. One of the recommendations of this report is for the establishment of an independent government/industry agency to investigate and oversee the regulatory and financial structures needed for a farm-based agroforestry/bioenergy industry in rural Australia.

This project is supported by funding from the Australian Government Department of Agriculture, Fisheries and Forestry under its Forest Industries Climate Change Research Fund program and the Rural Industries Research and Development Corporation. It was undertaken in conjunction with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and New South Wales Department of Primary Industries (NSW DPI). This grant was augmented by in-kind support from the Institute of Environmental Studies at the University of NSW (IES UNSW); the Blue Mountains World Heritage Institute (BMWHI); the Future of Australia's Threatened Ecosystems (FATE) program at the University of Sydney; the Hawkesbury, Nepean, Central West and the Lachlan Catchment Management Authorities (CMAs); along with the Central Tablelands councils at Oberon, Lithgow and Mudgee.

This report is an addition to RIRDC's diverse range of over 2000 research publications and it forms part of our Bioenergy, Bioproducts and Energy Research and Development (R&D) program, which aims to meet Australia's research and development needs for the development of sustainable and profitable bioenergy and bioproducts industries and to develop an energy cross sectoral R&D plan.

Most of RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by telephoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation

About the Authors

Associate Professor John Merson, a Principal Investigator on the project, is the Director of the Institute of Environmental Studies at the University of New South Wales (UNSW), and a Director on the Board of the Blue Mountains World Heritage Institute (BMWHI). John is also the coordinator of the post graduate research program in Environmental Policy & Management at the UNSW.

Peter Ampt, a Principal Investigator on the project, is a lecturer in natural resource management in the Faculty of Agriculture, Food & Natural Resources at the University of Sydney (USYD) and manager of the Future of Australia's Threatened Ecosystems (FATE) program.

Dr Crelis Rammelt, the Project Manager, is a lecturer and research supervisor at the Institute of Environmental Studies at UNSW and a contract Project Manager for BMWHI. Crelis is also the co-founder of the Arsenic Mitigation Research Foundation (AMRF), a Dutch–Bangladeshi action research organisation educating and working directly with communities in rural Bangladesh.

Alex Baumber, the Research Coordinator on the project, is currently pursuing his PhD at the Institute of Environmental Studies at UNSW, supervised by both John Merson and Peter Ampt. Alex's PhD is looking at ways in which bioenergy land-uses can provide incentives to revegetate degraded landscapes. His work on the project will double as a case study for his thesis.

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Abbreviations

BMWHI - Blue Mountains World Heritage Institute

CMA - Catchment Management Authority

CPRS - Carbon Pollution Reduction Scheme

CSIRO - Commonwealth Scientific and Industrial Research Organisation

DAFF - Department of Agriculture, Fisheries and Forestry

FATE - Future of Australia’s Threatened Ecosystems

GBMWHA - Greater Blue Mountains World Heritage Area

GIS - Geographic Information System

NSW DPI – New South Wales Department of Primary Industries

IES - Institute of Environmental Studies

LGA - Local Government Area

LGC - Large-scale Generation Certificate

LRET - Large-scale Renewable Energy Target

MIS - Managed Investment Schemes

NRM - Natural Resource Management

NSW - New South Wales

PRA - Participatory Rural Appraisal

PVP - Property Vegetation Plans

REC - Renewable Energy Certificate

RET - Renewable Energy Target

UNSW - University of New South Wales

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Executive Summary

What the report is about

This report presents the findings of a research project entitled *Potential new bioenergy agroforestry systems for the NSW Central Tablelands,* coordinated by the Institute of Environmental Studies (IES) and the Blue Mountains World Heritage Institute (BMWHI), co-located at the University of New South Wales (UNSW). The report describes how bioenergy feedstocks could be generated using agroforestry in the Central Tablelands region of New South Wales (NSW) based upon information from engagement with stakeholders, a survey of landholder attitudes and Geographic Information System (GIS) analysis. The report also includes recommendations for future planning, as well as details of how the work undertaken in this case study area can be applied to other regions.

Throughout this report, we clarify the linkages with two other projects led by Commonwealth Scientific and Industrial Research Organisation (CSIRO) and New South Wales Department of Primary Industries (NSW DPI) (see Appendix 1: Joint Summary). The UNSW/BMWHI project and NSW DPI project were part of a larger project entitled *'Adapting and mitigating climate change through the sustainable production and use of forest biomass for commercial scale bioenergy production'* for the Rural Industries Research and Development Corporation (RIRDC), funded by the Department of Agriculture, Fisheries and Forestry (DAFF).

The UNSW/BMWHI project currently includes two Phases:

- Phase 1 (September 2010 – May 2011): This phase was funded by DAFF and consisted of three stages: (i) stakeholder engagement and data collection, (ii) assessment and modelling, and (iii) social analysis and planning.

- Phase 2 (July 2011 – December 2011): This phase will commence after the end of the DAFF funding period and will be funded by RIRDC. This will involve returning to local stakeholders for a workshop around the results of Phase 1 and around the design of a business model.

This report presents the results of Phase 1.

Who is the report targeted at?

Regional and state land management agencies could use the findings of this study to develop programs that harness economic potential of bioenergy to deliver better regional Natural Resource Management (NRM) and development outcomes. The collaborative investment models explored through the project may also prove useful in shifting NRM investment from a single-property focus to a landscape-scale approach.

The report will also be of use to stakeholders in existing local industries such as saw-milling, electricity generation, furniture-making and other value-adding forestry-based enterprises. These stakeholders are critical to understanding the feasibility of bioenergy options and implementing them. They have access to existing biomass resources and are best placed to integrate bioenergy ventures into their existing businesses, find skilled workers and invest in the development of new facilities. Bioenergy industry participants are also well placed to capitalise on this research, both in order to establish a presence in the region, and to utilise the models developed in other areas.

Landholders are also a key target audience; there is strong local interest in alternative land-uses that may be more profitable and environmentally acceptable than current forestry and grazing activities.

Where are the relevant stakeholders located in Australia?

The study area is the Central Tablelands in NSW (33º 40’ S, 149º 50’ E), broadly defined in this case as the three Local Government Areas (LGAs) of Oberon, Lithgow and Mid-Western (based around Mudgee). The area covers parts of three Catchment Management Authority (CMA) areas: Hawkesbury-Nepean, Central West and Lachlan. The area is mostly included in the federal electorate of Macquarie, but overlaps with Parkes and other electorates (Map 1 presents the case study area).

This region provides an ideal case study from which to build a transferable regional assessment and development tool due to its combination of existing forestry industry resources, potential for new farm forestry development, proximity to major energy markets, and previous studies on land use and livelihood options in the region. The proximity of the study area to a World Heritage site and buffer zone also makes it a valuable study in terms of shifting land use towards more biodiversity-friendly outcomes.

Background

Regional studies are essential for the future development of a bioenergy industry in Australia, but a national model for undertaking such studies is currently lacking. Growth in the bioenergy sector has been largely driven by national and global-scale objectives, such as the desire to reduce dependency on non-renewable and emission-intensive fossil fuels. At the same time, many regions such as the Central Tablelands are experiencing land degradation, declining viability of traditional farming and forestry activities, and increased threats to biodiversity and livelihoods due to climate change. Opportunities exist in this and other regions for new agroforestry industries for generating bioenergy as well as other products derived from plantations that employ a mixture of species and generate multiple resources. These changes in land use have the potential to create new rural industries with economic, social and environmental benefits at a variety of scales.

Aims/objectives

The goal was to assess the potential for agroforestry based around bioenergy production to form a new sustainable land use option in the Central Tablelands of NSW. In particular, the project aimed to answer the following research questions:

1. What tree crops and bioenergy technologies might be viable in the case study region?
2. What potential economic and social benefits might a bioenergy-based agroforestry industry provide?
3. How might the widespread uptake of agroforestry for bioenergy contribute to landscape-scale natural resource management goals?
4. What incentives and barriers exist for the uptake of such land uses, and what policy measures could be employed to promote and guide them?

We hope that by seeking answers to these questions the project has generated knowledge and insights that will be relevant for landholders, investors, regional NRM and investment and planning bodies, and industry participants involved in the bioenergy and forestry sectors.

Methods used

This project followed a ‘What? So what? Now what?’ reflection process. This process describes key basic facts, analyses and evaluates the data, and synthesises the information into usable knowledge. The process included the following tasks:

1. Participatory Rural Appraisal (PRA) with a range of interviews and workshops;
2. Landholder Survey to quantify some of the findings from the PRA;
3. Spatial Analysis through Geographic Information System (GIS) modelling to generate agroforestry/bioenergy scenarios in combination with PRA and survey results.

Results from these three tasks have been integrated and included in the Discussion of Results, Implications and Recommendations sections of the report.

Participatory Rural Appraisal

We started by searching for the key factors involved in agroforestry/bioenergy systems, and for people's perspectives on this. This task included identifying and consulting with local stakeholders, and collecting data on existing point-source biomass resources, current land-uses, land values, potential options for bioenergy cropping and options for co-products.

Consultations included meetings with CMA and council partners as well as other industry, environmental and governmental groups. We conducted a Participatory Rural Appraisal (PRA), which involved interviews conducted over three days by a team of interviewers, followed by a stakeholder workshop to review the information gathered. Results were compiled into a report and fed back to the project partners and stakeholders. The bioenergy and agroforestry options were then assessed against the economic, social and environmental goals of key stakeholders, initially during the PRA, and then later through the survey.

We also collected data from local councils, local industry and NSW DPI including GIS maps and databases on current land use, land values, land capability and zoning. These data were analysed as part of the next two tasks. CSIRO was involved in this process to ensure that the knowledge generated by UNSW and its partners allowed them to clarify assumptions in their modelling work.

Landholder Survey

The purpose of the landholder survey was to assess the extent to which the identified views emerging from the research so far were representative of the whole region, or whether they varied for sub-regions. This contributed to the development of regional agroforestry/bioenergy scenarios as part of the next task. A survey was prepared for a random sample of landholders across the different council areas. The survey questions covered a range of social, economic and environmental issues and helped quantify some of the key factors emerging from the PRA.

Spatial Analysis

Part of the survey data and a range of GIS analyses were used to assess the areas most suitable for new agroforestry land uses. An ArcGIS^{TM} model was developed that can query a range of possible scenarios for each sub-region and output new layers showing the area within each sub-region that meets prescribed criteria. The relevant results from this work were passed on to CSIRO for their modelling of regional biomass supplies. This was done to ensure that their models could account for key issues and objectives identified by stakeholders. Other data on social and environmental issues raised by stakeholders that was not directly incorporated into CSIRO's modelling was further analysed in this project.

Discussion of results

Findings from the three tasks were integrated to address the four research questions posed under Aims/objectives. A range of native agroforestry species with potential for bioenergy emerged from the research, drawing on both stakeholder recommendations and previous studies. A mixture of plantation designs (i.e. blocks and strips) was most preferred by surveyed landholders, as was a mixture of rotations for both bioenergy and higher-value timber products. Electricity generation appears more promising than liquid biofuels in the near future, although increases in the price of Renewable Energy Certificates (REC) and/or the introduction of a carbon price will be required to make this viable.

Amongst both commercial graziers and lifestyle/hobby farmers, the potential environmental benefits of agroforestry were ranked higher than the economic and social benefits. Around half of the surveyed landholders said that in order to take up agroforestry, they would require a return greater than current land use returns. The other half said they would accept the same return or a lesser return depending on environmental co-benefits or other factors. This latter group could represent an opportunity for early adoption of bioenergy-based agroforestry with lower returns but higher environmental benefits.

The survey results showed that potentially the greatest environmental benefits from agroforestry would be windbreaks, habitat for wildlife and birds, salinity mitigation and protection against erosion. The spatial analysis revealed a number of areas where agroforestry development could be targeted to contribute to these objectives. Catchment Management Authorities (CMA) and other government agencies have a role to play in defining what activities are appropriate on marginal (low capability) land and how to classify plantations that actively seek to combine production with environmental benefits.

In terms of policy options, there was a clear disparity between the focus of government and industry stakeholders on market-based measures (e.g. to support the price of renewable energy or to promote the provision of ecosystems services such as carbon sequestration) and the preferences of landholders for direct on-ground support with establishment costs and information. Past experiences with regulatory change in areas such as native vegetation clearing, plantation investment models and the use of native biomass for electricity generation created scepticism among landholders regarding the risk of future changes once plantations are established.

Implications

From this research it is clear that for economic, environmental and social reasons bioenergy has the potential to become a beneficial new industry in the Central Tablelands region. However, there are a number of critical factors on which this will depend, such as:

- the preparedness of a significant percentage of landholders in the region to take up agroforestry
- funding or support to establish the infrastructure at both a farm and regional scale
- the concerns from landowners over legislation and government policy in relation to land management
- the compatibility of forms of government support with landholder-preferred mechanisms
- the match between appropriate bioenergy production systems and local biomass supplies, economic goals, community expectations and environmental targets
- the predictability of supply of biomass for electricity production and biofuel supply.

The key outputs of this project were (i) an assessment of the potential for new agroforestry based land-uses to contribute to a bioenergy industry within the Central Tablelands region, and (ii) a framework for undertaking similar regional assessments elsewhere. These outputs will be disseminated to key stakeholders during Phase 2 of the project to generate feedback about the results of scenarios and models.

Recommendations

If there is to be an effective and sustainable bioenergy industry in rural Australia, the following recommendations are necessary steps in its establishment. Due to the complexity and uncertainty associate with the proposed industry, as well as the multiple sectors involved, there is a crucial role for government and industry collaboration in its establishment. To assume that the market alone could deliver a sustainable bioenergy industry is, we believe, a mistake.

1. Stimulating adoption of bioenergy plantings by landholders

Industry stakeholders in the forestry and energy sectors need to devise strategies to reach landholder types who hold differing attitudes towards agroforestry. Many landholders will need to observe successful implementation before they make the decision to change. The matching of new agroforestry with existing biomass wastes could be a way to generate sufficient supply. Industry stakeholders also need to consider ways of converting government price support measures into support for establishing agroforestry for landholders.

2. Co-ordinated planning for a regional bioenergy industry

Local councils also have a role to play in appropriate zoning of potential plantation areas and planning for the infrastructure needed at a regional scale. These issues require cross-council cooperation. Catchment Management Authorities have a role to play in identifying forms of agroforestry involving bioenergy that can complement and contribute to regional NRM goals.

3. Getting the regulatory and other policy settings right

State and Commonwealth government agencies need to explore how present incentive schemes for renewable energy can be 'translated' into on-ground support mechanisms that are viable and acceptable from the perspective of landholders. The NSW Government should also consider whether the potential for future changes to regulations around plantation establishment and harvesting, native vegetation clearing and the use of native forest biomass for bioenergy could create investment uncertainty for bioenergy-based agroforestry.

4. Need for an independent agency to drive and monitor bioenergy initiatives

There is a strong case for an independent agency/institution to be created that can oversee the development of a viable and sustainable bioenergy industry in rural Australia. It would need to liaise with all industry groups and make recommendations to government at all levels. Considering the applicability of these issues to many different regions across Australia, such an agency may be best coordinated at the Commonwealth level or under the auspices of the Council of Australian Governments (COAG).

5. Follow up in the Central Tablelands

Phase 2 of this project will focus on the design of a business model for bioenergy from agroforestry in Central Tablelands region of NSW. This would also include an assessment of the number of landholders needed to commit to agroforestry to create the needed critical mass. A third phase will possibly involve a pilot project in the area, but the exact form will depend on results of Phase 2.

Introduction

This report presents the findings of a research project entitled *Potential new bioenergy agroforestry systems for the NSW Central Tablelands,* coordinated by the Institute of Environmental Studies (IES) at the University of New South Wales (UNSW) and the Blue Mountains World Heritage Institute (BMWHI).

Opportunities for bioenergy production in Australia

The opportunities for bioenergy production in Australia are growing due to:

- increasing awareness of the impacts of greenhouse gas emissions from the energy sector;
- increases in world oil prices; and
- the desire of governments to reduce dependency on non-renewable fossil fuels.

Photo 1 - Existing agroforestry in the Central West

At the same time, there are large areas of land in NSW that are currently degraded to some degree and on which it is not profitable to continue carrying out traditional farming or forestry activities. The Central Tablelands is one region where these issues coincide; possessing both opportunities for bioenergy production through existing (Photo 1) and new plantation forestry resources, and a need for land-use change driven by various economic, social and environmental factors.

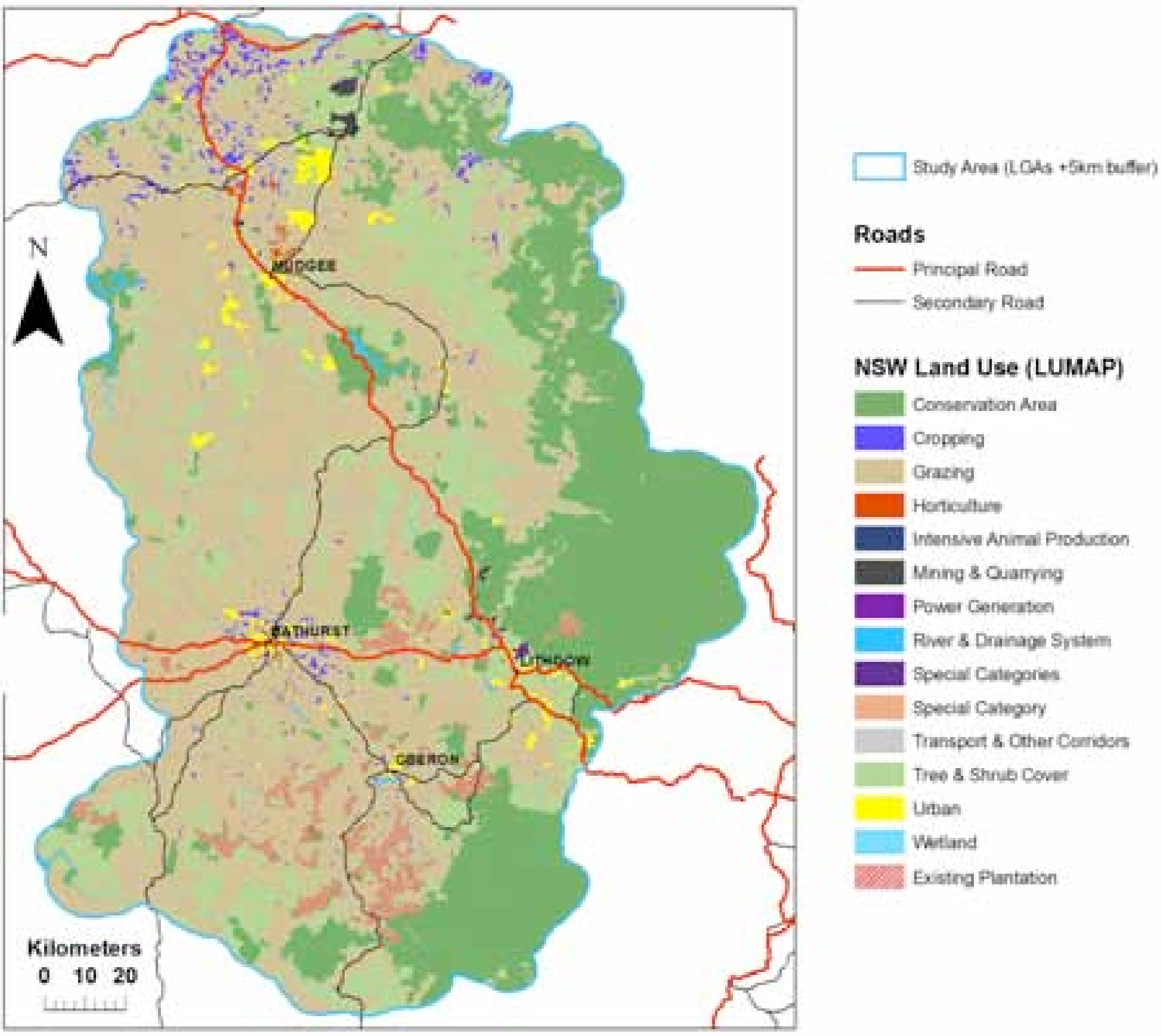
There are a number of strong drivers for growth in the bioenergy sector, including renewable electricity generation, biofuel production capacity and solid fuels for export. Electricity represents the greatest opportunity for woody biomass at present, with demand stimulated by the Australian Government's Large-scale Renewable Energy Target (LRET). Much research remains to be done in quantifying and characterising Australia's available bioenergy resources. Shifts in markets and technologies can have a dramatic impact on bioenergy resource availability, as waste products become resources in their own right and new production systems become viable. Supply chain logistics and economies of scale across the supply area are critical factors in the development of a successful bioenergy venture; in turn, a successful bioenergy industry could provide economic incentives to change land use across the supply area itself, potentially creating beneficial environmental outcomes if harnessed correctly.

Growing a mix of tree crops for bioenergy and other bioproducts (e.g. timber, woodchips) offers the possibility of using the land profitably as well as achieving catchment targets for increasing native vegetation, conserving biodiversity, combating salinity and erosion, protecting water quality and mitigating some of the impacts of climate change. At present, landscape regeneration is generally small or fragmented and often represents a net cost to landholders. Mixed-species plantations established under a landscape-scale planning framework could:

- create a mosaic of vegetation types and land-uses that protect riparian areas and water supplies
- create wildlife refuges and migration corridors
- sequester carbon
- revegetate key salinity recharge and discharge zones.

The development of industries based on woody biomass from various types of tree plantations could also provide a driver for strategic revegetation and more environmentally friendly land uses that reverse local land degradation and, in the case of the Central Tablelands, provide a buffer to the Greater Blue Mountains World Heritage Area (GBMWHA). Measuring and predicting these impacts on regional sustainability formed a key part of the regional bioenergy model developed during this project. The project also considered how these positive environmental outcomes could be an additional source of income for farmers and state land managers through emerging markets for ecosystem services, such as carbon credits or 'biobanking' (Department of Environment and Climate Change 2007).

The study region was defined as the Oberon, Lithgow and Mid-Western (based around Mudgee) Local Government Areas (LGAs), which feature a diversity of land use activities (Map 1). Protected areas dominate the eastern and south-eastern edges of the region while grazing is the dominant activity over most of the remainder. Cropping is significant around Bathurst and on the northern fringe of the region. Urban land uses are concentrated around the major centres of Bathurst, Mudgee and Lithgow (note that Map 1 includes some rural residential as 'urban').



Map 1 - Land use in the NSW Central Tablelands (NSW Government 2007)

The Central Tablelands has around 80,000 hectares (ha) of existing softwood (radiate pine or *Pinus radiata*) plantations (approximately 2/3 are state forests, 1/3 private land) providing a large under-utilised resource of forestry residues. Most existing plantations of radiata pine are concentrated in the southeast where rainfall is highest (~840 mm/annum at Oberon compared to 640 mm/annum at Bathurst and 680 mm/annum at Mudgee). The largest areas of current plantations lie in the south-eastern part of the study region and Oberon is a major centre for the processing of plantation timber. This existing industry could provide a strong basis for any regional bioenergy industry, through the availability of centralised wood processing wastes and harvest residues that are currently left within plantations. These resources could be supplemented by dedicated bioenergy plantations and/or mixed species timber/energy plantations (e.g. short-rotation energy species and long-rotation timber species).

In addition to the existence of an established plantation industry with its associated biomass supply and infrastructure, the study area also has other advantages: the workforce is skilled in forestry processing and value-adding; and the electricity generation facilities, chiefly the Wallerawang Power Station, already co-fires a small amount of wood processing residues. Other bioenergy and bioproduct options that could be integrated with existing local industries now or in the future include: wood pelletisation; second-generation biofuel production using lignocellulosic material; production and refinement of bio-crude; pyrolysis producing bio-oil and biochar that can be added to soils to improve fertility and sequester carbon; and integrated processing of activated carbon, solvents, native oils and foods. The region has a number of major industry partners that could take advantage of the research findings including Delta Electricity, Forests NSW and the Oberon Timber Complex.

The Central Tablelands is also experiencing significant demographic change, with pressure to subdivide larger landholdings into small blocks because of demand from ‘tree-changers’ looking for rural living and recreation. Significant numbers of smallholdings of 20–40 acres already exist, providing an additional opportunity for bioenergy and bioproduct development. These blocks are owned by people who are not dependent on farm income, but are interested in maintaining land value, making native species plantations an appealing option with low management requirements.

Links with other projects

This project interlinks closely with two other projects:

- The Commonwealth Scientific and Industrial Research Organisation (CSIRO) project on the assessment of environmental and economic opportunities and constraints associated with bioenergy production from forest biomass resources (submitted separately by CSIRO); and
- The New South Wales Department of Primary Industries (NSW DPI) project on determining the sustainability and commercial potential of biomass harvesting in state forests (submitted jointly through RIRDC).

This project and the NSW DPI project both fall under a larger project entitled ‘Adapting and mitigating climate change through the sustainable production and use of forest biomass for commercial scale bioenergy production’ for which RIRDC obtained funding from Department of Agriculture, Fisheries and Forestry (DAFF). The CSIRO project is also funded by DAFF as a separate, but related, project.

This project targeted specific areas of work that could feed into the CSIRO and NSW DPI projects as well as utilise the results of their studies. The NSW DPI work focused on assessing biomass resources in existing plantations in the case study area, while the CSIRO work focused on modelling appropriate bioenergy technologies, price supply curves, transport distances and carbon life cycle. This project focused on the feasibility of establishing new bioenergy-based agroforestry plantations in the case study region. It employed a stakeholder-driven, participatory approach to gain an understanding of the various economic, social and environmental issues surrounding such changes in land use. The project developed scenarios and gathered data to feed into CSIRO’s modelling work. The intention is to take results of this project, along with the CSIRO and NSW DPI work, back out to stakeholders during the second phase of this project in July–December 2011 in order to assess how well our scenarios match with their economic, social and environmental goals.

The bioenergy technology options selected for in-depth consideration in this project were narrowed down to three, in order to be consistent with the work of CSIRO:

1. co-firing for electricity generation (e.g. at the Wallerawang Power Station)

2. enzymatic conversion (e.g. ethanol produced from cellulosic material)
3. thermochemical conversion (e.g. to produce a combination of syngas and syndiesel).

The project also considered whether other potential bioproducts such as timber or pulpwood could be produced in conjunction with bioenergy. Consultation with existing agroforesters in the region sought to determine what these co-products may be and how this may impact on the volumes of biomass available for bioenergy.

This project also considered policy issues, such as the impacts of the Renewable Energy Target (RET), mandatory fuel blending requirements and the proposed Carbon Pollution Reduction Scheme (CPRS). CSIRO intended to incorporate the impacts of carbon prices and fuel prices into their analyses. This UNSW-led project focused instead on policy analysis and on ways in which national goals for renewable energy and emissions reduction can be integrated with local and regional goals for economic development, land use and natural resource management.

Background to the project

This project was instigated and driven through interaction between the Blue Mountains World Heritage Institute (BMWHI), the Institute of Environmental Studies (IES), and the Future of Australia's Threatened Ecosystems (FATE) program—all based at the University of NSW (UNSW). The issue of complementary development in the peri-urban/rural western edge of the Greater Blue Mountains World Heritage Area (GBMWHA) was discussed at a multi-stakeholder BMWHI research workshop in November 2004. During 2005 and 2006, the FATE program funded a consultant, Clare Carlton, to assist in the development of a proposal.

After preliminary discussions between interested partners, a workshop was held at UNSW in June 2006 to scope possible enterprise options. This looked at areas west of the Blue Mountains that could contribute to environmental regeneration and regional development whilst being compatible with the region's changing social dynamics. Bioenergy emerged as a leading enterprise option for the region and planning commenced to develop a research project based on an appropriate location.

A consultation meeting was held in Oberon in July 2007 with the key project partners as well as local landholders involved in farm forestry, saw-millers, foresters, investors and planners. From this meeting, the project expanded to include the Lithgow and Mid-Western LGAs, due to their similarities to Oberon, their level of interest upon learning of the project and their existing strategic alliance. A further meeting was held with the Central Tablelands Alliance Council in Mudgee in September where a proposed regional bioenergy strategy was discussed and supported. The location of the project across a number of watersheds on the Great Dividing Range also brought Central West and Lachlan CMAs into the project.

A preliminary research proposal (PRP) put to the Rural Industries Research and Development Corporation (RIRDC) in September 2007 was accepted and a full proposal submitted in early 2008. This was accepted under the condition that the project would be repackaged to align with two projects being developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and New South Wales Department of Primary Industries (NSW DPI). Funding came through by mid-2010, following further consultation in late 2009 and early 2010. For six years, key UNSW personnel drove ongoing consultations without any external funding support in order to make this project happen.

Objectives

Objectives of the project

The goal is to assess the potential for agroforestry, based around bioenergy production, to form a new sustainable land use option in the Central Tablelands of NSW. In particular, this project aimed to answer the following research questions:

1. What tree crops and bioenergy technologies might be viable in the case study region?
2. What potential economic and social benefits might a bioenergy-based agroforestry industry provide?
3. How might the widespread uptake of agroforestry for bioenergy contribute to landscape-scale natural resource management goals?
4. What incentives and barriers exist for the uptake of such land uses, and what policy measures could be employed to promote and guide them?

Two project phases are currently funded. However, this report deals only with Phase 1, which includes: data collection and stakeholder consultation; assessment and modelling; and social analysis undertaken during late 2010 and early 2011 using funding from DAFF (

Table 1). Phase 2 will run from July–December 2011 and is also funded as part of this overall RIRDC agreement. Phase 2 will involve a regional workshop to disseminate the results of Phase 1 and to further plan for a regional bioenergy industry in the Central Tablelands. Funding opportunities for a third phase (regional trials) will also be explored during Phases 1 and 2.

Contribution to RIRDC goals and objectives

The RIRDC Bioenergy, Bioproducts and Energy program objective addressed by this project is to meet Australia’s research and development needs for the development of sustainable and profitable bioenergy and bioproducts industries.

The project addressed these priorities through the assessment of the bioenergy potential of new agroforestry plantations in the Central Tablelands and the development of a model that can be used in different regions of Australia. The project is particularly focused on sustainability issues, looking at whether the development of a bioenergy industry would be considered appropriate against the three pillars of Environmentally Sustainable Development (ESD), and considering whether a bioenergy industry could actually drive landscape-scale change towards land uses that are more sustainable than present activities and more resilient to climate change.

Methodology

This project is an inquiry into a complex adaptive system and the potential for that system to incorporate energy from a biomass industry in a way that generates positive environmental, social and economic outcomes. To achieve our aims, we needed to first be able to describe the overall system and to define system components and how they interact with each other. We then needed to examine the potential for that system to incorporate energy from biomass. Incorporated in this is the development of plausible scenarios for the involvement of a diversity of landholders and the use of their land, and the possible location of any new infrastructure that would be required.

This document reports on Phase 1 of the project, which consisted of three tasks:

- Participatory Rural Appraisal (What are the key factors in agroforestry/bioenergy systems? What do people think of the idea?)
- Landholder Survey (To what extent are the identified views representative for the whole region?)
- Spatial Analysis (Where could agroforestry/bioenergy occur to align with landholder and NRM priorities?).

Results from these three tasks will be integrated and discussed under report sections Discussion of Results, Implications and Recommendations (What can we do about it? What would be needed for the implementation of an agroforestry/bioenergy industry?). We initially planned to undertake these tasks following the three stages mentioned in the original proposal:

- Stage 1. Stakeholder engagement and data collection
- Stage 2. Assessment and modelling
- Stage 3. Social analysis and planning

In practice, however, activities within the stages often overlapped with other stages, or were carried out in a different order. The actual sequence of activities is presented under 'Planning' in

Table 1. For the purposes of this report, it is clearer to present our work according to the tasks (i.e. Participatory Rural Appraisal, Landholder Survey and Spatial Analysis), not the stages. This section provides a broad overview of the methodologies used and how they complement each other. Further details on each of the tasks are provided in the next three major sections**.**

Participatory Rural Appraisal

Consistent with a systems-based research, in the exploratory stages we adopted a number of strategies that take on board multiple perspectives of how the system functions. These strategies included:

- collecting published material relevant to the project including from local government, CMAs, state agencies and research literature
- interviewing key local and industry informants
- meeting relevant stakeholders and experts
- conducting a Participatory Rural Appraisal.

Data collection included existing point-source biomass resources, current land-uses, land values, potential options for bioenergy cropping and options for co-products (e.g. timber, composite wood products, carbon credits).

This preliminary stakeholder engagement led to the identification of plantation and farm forestry activities as key development goals by local councils and landholders. Strategic revegetation (for biodiversity, water protection and increased resilience in the face of climate change) was identified as a key goal for CMAs and the BMWHI. Further consultation on these objectives and options for agroforestry, biomass processing and bioenergy technologies was undertaken in order to scope a number of alternative tree planting scenarios which were communicated to CSIRO for use in their project (under their Scenario Planning and Investment Framework).

Photo 2 - Landholder consultation

Stakeholder consultation aimed to identify potential sites for biomass/bioenergy processing facilities (e.g. the wood processing facilities near Oberon and the Wallerawang Power Station). Data collection included current point-sources of biomass in the region (such as wood-processing residues and green waste) using data from councils, local industry stakeholders and collaboration with NSW DPI. Data was also collected on current land use, land values, land capability and planning rules that can be analysed using ArcGIS™. This data collection and GIS analysis drew on the in-kind contribution of local council and CMA partners.

Participatory Rural Appraisal (PRA) was the methodology chosen to rapidly assess the context in which this project was undertaken, to involve key local and expert stakeholders and to formulate the most relevant questions for the subsequent quantitative survey. PRA methodologies have been designed, tested and found to be appropriate for such purposes in Australia and overseas (Ampt 1993, Ison & Ampt 1992). Peter Ampt (Faculty of Agriculture and Natural Resources, Sydney University) has strong experience with PRA and is currently employing a similar approach under a Caring for Our Country grant. The methodology relies on project personnel working together with local participants to interview key informants at different locations (Photo 2). Interviewees were selected to include as wide a range as possible. Interviews are undertaken over a short period of time with scheduled daily feedback sessions, concluding with a final workshop with local people.

The findings of each of the activities were documented and discussed within the team, and contributed to the development of a rich picture of the study area. The team progressively developed an understanding of the potential for energy from biomass, and the nature of the industry that might be compatible with the local situation.

The findings of this process are mainly reported in the report section Participatory Rural Appraisal.

Landholder Survey

From this knowledge and understanding, a series of critical questions was developed and incorporated into a Landholder Survey. The questions covered a range of social, economic and environmental issues. The PRA interviews were used as a basis to design the questionnaire. The objective was to quantify various statements by landholders regarding agroforestry and bioenergy (and agroforestry for bioenergy). The survey was sent to a random sample of landholders (across different council areas). The findings of this process are mainly reported in the report section Landholder Survey.

The questionnaire was designed so that the quantitative data gathered could be combined with key population and spatial factors assessed through GIS as part of the following task.

Spatial Analysis

In parallel with these first two exploratory tasks, we undertook spatial analysis of the target area using various GIS layers. Through this process, we put together the scenarios for landholder adoption of the sort of tree plantings that would make possible a local energy-generating biomass industry. The findings of this process are mainly reported in the report section Spatial Analysis.

CSIRO, under its project, had primary responsibility for modelling regional biomass supplies.[1] UNSW and its partners collaborated with CSIRO to ensure that the models incorporate the key issues and objectives identified by stakeholders.

The spatial analysis component of the project sought to determine four main elements:

1. the maximum available area of land for new plantations in the study area based on regulatory constraints
2. the total area of private rural land in the study area for use in further analysis using the landholder survey data
3. the spatial distribution of key land use factors such as landholding size, land use activities and land capability for comparison with the PRA and survey results
4. the spatial distribution of natural resource management issues that could potentially be addressed through revegetation activities.

Discussion of results

The aim of this analysis was to identify how the different aspects of bioenergy production and agroforestry align or conflict with the various economic, social and environmental goals of stakeholders. Experiences in other regions (e.g. agroforestry in northern Queensland) have shown that social and environmental factors (e.g. aesthetics, valuing of biodiversity, dependency on farm income, risk profiles) are critical in terms of understanding which landholders may adopt new land uses, what policy incentives will be most effective in promoting uptake, and what barriers may emerge (e.g. community opposition to certain land use changes, mistrust of government agencies or corporations due to past experiences).

Our work also involved analysis of policy measures that could be employed to encourage uptake of bioenergy-based agroforestry in the region and to guide it in a manner that is consistent with the goals of councils, CMAs, landholders and other stakeholders. This analysis examined the range of policy measures that are employed at the local and regional level (e.g. by local councils and CMAs) and attempted to integrate these with state and national policy measures such as the Renewable Energy Target (RET), mandatory renewable fuel blending and the proposed Carbon Pollution Reduction Scheme (CPRS). This analysis was largely qualitative (i.e. which policy measures can guide land use desired changes vs. undesired directions) rather than quantitative (i.e. what Renewable Energy Certificate (REC) price is required to cause a certain change in land-use).

The results of our assessments were taken back out to key stakeholders by circulating a first draft of this report. The results from CSIRO were not available at the time of completing the draft and could not be sent through to the stakeholders (see

Table 1). During Phase 2, we will disseminate the final results through a regional workshop. The scenarios presented to stakeholders will feature a range of different components, including different bioenergy technologies (the three options being assessed by CSIRO), different levels of economic return, different plantation species (potentially including mixed species), different proportions of land being converted to agroforestry, and different ways of integrating plantations into the landscape.

[1] Detailed productivity modelling of alternative plantation species (using 3-PG) was handed over to CSIRO. Close consultation with CSIRO ensured that our work adds to their modelling work on biomass supplies from new plantations and avoids unnecessary duplication. The incorporation of data on the suitability of local biomass for production of cellulosic ethanol into the project is deferred to phase 2. Analyses undertaken by Prof Peter Rogers in the School of Biotechnology and Biomolecular Sciences at UNSW as part of a separate NSW Climate Action Grant project.

Planning

Table 1 - Project Planning (Gantt chart)

Tasks	2010								2011					
	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Initial project meeting with councils, CMAs and other interested stakeholders		X												
Contacting stakeholders & coordinating interviews (landholders, forestry, councils/CMAs, NGOs etc.)		X	X											
Developing interview questions and methodology		X	X											
Undertaking interviews and holding local workshop in line with rapid appraisal methodology			X	X										
Compiling interview results			X	X	X									
Developing regional agroforestry/bioenergy scenarios in consultation with CSIRO				X	X	X								
Determining key factors for further analysis (e.g. biodiversity, land/water & social goals which CSIRO can't incorporate directly into models)				X	X	X								
Analysis of factors by UNSW/BMWHI/FATE (qualitative analysis, more interviews, maybe survey)					X	X	X	X	X	X				
GIS analysis (e.g. land availability/suitability, logistics)					X	X	X	X	X	X				
Policy analysis (energy, plantation management, NRM)					X	X	X	X	X	X				
Milestone – Progress report due to DAFF 31/12/10								X						
Milestone – Finalise analysis & liaise with CSIRO, NSW I&I and project partners								X	X	X				
Stakeholder consultation on results of modelling and analysis (interviews and/or workshop)										X	X	X		
Prepare final report												X	X	
Post-project workshop and business planning analysis														

Participatory Rural Appraisal

Introduction

Photo 3 - Interview with a landholder

Photo 4 - PRA Workshop

The participatory rural appraisal (PRA) involved two intensive days of interviews across the region (Photo 3 and Photo 4), with two evening review workshops, followed by a workshop on the third day to pull together key themes and issues arising from the interviews. Interviews took place on Monday 30 August and Tuesday 31 August, with the workshop on Wednesday 1 September.

The interviewing team consisted of approximately ten people divided into pairs, with each pair generally consisting of one researcher from the UNSW, USYD, or the BMWHI. The teams were joined by community stakeholders from local government, CMAs, industry and Landcare groups. Preliminary consultation identified key informants in the Central Tablelands region, including landholders, government agencies, industry participants (especially forestry and energy sectors) and community groups.

Key informants were approached to participate as either:

- an interviewee
- a local partner on the interviewing team
- a workshop participant.

Each interview team first outlined a possible scenario based around plantations of native trees that are managed to produce bioenergy and other products and to provide a variety of environmental and social benefits. Each team used a script and images to outline this scenario (see Appendix 2: PRA interview scenario).

Interview questions (see Appendix 3: PRA interview questions) were identified based on their potential to:

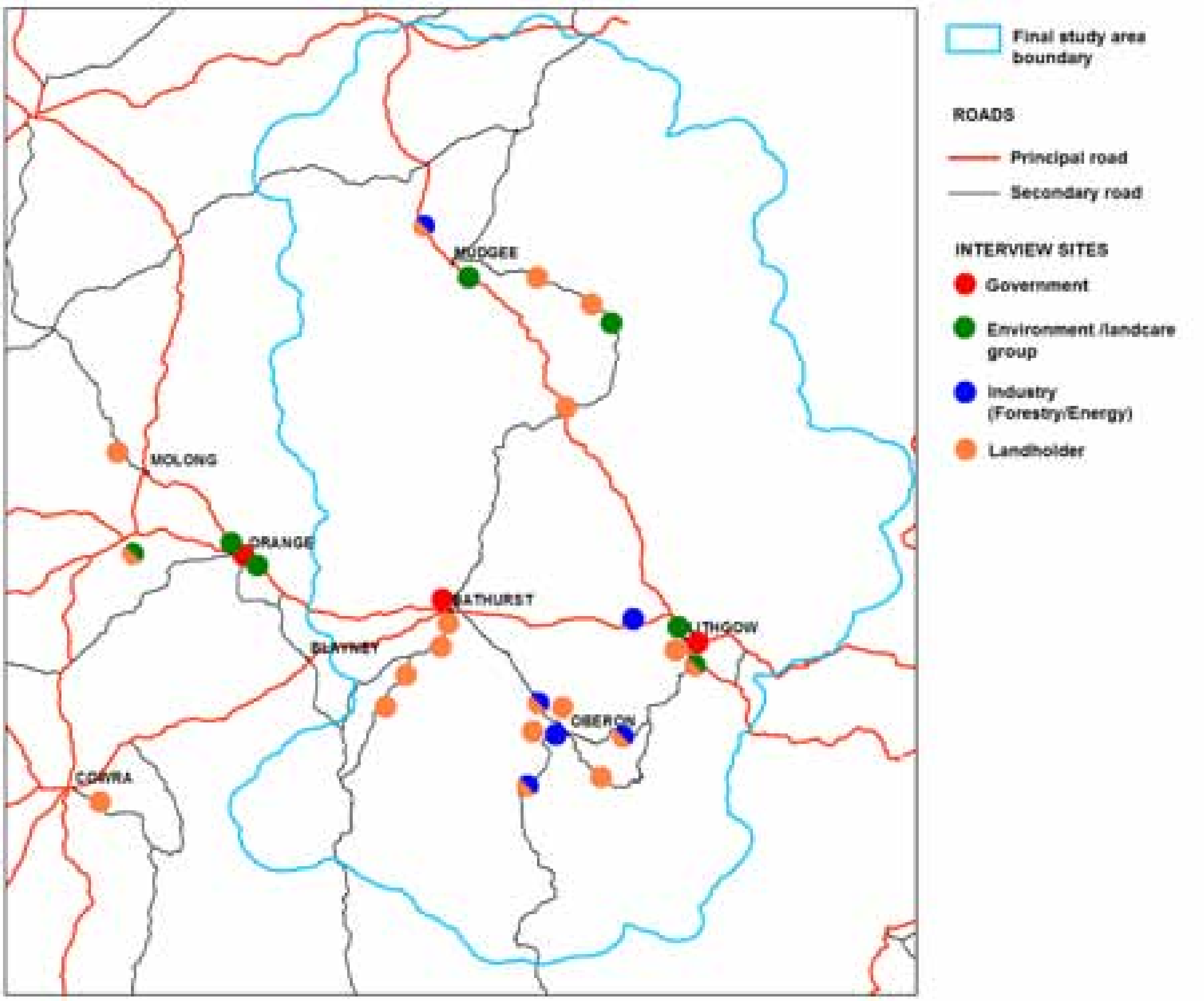
- obtain background information on the informant and/or the district
- facilitate learning from past experiences with growing trees, processing tree products or producing energy
- gather data that can be used in further analysis
- test assumptions (of the research team or of previous research)
- identify incentives and barriers for the uptake of bioenergy-based agroforestry
- test key informant's responses to possible scenarios, actions or policy measures.

Interviews were carried out in an area from Mudgee in the north to Oberon in the south, from Lithgow in the east to as far west as Molong and Cowra (see Map 2). We undertook 29 interviews with key informants.

The interviewees covered the following categories (note that several covered more than one category):

- 19 landholders (11 commercial, 3 semi-commercial and 5 small non-commercial)
- 6 industry representatives (forestry, nursery and energy sectors)
- 4 environmental group representatives
- 3 landcare group coordinators
- 3 government representatives (council, CMA and NSW Government)

The interviewed landholders were chosen in order to represent some of the diversity of views in the community, including people who had undertaken past tree planting (environmental plantings and/or agroforestry trials). The data collected was written up in a report (see Appendix 4: PRA results) and summarized in this section. These results were used to help formulate survey questions and the agroforestry scenarios presented in the next sections.



Map 2 - PRA interviews

General findings for the region

The PRA demonstrated that some factors varied significantly by location while others did not. Several factors were common across much of the region:

- There is a large number of small non-commercial (or semi-commercial) landholders, which may require a cross-property approach for bioenergy-based agroforestry.
- Economic risk was the greatest barrier and it was widely accepted that a higher REC and/or carbon price is required to make biomass electricity cost-competitive. Short-rotation plantations were favoured due to the shorter wait for returns.

- Native plantations were seen to offer potential co-benefits such as windbreaks, soil protection, amenity and habitat for biodiversity. Many landholders indicated that these co-benefits might make agroforestry viable at lower rates of economic return than their current land uses (although not on the most productive land).
- The most favoured support mechanisms were establishment support (financial and information) and payments for ecosystem services (especially carbon).

The PRA results were used to divide the study region into three interrelated sub-regions. In this section, we present a summary of the results for each sub-region. More detailed findings per region are found in Appendix 4: PRA results)

The South-East: Oberon/Lithgow

These areas were combined due to similarities such as existing pine plantations, high levels of remnant native vegetation and high levels of small non-commercial landholders. This sub-region also contains the two most promising locations for a regional bioenergy facility utilising biomass from across the Central Tablelands – Oberon timber complex (due to existing wood wastes) and Wallerawang Power Station west of Lithgow (where biomass co-firing has been trialled).


Photo 5 - Potential multiple use of biomass

These factors indicate that this area may be the best location for a pilot bioenergy-based agroforestry scheme. A cooperative business could work across many small properties, with larger properties participating by allocating their less productive land or replacing areas currently growing pine. Plantings would be primarily for bioenergy, although some longer-rotation timber species could be included in a mixed-species layout. Biomass from agroforestry could be pooled with existing residues from pine harvesting and processing (Photo 5).

Delta Electricity operates the Wallerawang Power Station and has been trialling the use of biomass for co-firing with coal over recent years (at a replacement level of around 1%). Delta has recently developed a proposal to use biomass for 20% of the plant's fuel needs, which would require a combination of biomass sources such as local plantation forestry residues, urban wood wastes (from Sydney), invasive native scrub removed from areas of western NSW and purpose-grown bioenergy tree crops (Horner 2010b). Notably, Delta has not looked closely at the Central Tablelands region as a potential site for purpose-grown bioenergy tree crops, but rather has commenced a trial more than 200km west of Wallerawang around Forbes, where land is cheaper and income from competing land use options is lower (Delta Electricity 2010).

The North: Mudgee/Rylstone

This sub-region features four main landholder groups: small non-commercial landholders, innovative commercial farmers, more traditional commercial farmers and mining companies. The first two groups could participate in a similar scenario to Oberon/Lithgow, while the more traditional farmers are less likely to participate at this early stage. For mining companies, native plantations could offer a revenue-neutral means of revegetating and buffering mine sites. Bioenergy options include transport to Oberon/Wallerawang or a small-scale local facility. Plantation forestry is not well established in this area, but some agroforestry trials have been planted (requires a data audit).

The South-West: Bathurst

A cross-property management option could tie in with existing collaborative arrangements such as sharefarming and community title. Transport of biomass to Oberon or Wallerawang appears the most likely bioenergy option.

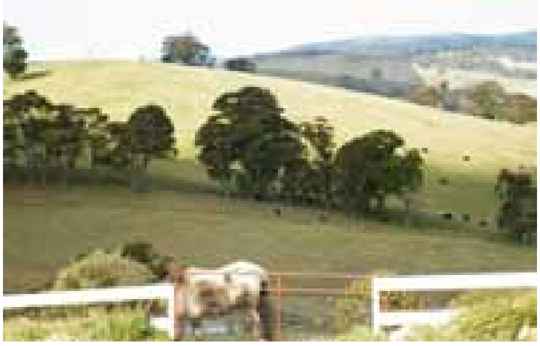


Photo 6 - Tree plantings for stock shelter

High-value grazing land and rural residential demand around Bathurst, combined with lower rainfall levels mean native agroforestry is unlikely to compete economically in this area. However, the desire for potential co-benefits from plantings is high due to extensive past clearing, a need for stock shelter (Photo 6) and salinity problems in some areas. Views on how much of the landscape should be revegetated varied from 1–5% amongst commercial farmers to more than 20% amongst non-commercial smallholders who had undertaken past planting.

Other areas

Although a small number of interviews were carried out around Orange, Molong, Cudal and Cowra, these areas were ultimately excluded from the current study due to their distance from the core Central Tablelands region and differences in climate and land use.

Landholder Survey

Introduction

The Participatory Rural Appraisal (PRA) indicated that some factors assessed varied significantly by location while others did not. The results were used to divide the study region into three inter-related but quite different sub-regions, namely the South-Eastern (SE) part including and surrounding Oberon and Lithgow; the South-West (SW) including and surrounding Bathurst; and the North (N) including Mudgee and Rylstone. In order to start developing regional agroforestry/bioenergy scenarios for each of the three sub-regions, a survey was developed and sent out to assess the different characteristics of each sub-region in relation to new agroforestry land uses and bioenergy industries.

The survey was sent out by the middle of January 2011. Results were analysed in February and March 2011. The method included the following:

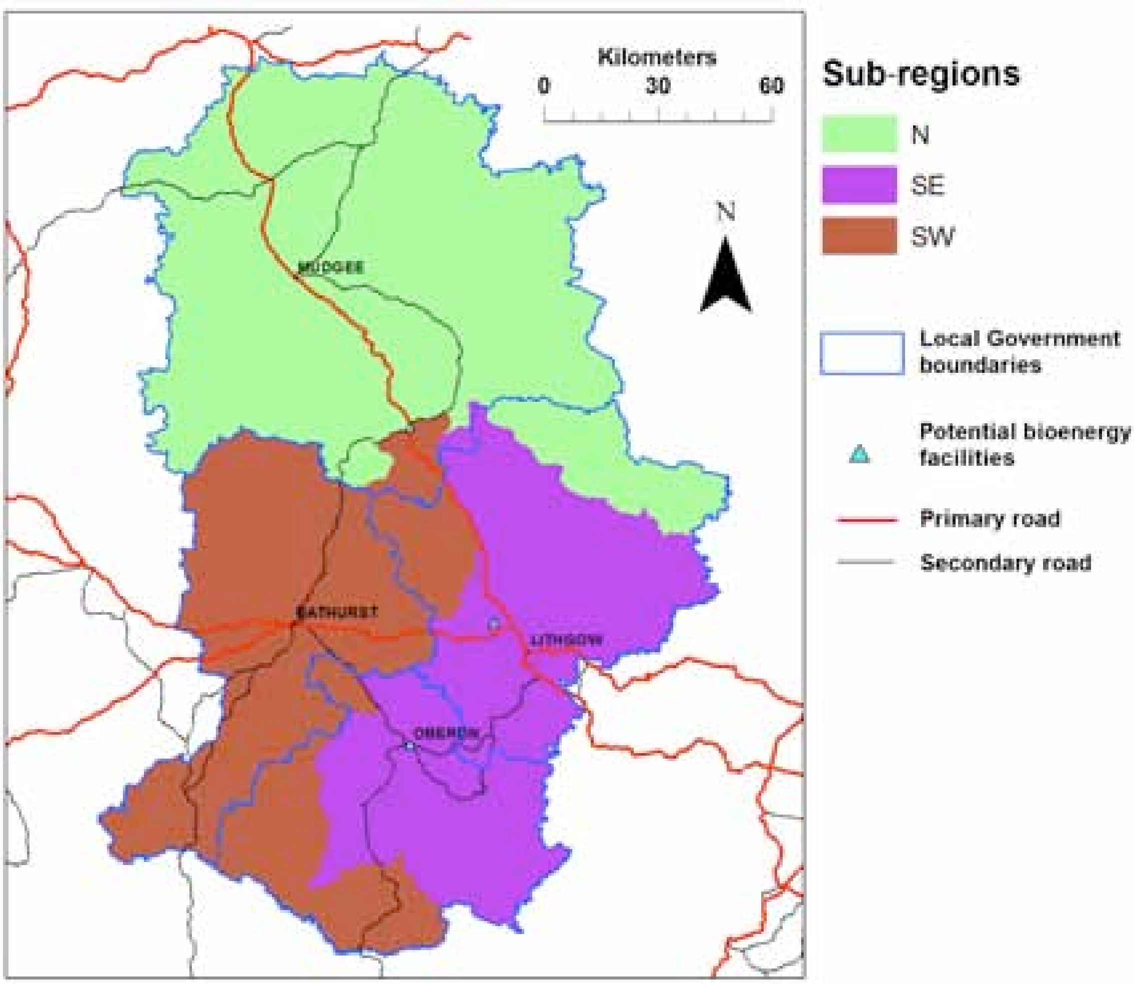
- The PRA informed the design of the questionnaire (Appendix 5: Survey questionnaire), including questions on property characteristics (location, size, land use and capability), experience with tree planting, perspectives on agroforestry, level of interest and options for implementation. Where appropriate, we also tried to remain close to classifications used in other similar surveys so that these can be compared in the future.
- Four local councils and three CMAs are partners in this project (Mid-Western, Oberon, Lithgow and Bathurst councils, Hawkesbury-Nepean, Lachlan and Central West CMAs). We sent the questionnaire to our partners and asked for contact lists of landholders.
- We selected a random sample from those lists and weighted according to postcodes to get a similar number in each sub-region.
- Overall, 784 surveys were sent out, with 159 responses received for an overall response rate of 22% (after accounting for 59 surveys that were returned to sender).
- The survey was mailed with an anonymous prepaid return envelope. Respondents were asked to provide their postcode so that we could match them with a particular sub-region.
- Using Microsoft Excel® and ArcGIS™, analysis of factors included: large versus small landholdings, commercial versus non-commercial farms, and others. We used the survey data to quantify and test some of the PRA assumptions.

Note: In this section, the bar chart error bars represent a 95% confidence interval (CI)[2].

Characterising land size, use and capability

In this section, we examine land size, use and capability for the overall Central Tablelands region, and we also compare different sub-regions within it. From the PRA, it was determined that the issues around agroforestry and bioenergy varied between three major sub-regions: the South-Eastern (SE) part including and surrounding Oberon and Lithgow; the South-West (SW) including and surrounding Bathurst; and the North (N) including Mudgee and Rylstone. Respondents to the landholder survey were asked to provide their postcode, which was used to divide them amongst the three sub-regions (see Map 3). The three sub-regions approximate LGA boundaries (i.e. SW=Bathurst, N=Mid-Western, SE=Lithgow & Oberon) but are not an exact match due to the differences between LGA and postcode boundaries.

[2] A particular kind of interval estimate of a population parameter used to indicate the reliability of an estimate.



Map 3 – Central Tablelands sub-regions

Land size patterns

Respondents were divided into four categories according to size of landholding: less than 40 hectares (ha), 40 to 100 ha, 100 to 850 ha and greater than 850 ha. These size classes were based on the minimum subdivision sizes permitted in the four LGAs (40 ha in Oberon and Lithgow, 100 ha in Bathurst and Mid-Western) and the minimum viable size for a commercial farm at Oberon (850 ha) as determined by a 2008 land use analysis commissioned by Oberon Council (Insite Economic and Social Planning Pty Ltd 2008).

Table 2 – Comparing land size patterns from survey data with cadastral data

Property Size Class	% of survey respondents in each class (4% gave no property size)	% of land held by survey respondents in each class	% of private rural land in each class from GIS cadastral layer
<40 ha	30.0	0.6	5.5
40−100 ha	21.0	2.0	9.4
100−850 ha	32.0	19.0	57.0
>850 ha	13.0	78.0	28.0

Table 2 compares the breakdown in property size from the survey with the breakdown from the cadastral layer used in the GIS analysis. The survey results featured a large number of small landholders holding only a small percentage of the total land in the region (~50% of landholders held less 3% of all land). However, comparison to the GIS cadastral data indicates that the survey results may be skewed towards large landholdings, with 78% of all land in the survey falling within properties greater than 850 ha, compared to only 28% in the cadastre. A further complication is that the cadastral data does not account for situations where a single landholder holds more than one property unit (which was reported in the PRA to be common amongst commercial landholders), meaning that the over-representation of large landholdings within the survey data may not be as large as it appears (i.e. some properties classed as 100–850 ha in the cadastre may actually fall within larger landholding agglomerations). These discrepancies have important implications for the analysis of survey results and development of potential agroforestry scenarios, and are discussed further in the sections on Spatial Analysis and Discussion of Results. Figure 1 shows the regional distribution in landholding size from survey and GIS analysis.

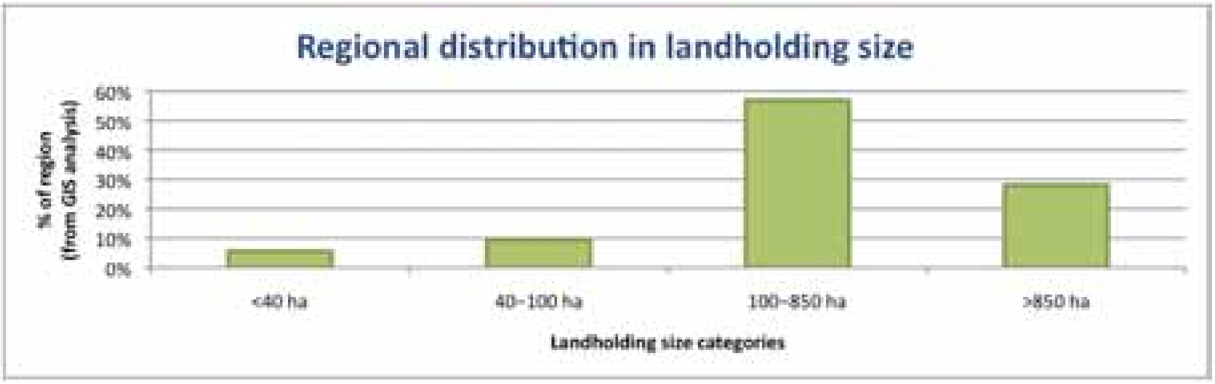


Figure 1 – Regional distribution in landholding size from survey and GIS analysis

During the PRA, interviewees mentioned a mix of landholding sizes across the region. For example, the SW was presented as particularly affected by subdivision, but with minimum block sizes. The N was also mentioned as being particularly affected, without limits to subdivision. Our survey supported PRA findings regarding the SW, but not regarding the N. Smallest average land sizes were found in the SE and SW. The largest two categories were found in the N, followed by the SE for properties in the 100–850 ha category, and by the SW for properties in the >850 ha category (see Figure 2). This pattern corresponded with the GIS cadastral data, which showed a concentration of smaller properties (<40 ha) in the SE and SW and concentrations of large properties (>850 ha) in the N and SW.

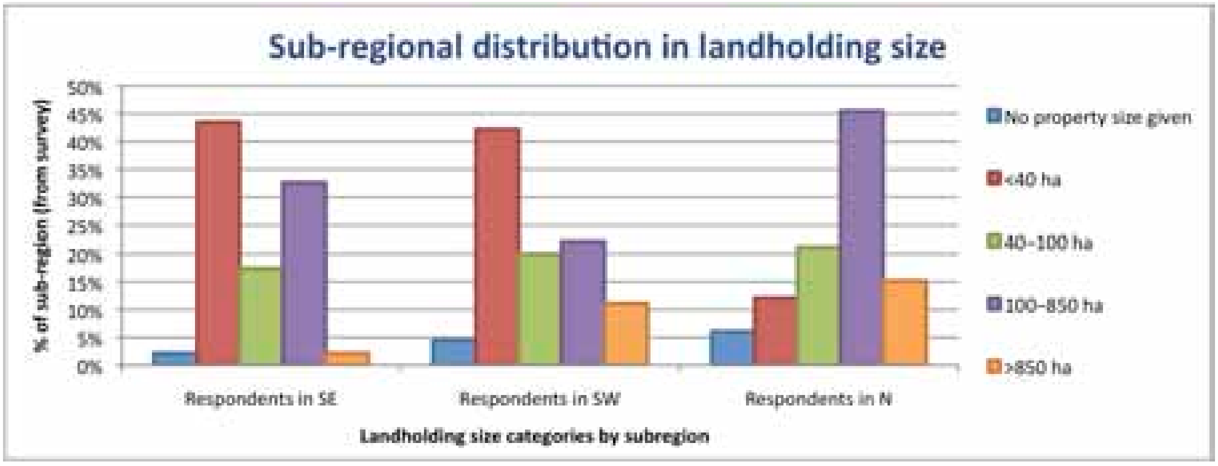
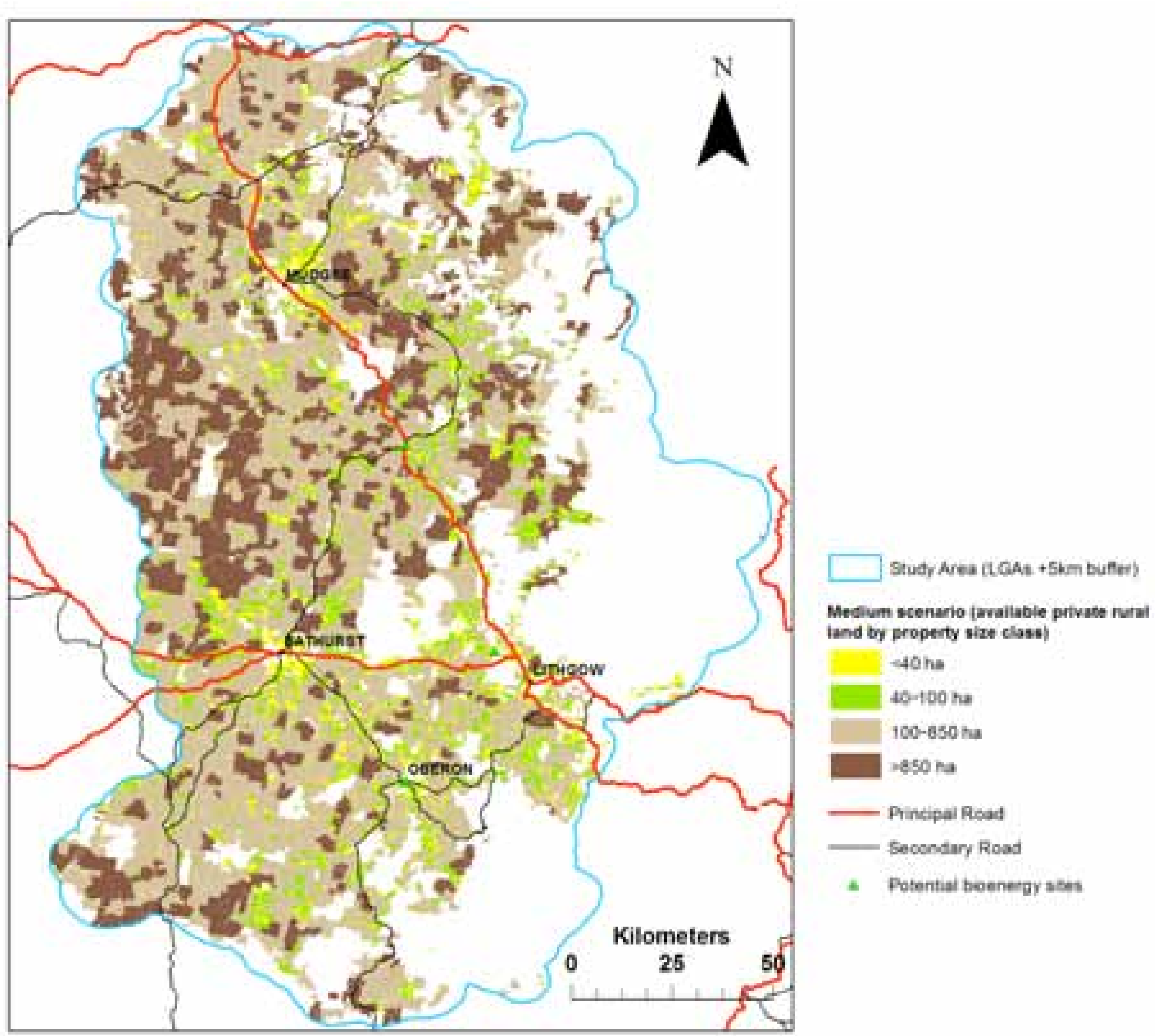


Figure 2 – Sub-regional distribution in landholding size

The area of private rural land (i.e. not crown land, urban, mining, transport or power generation) was assessed through GIS (Map 4). Overall, 66% of the region was determined to be private rural land, with a number of evident geographical patterns. Small properties (<100 ha) were found to be concentrated around the main urban centres (particularly Bathurst and Mudgee) and along main roads.

Large properties (>850 ha) were found mostly in the western and northern parts of the region, with the largest concentration in the area to the north-west of Bathurst and south-west of Mudgee.



Map 4 – Area of private rural land divided according to property size

Land use patterns

The current land use pattern in Figure 3 demonstrated two main types of land use amongst survey respondents: commercial grazing (listed as a major use by 47% of respondents) and lifestyle/hobby farming (35%). These were followed by conservation of remnant native vegetation (18%) and environmental plantings (e.g. revegetated corridors) (8%). Other types of land mentioned by respondents included viticulture, bushland, residential, fruit plantation and horticulture (these uses represented a very small percentage). The pattern for the whole region was very similar to that of each sub-region. It must be noted that most of the conservation of remnant vegetation land use in Figure 3 was undertaken on properties alongside commercial grazing or lifestyle/hobby farming. The two largest categories (commercial grazing and lifestyle/hobby farming) will be used throughout this report when comparing major land use.

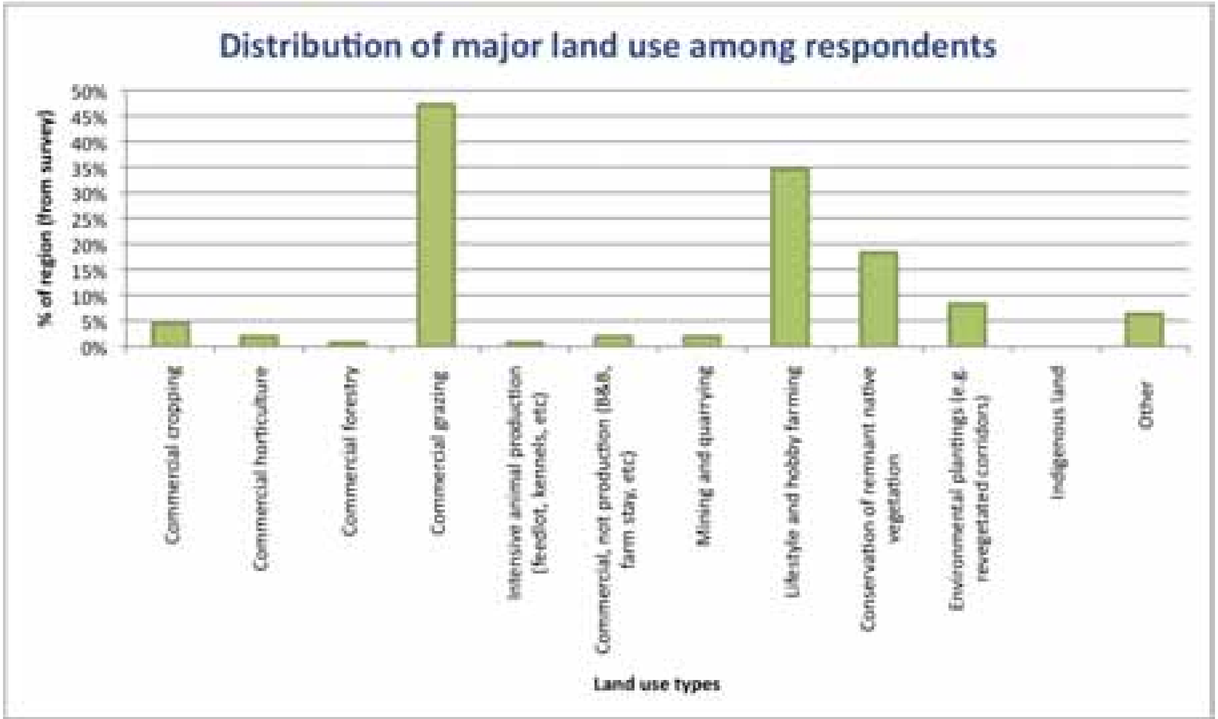


Figure 3 – Distribution of major land use among respondents

Land use patterns varied across the Central Tablelands region. During the PRA, interviewees indicated that landholders in the N were composed of a range of commercial innovators, conservative farms and small non-commercial landholders; in the SE there was a large group of commercial tree planters; the SW was dominated by grazing. We attempted to quantify land use patterns with the survey by comparing the percentage of landholders selecting one or more of the following as major or minor land use: commercial forestry, commercial grazing, lifestyle/hobby farming, conservation of remnant native vegetation and environmental plantings. Figure 4 shows sub-regional differences in major land use. Figure 5 shows sub-regional differences in minor land use. Please note that respondents could select more than one land use.

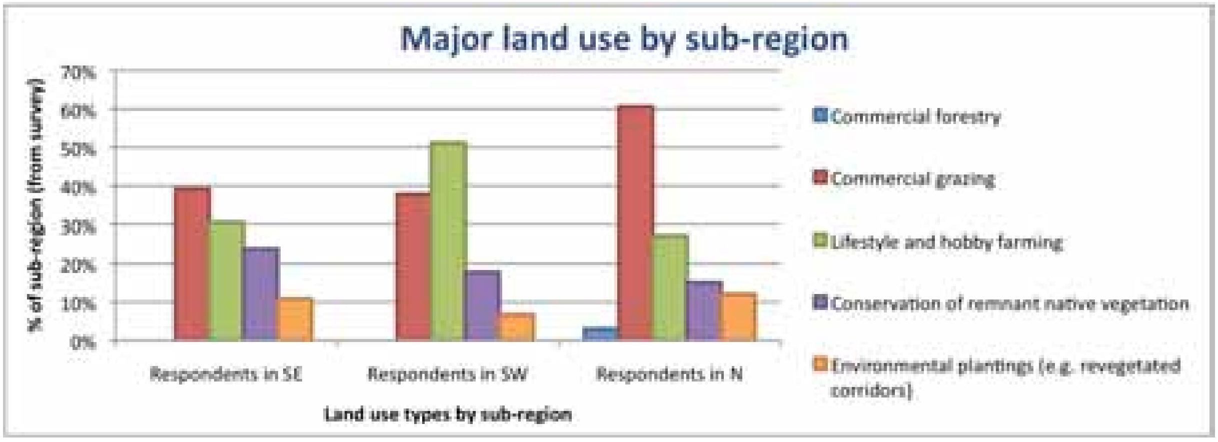


Figure 4 – Major use by sub-region

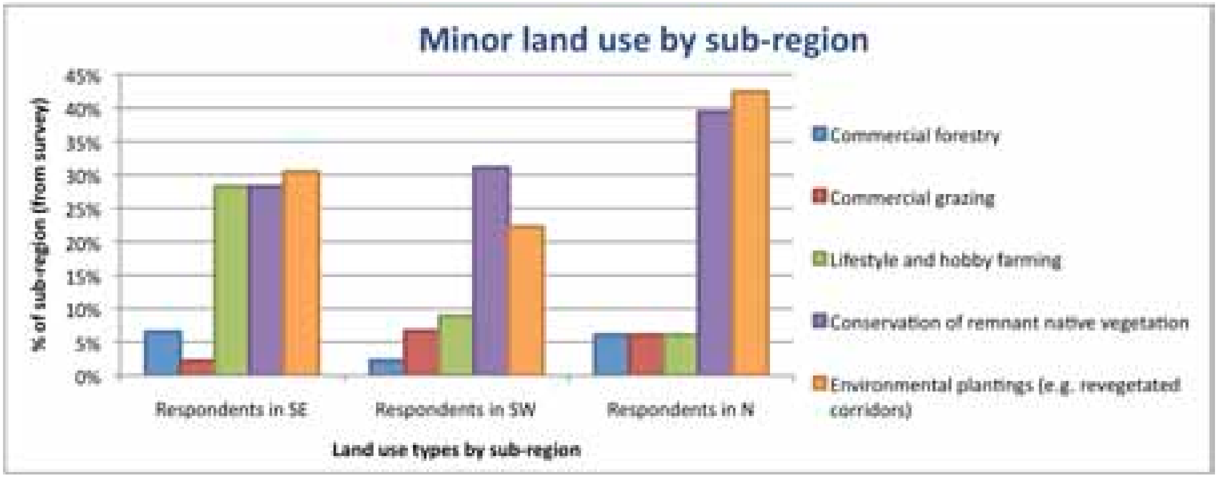


Figure 5 – Minor use by sub-region

In terms of major land use, the survey indicated that lifestyle/hobby farms dominated the SW (not grazing as suggested by the PRA), followed by the SE and N. Commercial grazing was most prevalent as a major land use in the N, and virtually equal in the SE and in the SW. Conservation of remnant native vegetation and environmental plantings were important minor land uses in all three sub-regions, particularly in the N. Commercial forestry ranked quite low in all sub-regions and, contrary to what we were told during the PRA, it was actually higher in the N (3% major, 6% minor) than in the SE (7% minor).

Land capability patterns

We also attempted to assess the type of land, based on NSW Land Capability classifications that may be more relevant in assessing the future potential for agroforestry than current major/minor land uses.

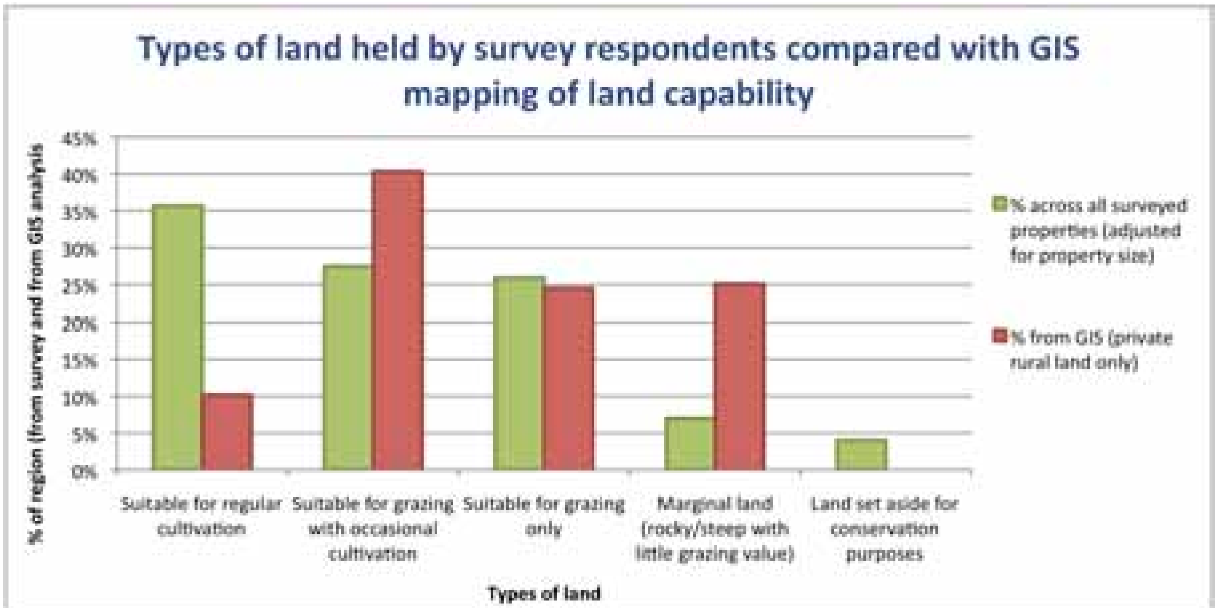


Figure 6 – Types of land held by survey respondents compared with GIS mapping of land capability across all private rural land in the study area (Department of Infrastructure, Planning and Natural Resources 2004)

Figure 6 compares the proportions of land in each land capability classes as listed by surveyed landholders (weighted according to property size) with the proportions across all private rural land in the study area according to NSW land capability mapping[3] (DIPNR 2004). Surveyed landholders reported higher proportions of cultivable land and lower proportions of marginal land compared with the NSW Land Capability mapping. This could be either a result of the survey sample being biased towards more productive land or a result of landholders using a broader standard of high capability land and a narrower standard for low capability land than that used by NSW Government agencies.

The types of land also varied by sub-region (only land set aside for conservation is similar). In Figure 7, properties in the three sub-regions are compared in terms of the productive capabilities (defined by particular types of land, suitable for different purposes, and corrected for property size). The estimated proportion of land suitable for grazing (either with or without occasional cultivation) dominated other land capabilities both in the N and SE. There was a relatively high percentage of land suitable for regular cultivation in the SW. The proportion of marginal land was lowest in the SW and highest in the SE.

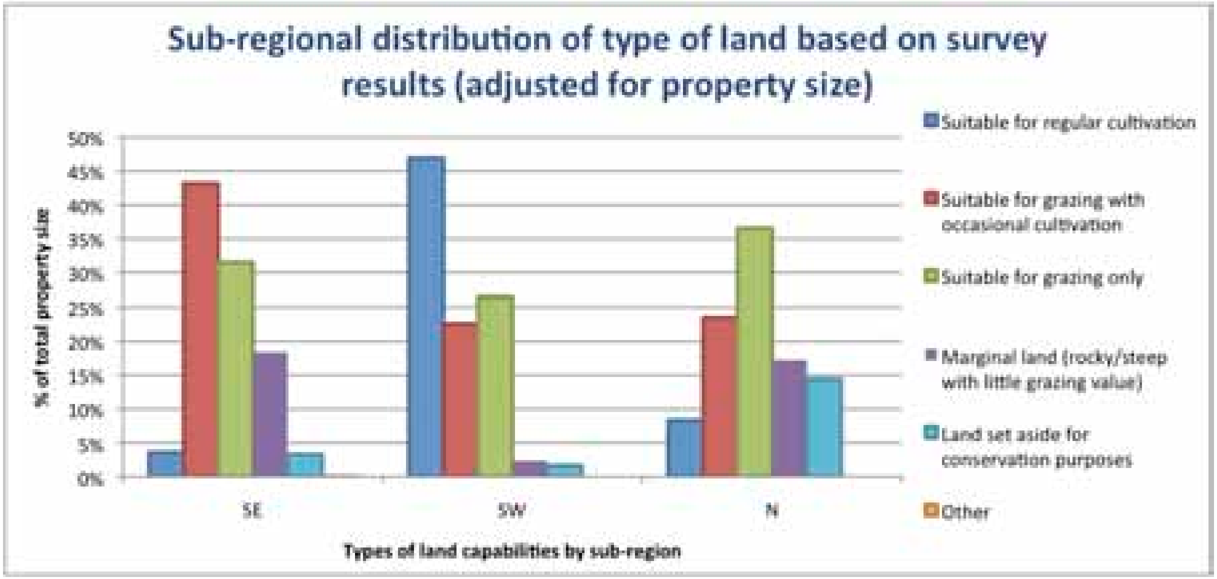


Figure 7 – Sub-regional distribution of type of land based on survey results (adjusted for property size)

Map 5 shows the distribution of marginal and grazing land capability types across the region (DIPNR 2004). According to this, the largest areas of marginal land ('other' in Map 5) were found in the N sub-region, but there were also significant areas of marginal land in the SE (around Lithgow) and in the SW (north of Bathurst and along the southern periphery of the region). Grazing lands were found across all sub-regions. Figure 7 seems to indicate that most marginal land was not found in the N, but in the SE, but that figure was not adjusted to property size. In other words, marginal land was found to be most prevalent in the SE (lowest in the SW) as a percentage of property sizes, but in absolute size, it was highest in the N.

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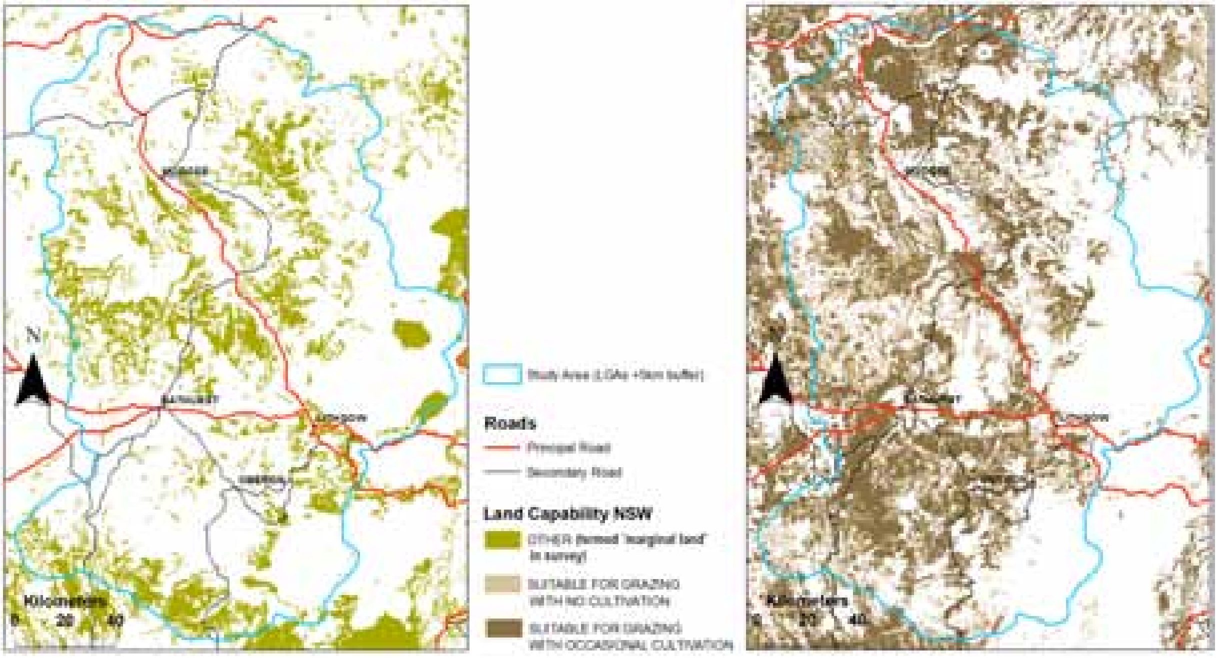
[3] 'Marginal land' was used in the survey as a description for land classed 'other' (Classes VII and VIII) under NSW Land Capability mapping. Class VII refers to 'areas of steep slopes, shallow soils and/or rock outcrop' and Class VIII refers to 'cliffs, lakes or swamps and other lands unsuitable for agricultural and pastoral production' (Emery 1988).



Map 5 – Distribution of marginal land (left) and grazing lands (right) in the study region (DIPNR 2004)

Comparing land size and land use

There were notable differences in major land use according to property size. Figure 8 shows the survey results for commercial cropping, commercial grazing, lifestyle/hobby farming, conservation of remnant vegetation and environmental plantings in the four property size categories (respondents could tick more than one major land use). Commercial graziers clearly dominated in the larger property sizes; lifestyle/hobby farmers dominated in the smaller sizes. Commercial cropping only appeared as a major land use in the 100−850 ha and >850 ha size classes. No landholders in the >850 ha class nominated conservation of remnant vegetation or environmental plantings as major uses, although many nominated these two uses as minor uses (58% for conservation of remnant vegetation and 26% for environmental plantings).

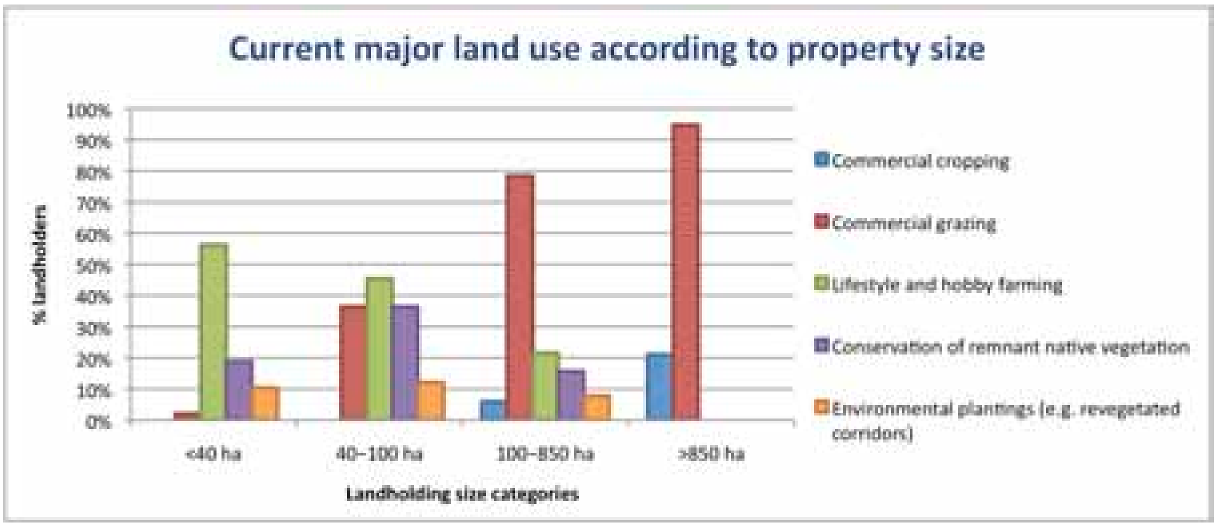


Figure 8 – Current major land use according to property size

Comparing land size and land capability

A similar picture emerged when property size was compared to the suitability of particular types of land instead of current land use. Respondents in the survey stated differences in productive capacity of land (type of land) depending on their property size. Land suitable for grazing and cultivation was more prevalent on larger properties; marginal land and land suitable for conservation was more prevalent on smaller properties.

The PRA interviews revealed that landholders with large properties generally have little marginal land, and might have subdivided their marginal land in the past. To assess this, we compared land capability, i.e. the amount of marginal land and the amount of land suitable for grazing, to property size (Figure 9). The graph shows that as property size increased, available marginal land indeed decreased, and land suitable for grazing increased (both with or without occasional cropping). This supports the hypothesis that landholders with large properties have previously sold off their marginal land, although it could also reflect different interpretations of the term ‘marginal land’ by landholders of different property sizes.

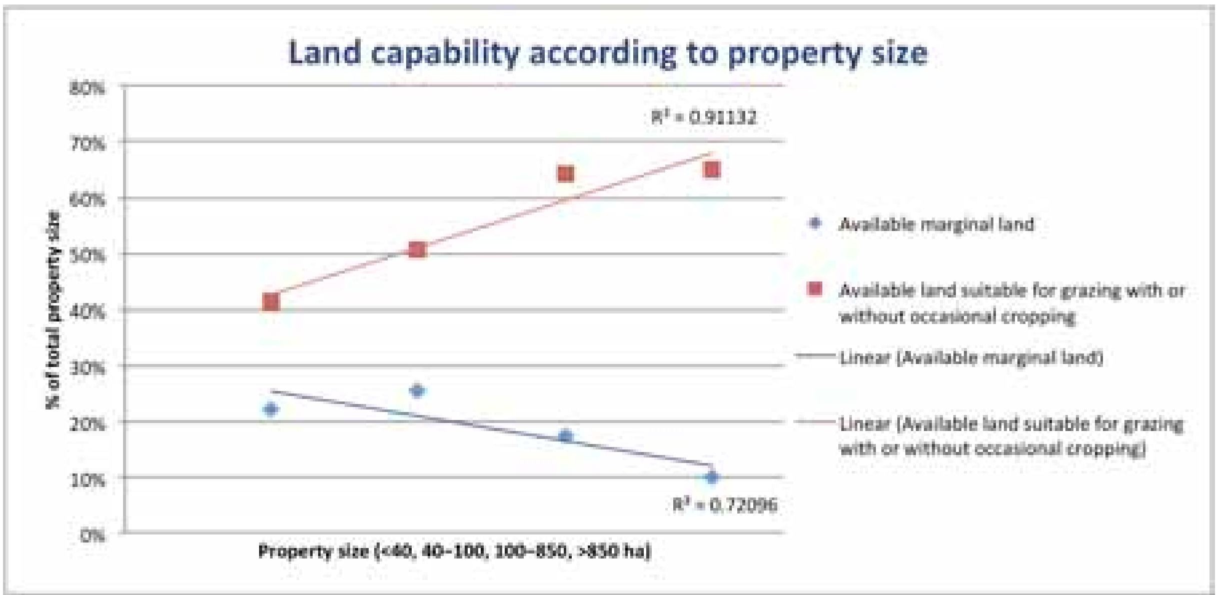


Figure 9 – Land capability according to property size

Perspectives and potential for agroforestry for bioenergy

General perspectives among landholders

When asked to score a range of economic, social and environmental statements, the responses from commercial graziers and lifestyle/hobby farmers did not show much disparity. Overall, the former agreed slightly more with: ‘Farmers have to prioritise making an economic return over improving environmental outcomes’; ‘Farmers should be paid to manage their land to provide benefits for the wider community’; ‘The science behind climate change is doubtful’; ‘Good agricultural land should grow food, not trees’; and ‘Tree planting is more acceptable on marginal land’. Lifestyle/hobby farmers agreed slightly more with: ‘Farmers have a responsibility to manage their land to provide benefits for the wider community’; ‘Human use of fossil fuels is changing the climate’; and ‘Planting trees should involve native rather than exotic trees’. Although it is a generalisation, commercial factors seemed to weigh slightly more than social and environmental ones for commercial graziers, and vice versa for lifestyle/hobby farmers (Figure 10).

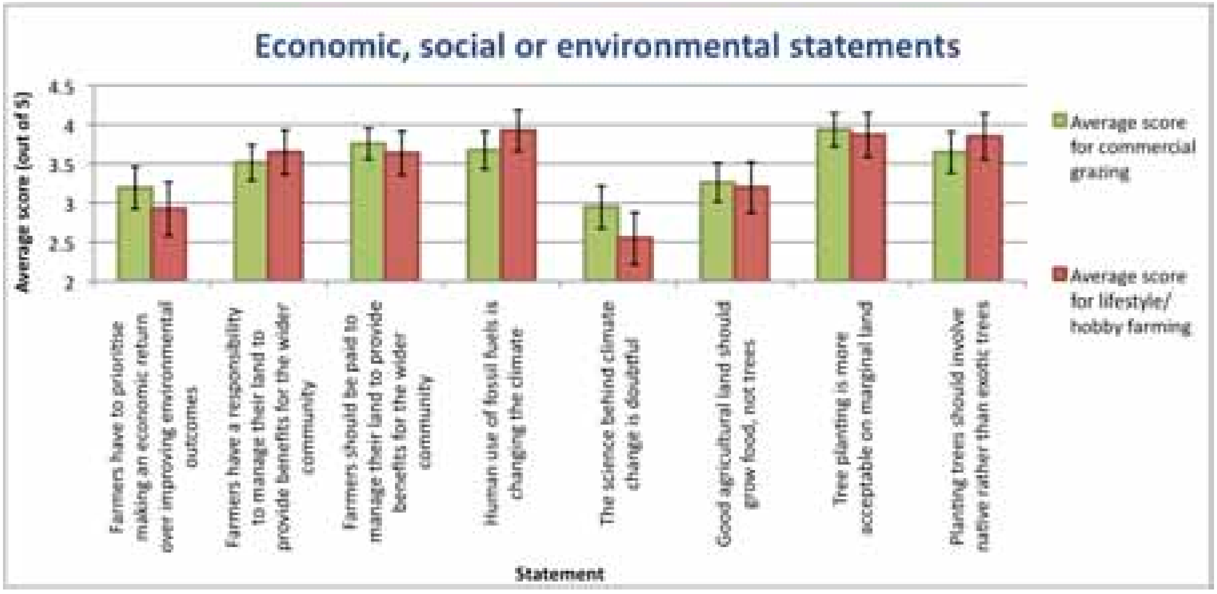


Figure 10 – Economic, social or environmental statements

There were no large sub-regional disparities in the way respondents rated these economic, social and environmental statements. Only a few statements seemed to indicate some difference, such as giving priority to economic returns, being paid to provide benefits, having doubts about climate change, prioritising land for food and focussing tree planting on marginal land (Figure 11).

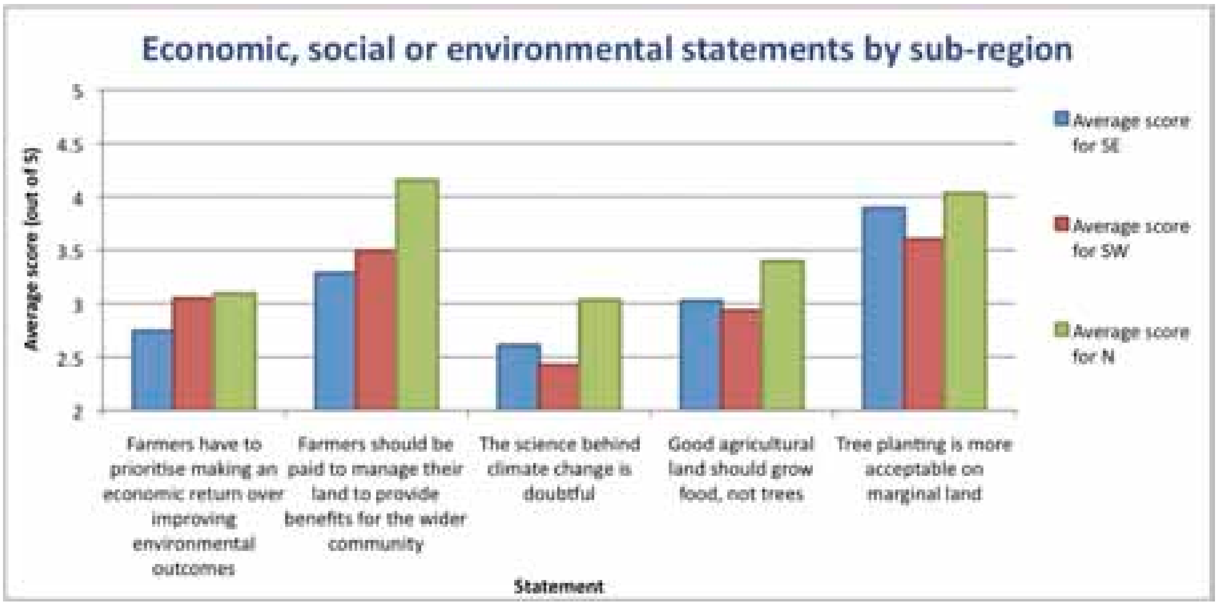


Figure 11 – Economic, social and environmental statements by sub-region

It is often assumed that the belief in climate change would positively influence the level of interest towards agroforestry/bioenergy (here measured as the amount of land nominated for agroforestry proportional to total property size). In Figure 12, we compare the amount of land nominated to three different responses related to climate change (‘Human use of fossil fuels is changing the climate’, ‘Agroforestry stores carbon to mitigate climate change’, ‘Agroforestry helps adapt to climate change impacts’). In general, the level of agreement with these statements was positively correlated with the amount of land nominated. The correlations were, however, quite weak based on R^2 values[4].

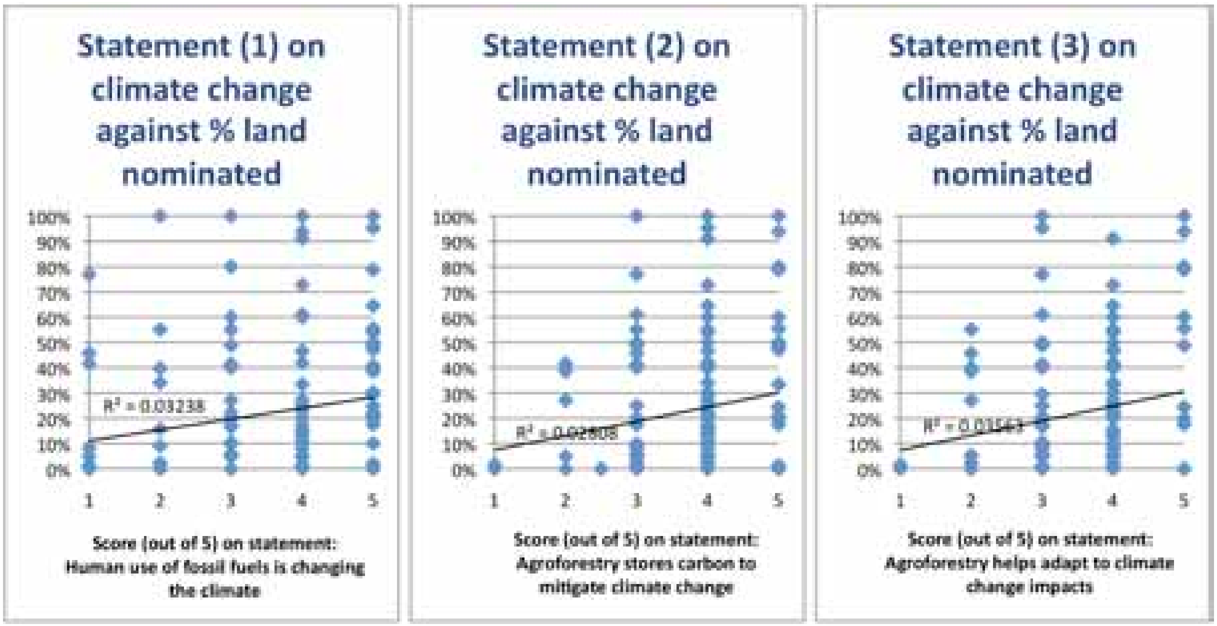


Figure 12 – Statements on climate change against % land nominated

[4] The coefficient of determination R^2 is used in linear regression to analyse the relationship between two variables.

Current experience with tree planting or tree cropping

There was a high level of experience with tree planting and tree cropping in the region, both for commercial and non-commercial purposes. From our survey, 21% of landholders mentioned some experience with commercial agroforestry and 84% of landholders had experience with non-commercial agroforestry. Respondents expressed a range of aims for undertaking agroforestry, as shown in Figure 13. Other specified experience includes trees for regeneration, olive/nut/seed production, fodder and shelter.

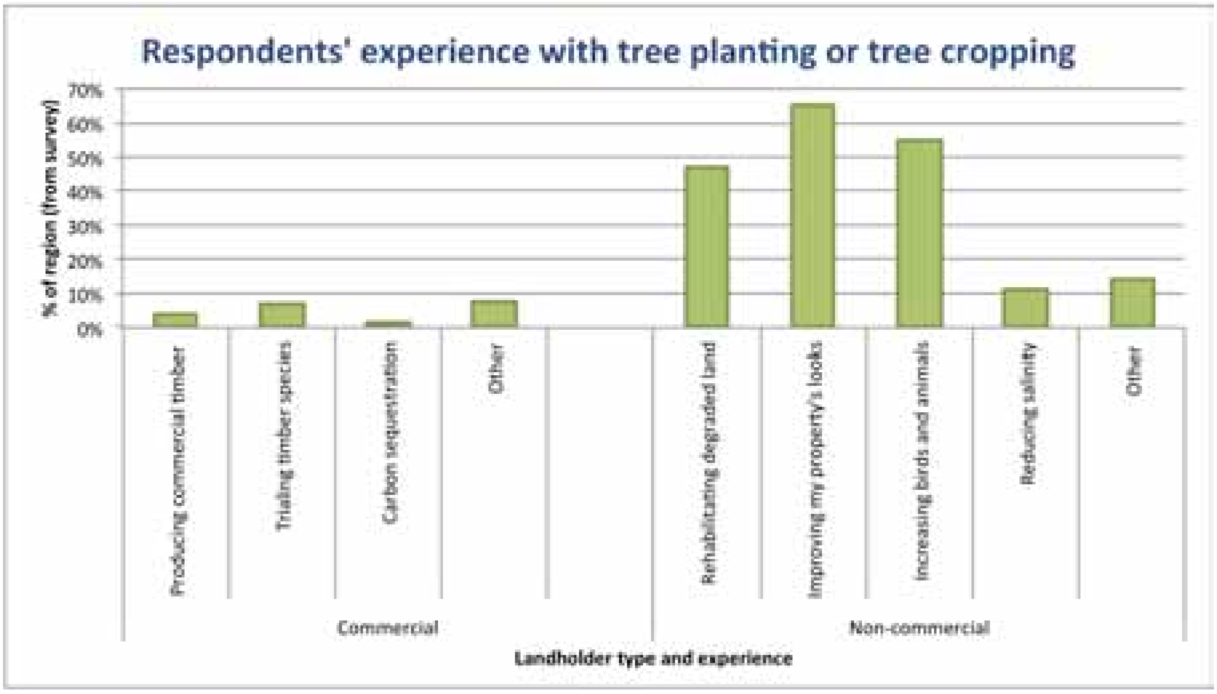


Figure 13 – Respondents' experience with tree planting or tree cropping

We compared the levels of experience with agroforestry between the two major land use categories, i.e., commercial grazing (47%) and lifestyle/hobby farming (35%). There were no major differences between landholder groups. The percentage of respondents with experience in non-commercial tree planting and tree cropping was 84% and 82% for graziers and lifestyle/hobby farmers, respectively. Twenty-one per cent of respondents involved in commercial grazing and 16% involved in lifestyle/hobby farming indicated some experience with commercial agroforestry. The PRA and survey did reveal notable sub-regional differences. Most experience was found in the SE, followed by the N (Figure 14). There may also be differences within sub-regions. For example, interviews in the SE brought to light that farm forestry is uncommon the Lithgow region. In Oberon, on the other hand, landholders planted radiata pine in the 1970s.

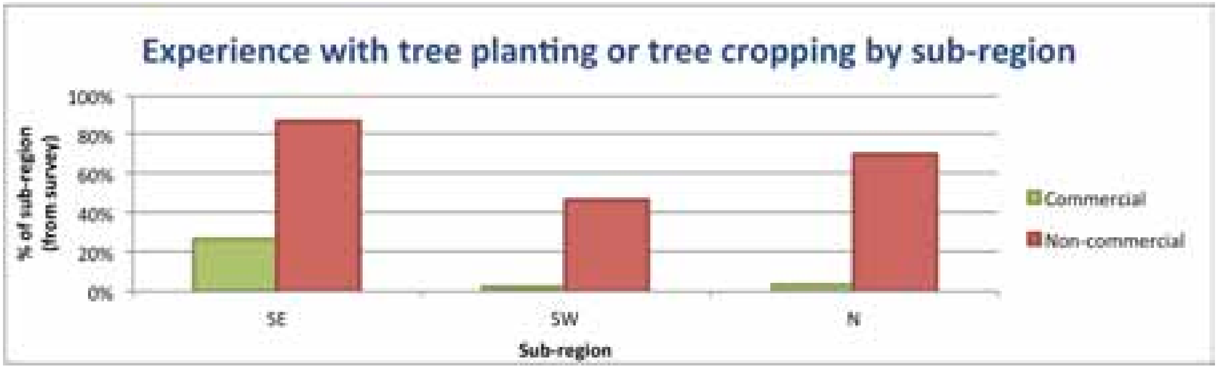


Figure 14 – Experience with tree planting or tree cropping by sub-region

Perceived benefits of and barriers to agroforestry

To assess landholders' perceptions of the benefits of agroforestry, they were asked to rate a range of potential benefits falling within three different categories: environmental, economic or social. The environmental benefits scored slightly higher than the other benefits (Figure 15a). The four highest stated benefits all fell in the environmental benefits category (Figure 15b); providing windbreaks and shelter for stock ranked first, and attracting wildlife and birds ranked second.

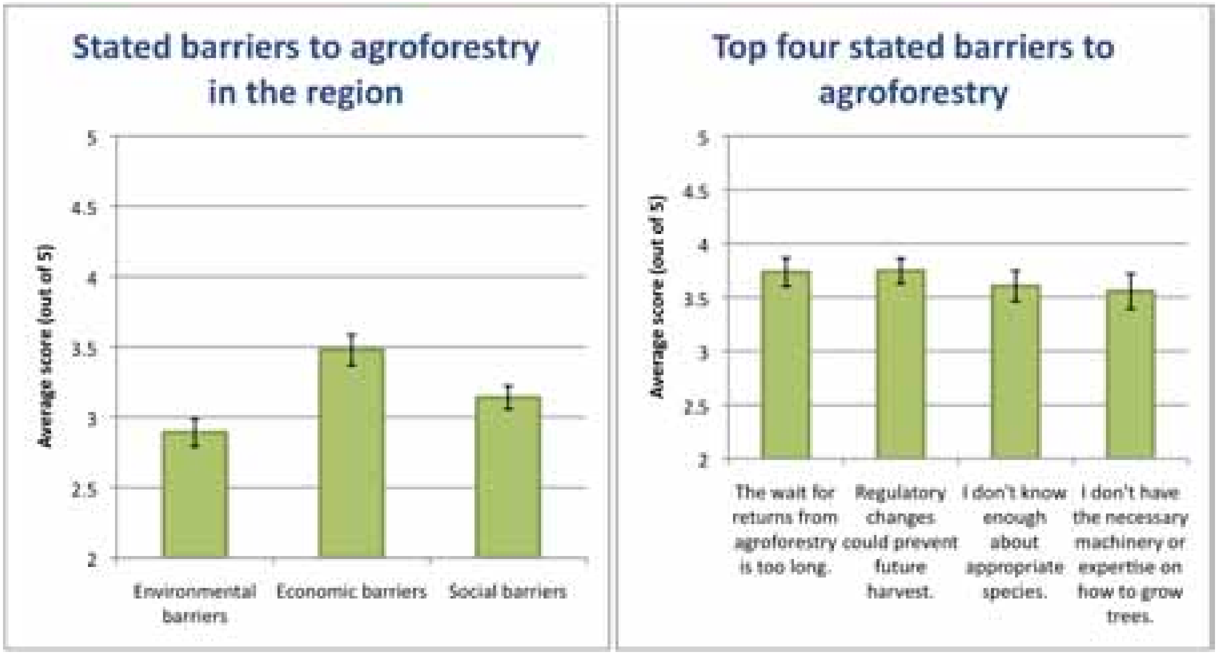


Figure 15 – a. Stated benefits of agroforestry in the region, b. Top four stated benefits of agroforestry

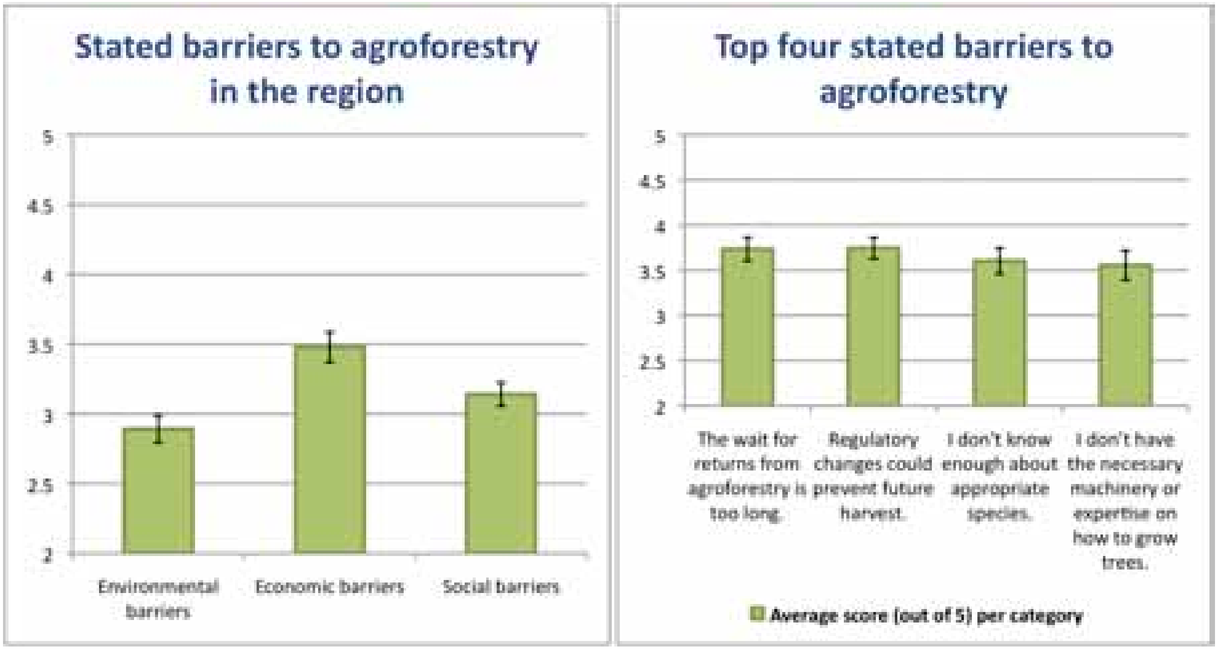


Figure 16 – a. Stated barriers to agroforestry in the region, b. Top four stated barriers to agroforestry

Barriers to agroforestry were also categorised as environmental, economic or social. On average, economic barriers were perceived the highest, environmental barriers were considered the lowest

(Figure 16a). However, the four highest stated barriers were not just economic but also related to perceived problems with regulations, and lack of knowledge and skills for agroforestry (Figure 16b).

The PRA revealed that there is interest in agroforestry, but this could be biased due to the type of landholders that agreed to be interviewed. The survey provided a better tool to assess the level of interest. A higher perception of benefits (Figure 15a) together with a lower concern for barriers (from Figure 16a) could indicate a higher level of interest. Figure 17 shows four net benefit categories derived by subtracting the average score for barriers from the average score for benefits (<0, 0–0.5, 0.5–1, >1), each possibly representing a different level of interest. For 20% of surveyed landholders, barriers outweighed the benefits; for the remaining 80% of landholders, benefits outweighed the barriers at different levels.

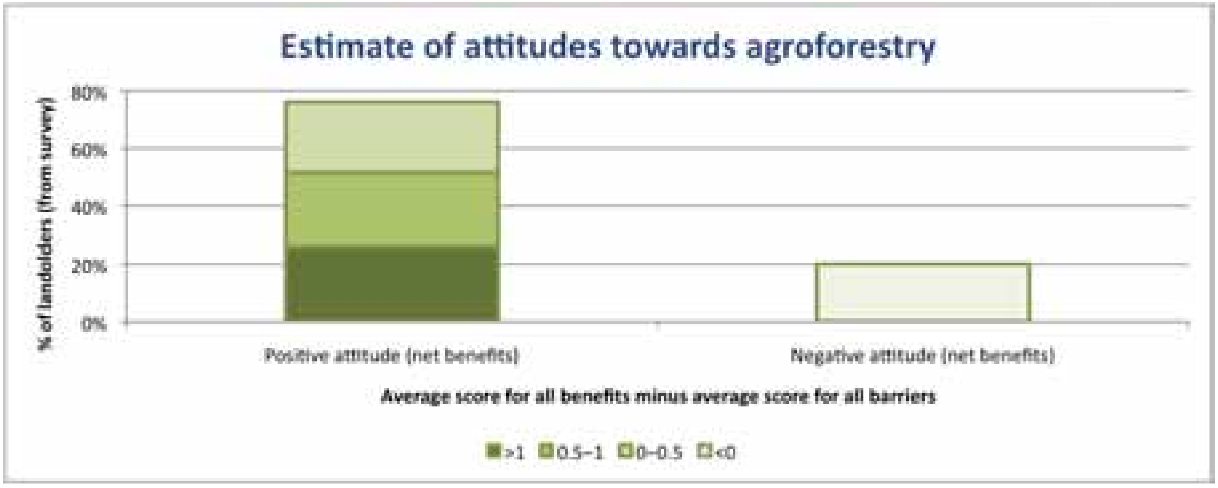


Figure 17 – Estimate of attitudes towards agroforestry

The earlier observation that economic barriers to further adoption of agroforestry would weigh the most, and environmental barriers the least seems true for both major land use categories (graziers and lifestyle/hobby farmers). Moreover, as we can see from Figure 18, lifestyle/hobby farmers gave higher scores to all benefits, compared to graziers (Figure 18).

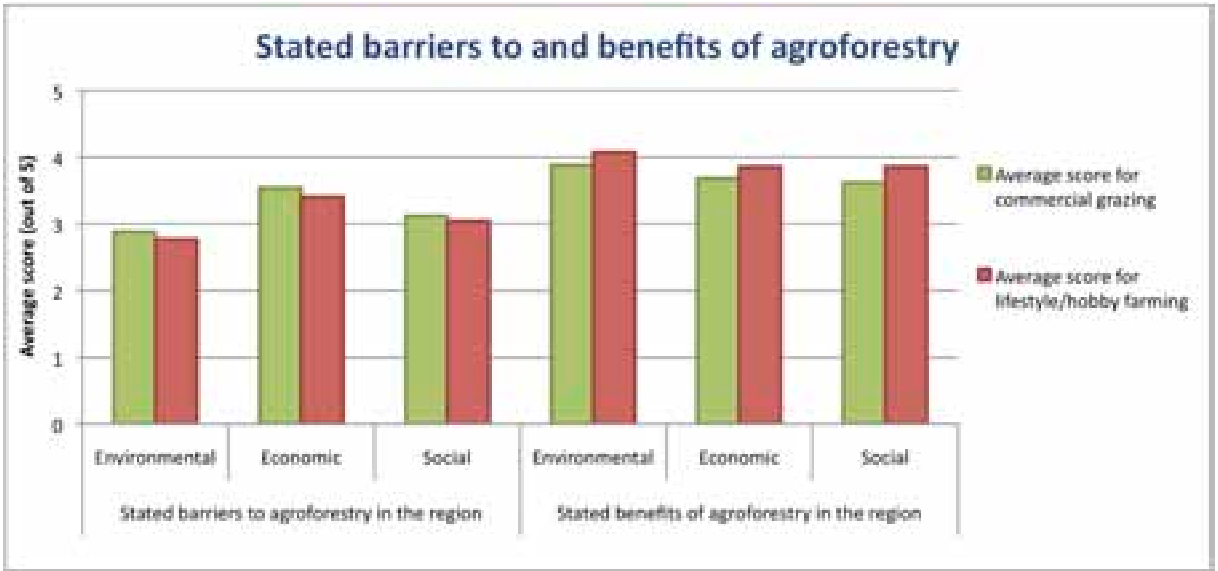


Figure 18 – Stated barriers to and benefits of agroforestry

The PRA revealed that in the SE (Oberon), landholders valued benefits from agroforestry in protecting against erosion. Also, in the SE (Lithgow), interviewees suggested that agroforestry/bioenergy systems would be perceived as beneficial in order to diversify. If it becomes viable, more and more landholders would potentially move into such systems, as they start seeing this as a possible investment in their superannuation. In the N, erosion was not seen as a problem. In the SW (Bathurst), there was a large group of innovative farmers that seemed to identify with a range of new benefits from agroforestry. From the survey data, the benefits of agroforestry were assessed by comparing the average scores between sub-regions. The average ranking of all benefits was highest in the SE, and slightly lower in the SW than in the N (Figure 19). The survey also revealed several notable differences in particular benefits per sub-region (Figure 20). Respondents from the SE indeed gave a higher score to erosion protection compared with those in the N. The pattern was similar for superannuation benefits, although less pronounced. The SE scored higher on wildlife attraction benefits. Diversification benefits were ranked similarly in all sub-regions.

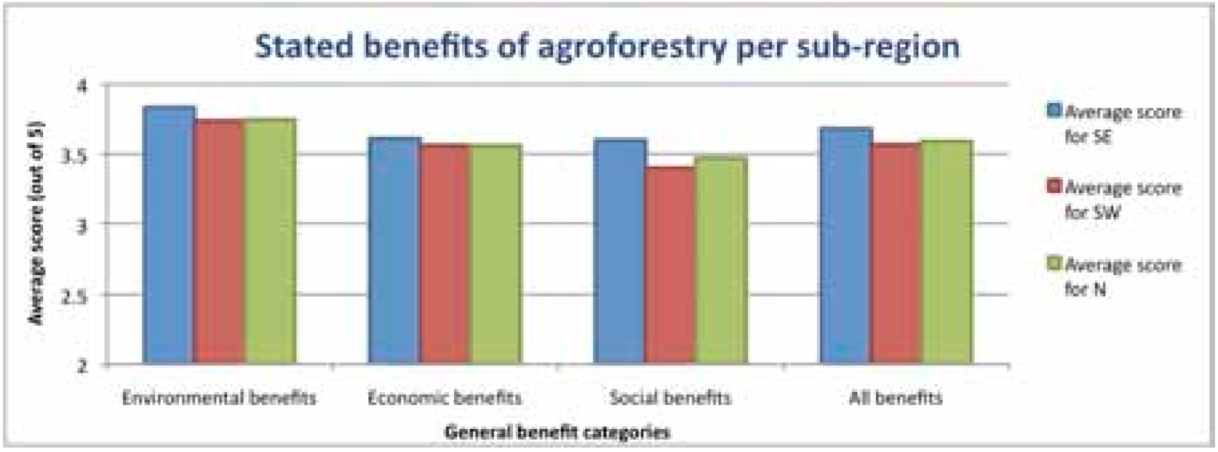


Figure 19 – Stated benefits of agroforestry per sub-region

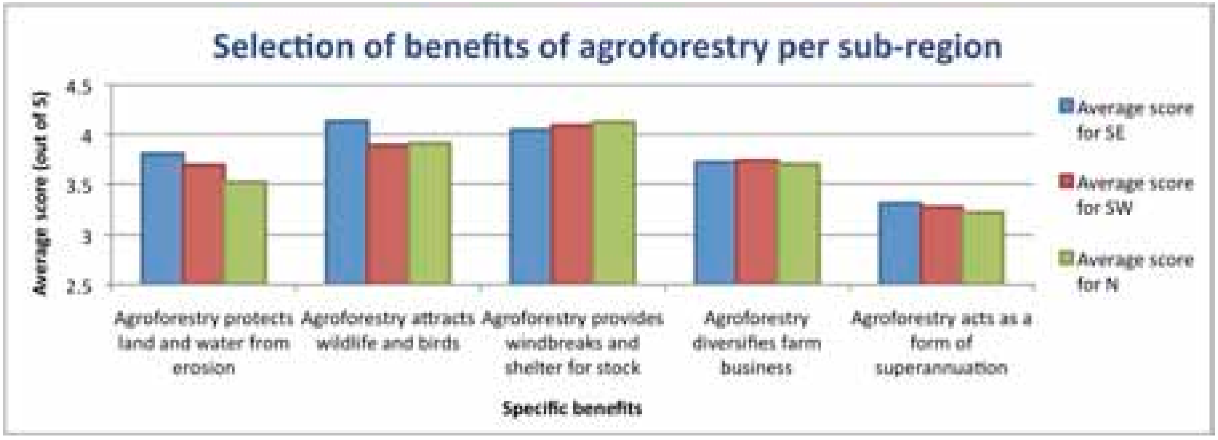


Figure 20 – Selection of benefits of agroforestry per sub-region

From the PRA, it became clear that there was a mix of perceived barriers. In the SW, landholders saw red tape and felt uncertain about regulations. They perceived a possible increase in fire risk and a lack of cooperation between landholders as potential obstacles to adopting more agroforestry. In the N, interviewees identified problems with road infrastructure and fire risk to some extent. In the SE (Lithgow) the barriers that were mentioned were fire risk and water scarcity. The survey revealed that the picture for the overall Central Tablelands (Figure 16) was very similar for each of the sub-regions (Figure 21). For the following barriers to agroforestry, the survey results seemed to fit the PRA findings: 'Regulatory changes could prevent future harvest' (a barrier in all regions, not just the N); 'Agroforestry increases fire risks' (lowest stated barrier in the N); and 'Agroforestry has a negative impact on water availability' (quite low in all sub-regions, but lowest in SW) (Figure 22). Respondents in the N were most concerned with capital and operation and management costs; in the SW, with knowledge and expertise; in the SE, with fire risk.

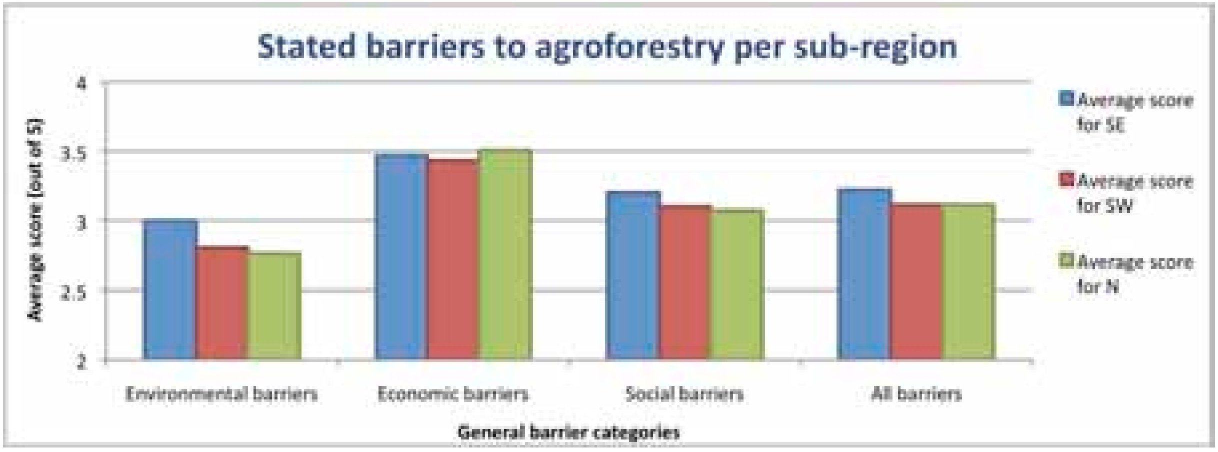


Figure 21 – Stated barriers to agroforestry per sub-region

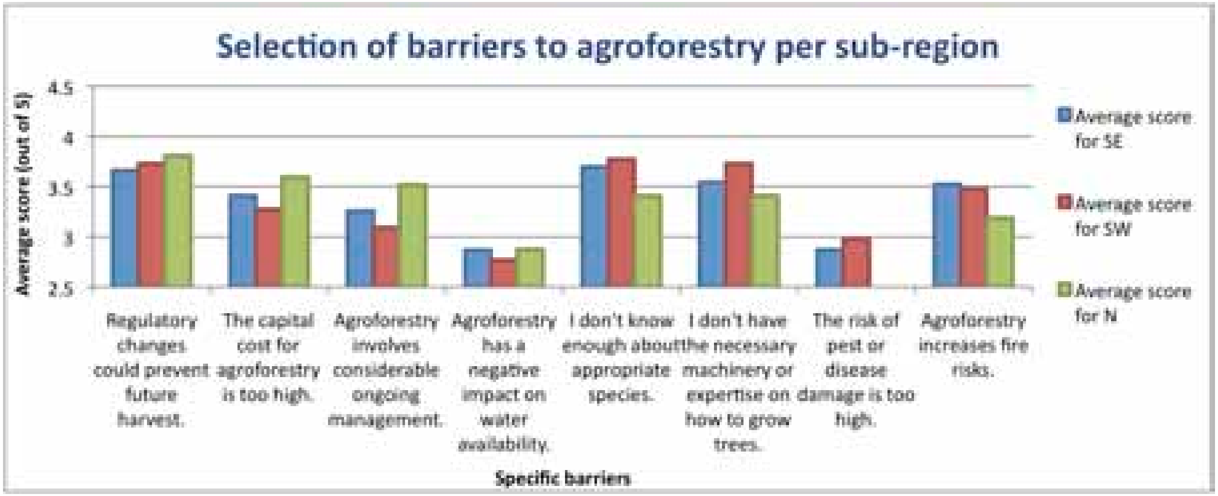


Figure 22 – Selection of barriers to agroforestry per sub-region

Land nominated and level of return

Besides the 'net benefits' approach (see above), another proxy for assessing landholders' willingness to go into agroforestry/bioenergy systems was simply to look at the amount of land nominated in response to the question 'If you were to get involved, how much of your land would you think about turning over to agroforestry?'. In the survey, 66% respondents indicated that they would put some land into agroforestry, depending on a range of factors. Figure 23 shows that there was a positive correlation between a respondent's net benefit score and the percentage of their property they nominated for agroforestry. However, a stronger relationship was found between a respondent's net benefit score and the level of return they would require to consider switching to agroforestry (i.e. a return that was the same, lesser or greater than their current land use). Overall, 50% of respondents said they would require a greater return than current land uses to switch; 19% said they would accept the same return; and 6% said they would accept a lesser return (16% chose 'depends'). Those landholders who said they would accept a return that was the same or lesser than their existing return had significantly higher net benefit scores for agroforestry than those who said they would require a greater return in order to switch (Figure 23).

In this report, the level of return (categorised as 'lesser or same' and 'greater') was used as the measure for assessing the respondents' interest in agroforestry. This way, we avoided the somewhat arbitrary cut off values used with the 'net benefits' approach (<0, 0−0.5, 0.5−1, >1). Moreover, the group of landholders saying they would accept a lesser or same return correlated well with the group giving high net benefit scores.

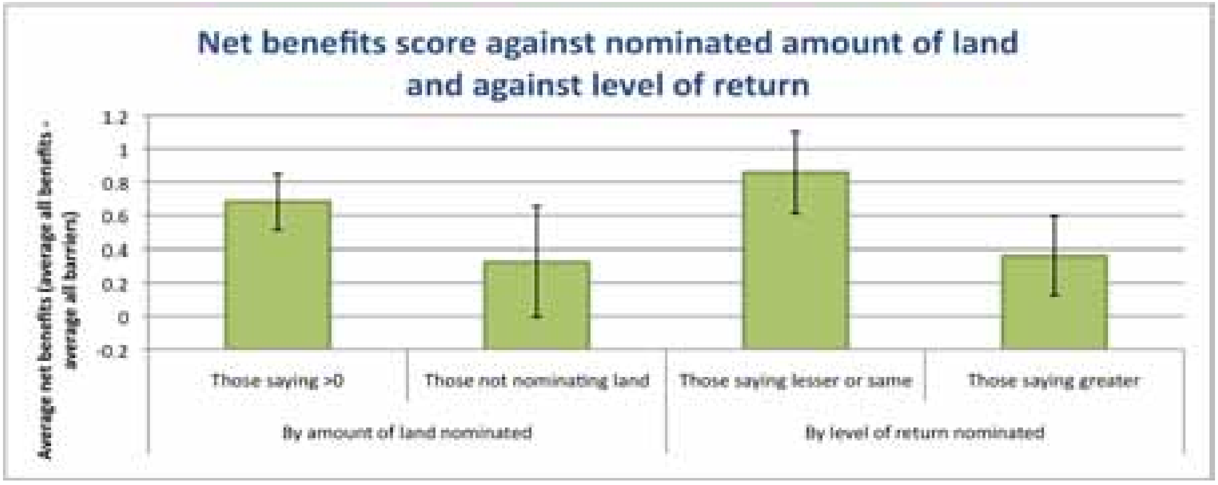


Figure 23 – Net benefits score against nominated amount of land and against level of return

For those landholders who are prepared to put some land towards agroforestry, the type of land to be used varied (Figure 24). Marginal land was nominated most (51%), followed by grazing land (38% for grazing only and 35% with occasional cropping); cultivation and conservation land were nominated least. Respondents could select one or more options from the survey. The preferred type of planting was a combination of strip and block plantings (55%), followed by block plantings (21%) and strip plantings (8%).

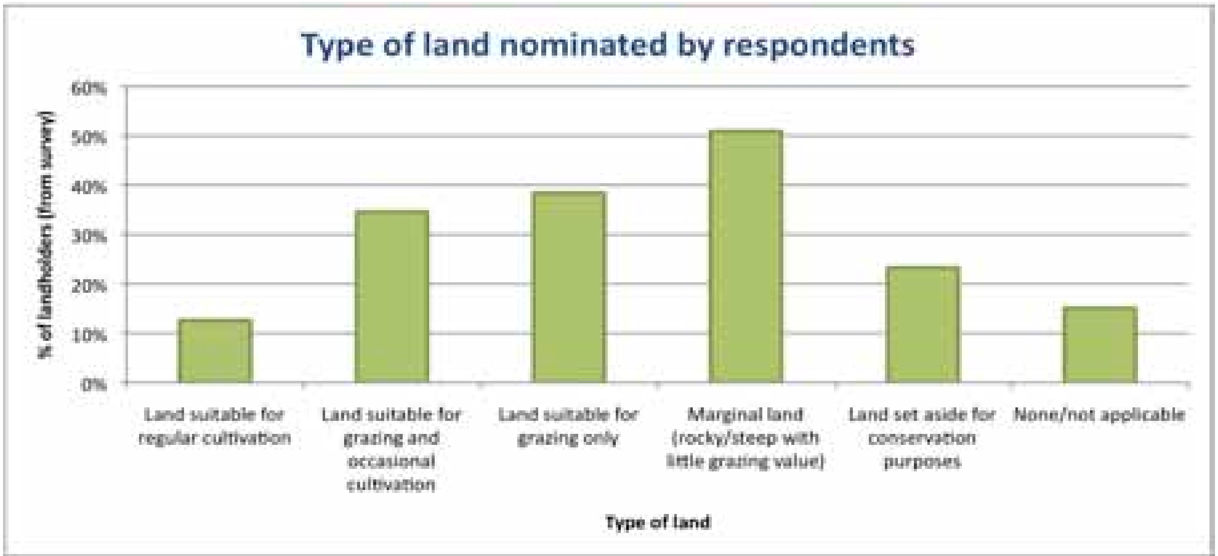


Figure 24 – Type of land nominated by respondents

The PRA interviews often revealed that the level of return needed for uptake depended on the type of landholder, with lifestyle/hobby farmers not requiring the same return as commercial landholders. The survey data supported this finding, with Figure 25 showing that commercial graziers were more likely to require a greater return and lifestyle/hobby farmers were more likely to accept a return that was the same or less. Among respondents that nominated a dollar figure, landholders in the commercial grazing category indicated a required average return of $1,365 per hectare; whilst lifestyle/hobby farmers needed $631 per hectare. The PRA also suggested that the level of return would depend on the type of land to be used, with prime land requiring a greater return than marginal land. The survey data was unable to show a clear result in this area, as most landholders nominated multiple types of land and only 37% were prepared to put a dollar figure on the return they would require. The 16% of respondents who chose ‘depends’ for the required level of return cited factors such as need for capital injection; the need for consistent returns over time; whether they had a return from the land at present; whether it would compare with their return from superannuation funds; and whether there will be other advantages.

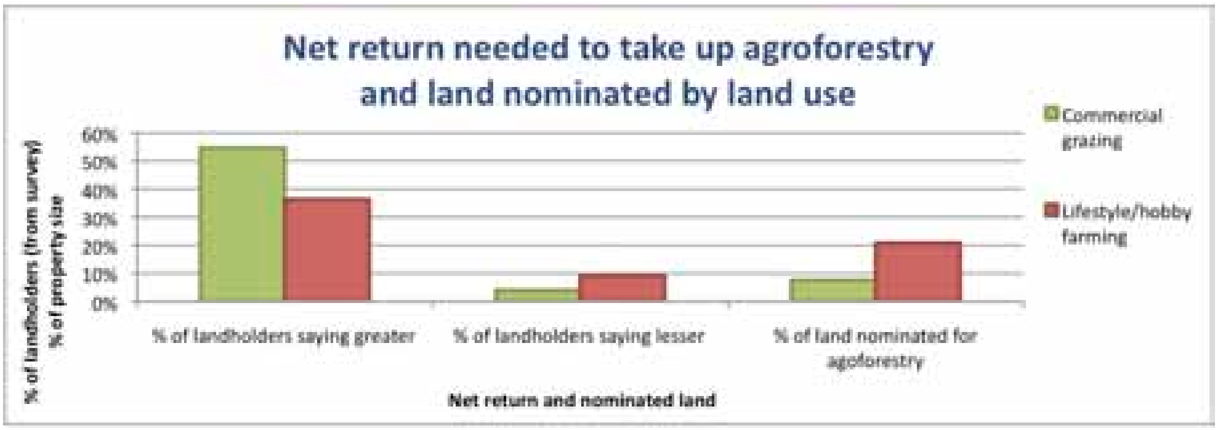


Figure 25 – Net return needed to take up agroforestry and land nominated by land use

During the PRA, interviewees indicated that the current main land use would affect what landholders would consider setting aside for agroforestry. For example, commercial graziers were said not to be willing to put any grazing land into agroforestry. The survey data allowed us to compare the type of land nominated for agroforestry to major land use (either commercial grazing or lifestyle/hobby farming). Figure 26 shows a similar pattern of preference for the types of land that would go into agroforestry between the landholder groups; the only difference was between land suitable for occasional grazing and land suitable for grazing only. Marginal land was the preferred option for both groups, followed by grazing land with or without occasional cropping capability. This contradicts, to some extent, the impression given by the PRA interviews. Respondents even nominated some land set aside for conservation.

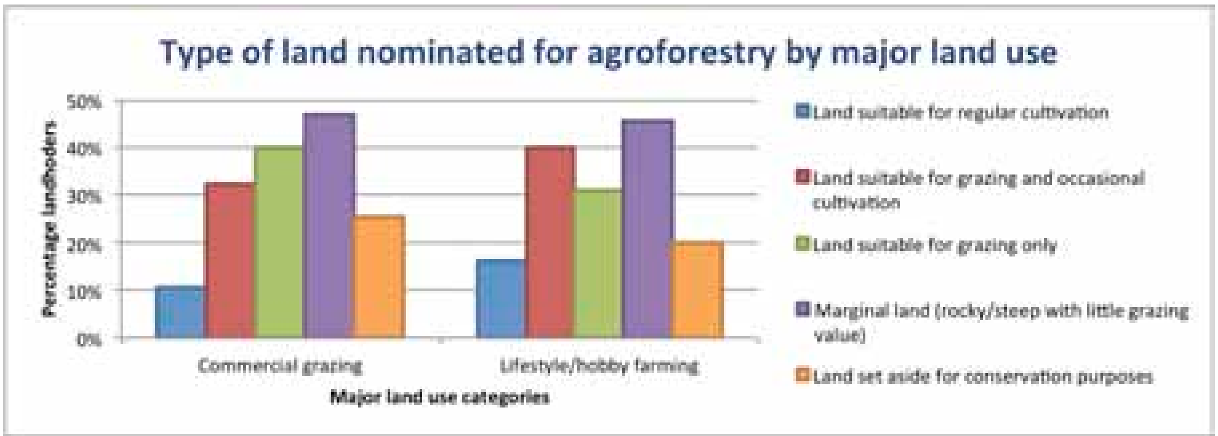


Figure 26 – Type of land nominated for agroforestry by major land use

As explained previously, the potential amount of land nominated for agroforestry could be used as one possible proxy for the level interest of landholders to move into agroforestry/bioenergy systems. Table 3 shows that, according to the amount of land nominated (as a percentage of property size), landholders in the SE could be considered most interested, followed by those in the N, with those in the SW showing the least interest.

Table 3 – Amount of land nominated by sub-region

	SE	SW	N
Number of hectares nominated, adjusted	1095	1869	3106
% landholders nominating >0 ha for agroforestry	63%	62%	79%
% of total property area nominated for agroforestry	14.8%	6.0%	12.6%

In the sub-regions there were notable differences in required levels of returns from agroforestry/bioenergy (compared to current land use returns). Landholders in SE again appeared to be most willing to convert to agroforestry (i.e. more saying 'the same or lesser' was required and less requiring a greater return), with those in the N ranking last in terms of willingness (Figure 27). The dollar figures for a nominated net return are averaged per region in Table 4. The amount stated by landholders in the SW was less than a third of the amount nominated in the SE, and less than half of that of the N. Interestingly, respondents in all sub-regions put forward dollar-value returns from agroforestry that are well above 'typical' sheep grazing returns.[5] PRA interviews revealed that the level of return needed for uptake depends on land use. In the N, farmers with larger properties required higher returns than non-commercial landholders with smaller properties. These results match up as the proportion of 'graziers' to 'lifestyle/hobby farmers' was highest in the N, and lowest in the SE (see Figure 4 and Figure 5).

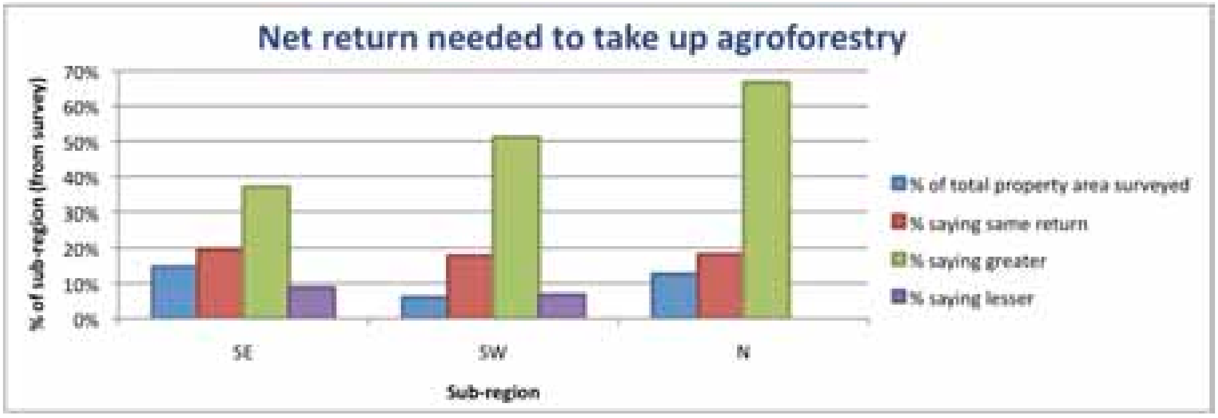


Figure 27 – Net return needed to take up agroforestry

The average ranking of all benefits was highest in the SE, and slightly lowest in the SW (Figure 19). This matched the sub-regional differences in level of interest, as measured by the average amount of land nominated for agroforestry in each sub-region (Table 3). This also coincided with the sub-regional comparison of levels of previous experience with agroforestry (Figure 14).

Table 4 – Average level of return compared per region

	SE	SW	N
Average return required by those nominating a figure (in $/ha/yr)	996	305	644
Typical gross margin from sheep grazing (in $/ha/yr) (For Oberon, Bathurst and Mudgee, from NSW I&I and LPMA data)	271	98	73

[5] Calculated based on NSW Land Property Management Authority (2010) "blue book" values for typical grazing property size and dry sheep equivalents (DSEs)/ha for Oberon, Bathurst and Mudgee, combined with Industry and Investment NSW (2010) Farm Enterprise Budget Series values for 18 micron merino wethers w/ fodder.

Implementing agroforestry for bioenergy

Preferred support schemes

Landholders were asked what type of support scheme would be most effective in driving uptake. Figure 28 shows the overall ranking of five types of support schemes in the region. The pattern was similar when comparing the sub-regions, and when comparing landholder groups according to major land use. The most popular scheme seemed to be upfront establishment support with a score of 4 out of 5. The least popular scheme was price support for products, followed by a payment for ecosystem services. Even at the low end of the confidence interval (CI), upfront establishment scored higher than a product price support scheme at the high CI end. Respondents in the N generally gave the highest ranking to support schemes overall, whilst the SE gave the lowest (Figure 29). This distribution also matched the differences in net return needed to take up agroforestry (Figure 27).

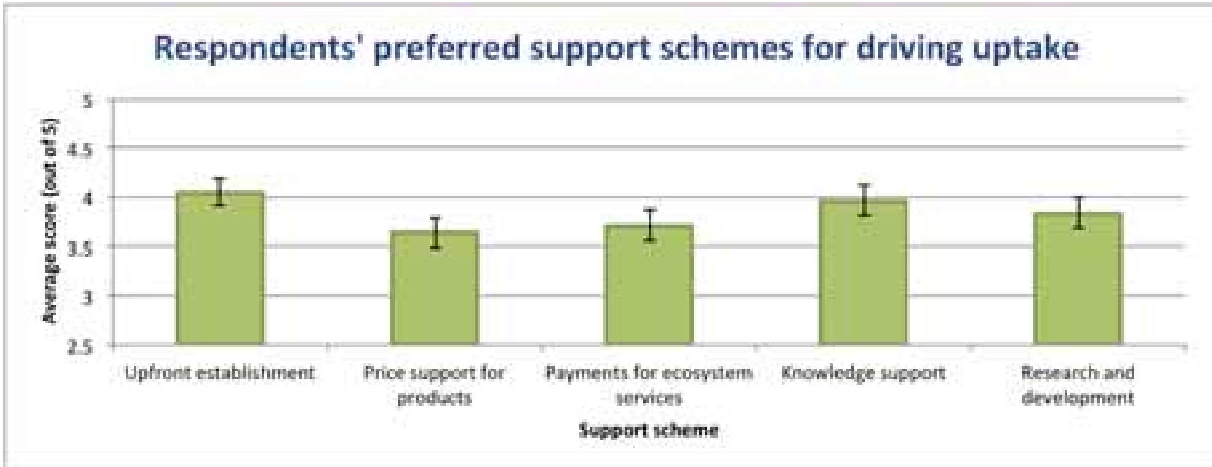


Figure 28 – Respondents' preferred support scheme for driving uptake

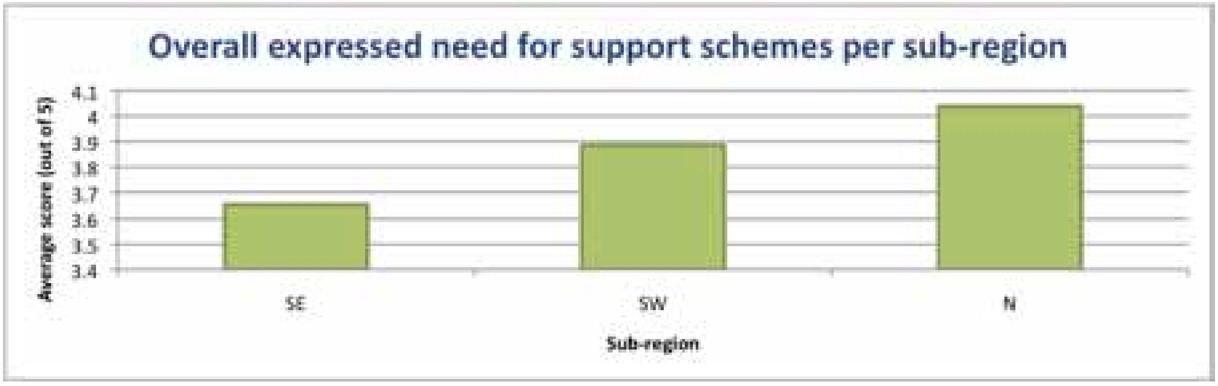


Figure 29 – Overall expressed need for support schemes per sub-region

Landholders in the two major land use categories ranked their preferences similarly for different types of support mechanisms (Figure 30). The main difference was that commercial graziers ranked all mechanisms higher than lifestyle/hobby farmers. The PRA interviews indicated that the preferred options for support depended much more on the level of return needed than on current major land use categories. This seems to be supported by the survey. As seen in Figure 31, price support and upfront establishment schemes scored lower for landholders that stated they were happy with same/lesser returns from agroforestry and higher for those requiring higher returns. Payment for ecosystem services scored higher for those selecting same/lesser returns from agroforestry, and lower for those requiring higher returns.

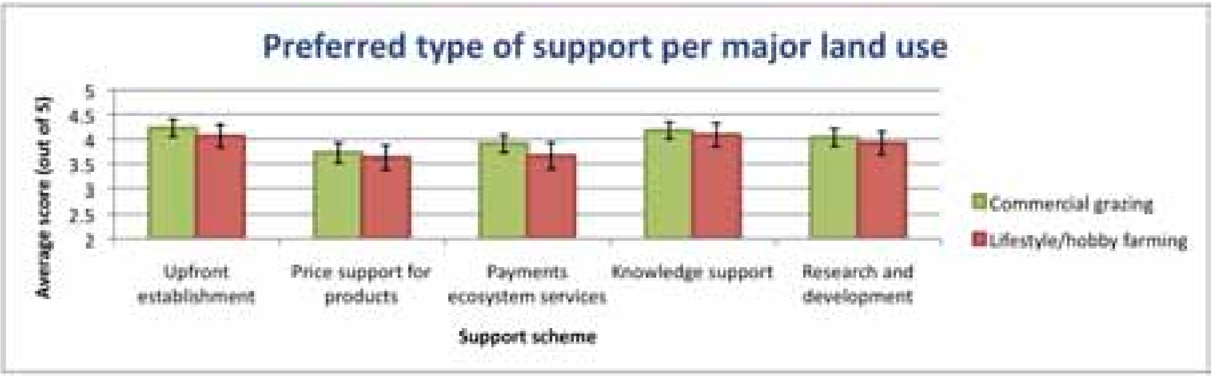


Figure 30 – Preferred type of support per major land use

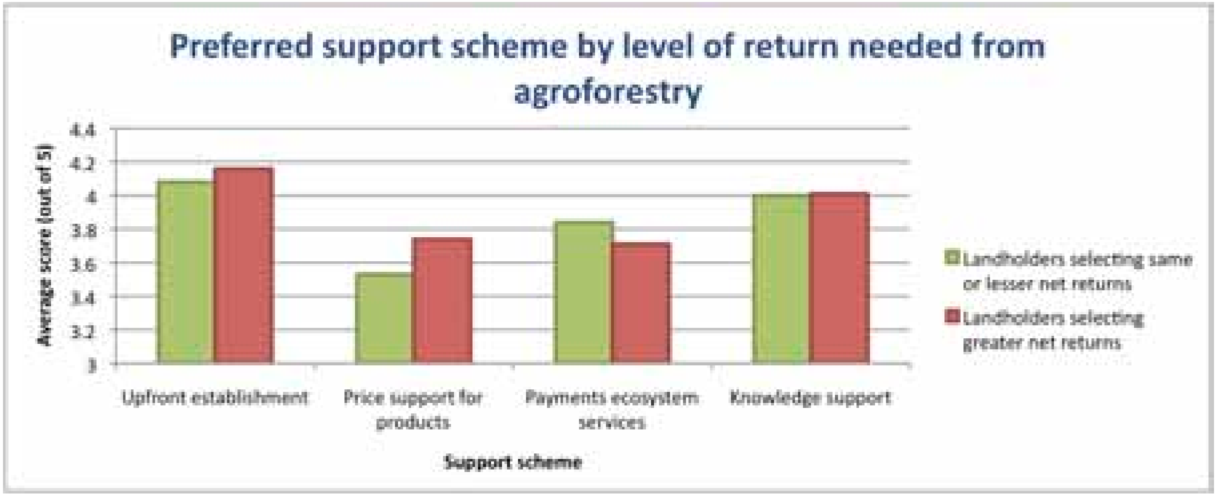


Figure 31 – Preferred support scheme by level of return needed from agroforestry

The survey results (Figure 32) indicated that landholders involved in commercial grazing generally preferred the following approaches to implementation of agroforestry on their land: a mix of trees with different rotations—some for bioenergy and some for timber; and using sites where the value of existing use is lowest. Lifestyle/hobby farmers generally preferred: committing to agroforestry for 70–100 years if it meant extra income from carbon credits; a longer rotation (15–30 years) for higher value products, such as timber; and using sites where biodiversity benefits were greatest.

Results from the PRA indicated that there are regional differences in how agroforestry would be implemented. Some scenarios are likely to be based on combining short-rotation plantations with agroforestry for timber. Interviewees in the N (Mudgee/Rylstone) showed interest in short-rotation (*Casuarinas*) or fast growing eucalyptus. Figure 33 shows the results from our survey. Although the differences were not very significant, a few observations can be made. Respondents in the SE generally scored lower on the preference for a shorter rotation (1−5 years) for lower value products, such as bioenergy, as well as on the preference for a mix of trees with different rotations—some for bioenergy and some for timber. The SE scored relatively higher than the other sub-regions on the selection of sites where growth rates of the trees would be highest. The SW scored relatively lower on the selection of sites where access for harvesting is easiest, as well as on the selection of sites where agroforestry adds value to existing land use (e.g. to reduce erosion, salinity). It scored higher on the preference for a shorter rotation for lower value products. The N scored lower on the preference of sites where biodiversity benefits were greatest, as well as on longer rotation (15−30 years) for higher value products, such as timber. The N scored relatively higher than other sub-regions on the commitment to agroforestry for 70−100 years, if it meant earning extra income from carbon credits.

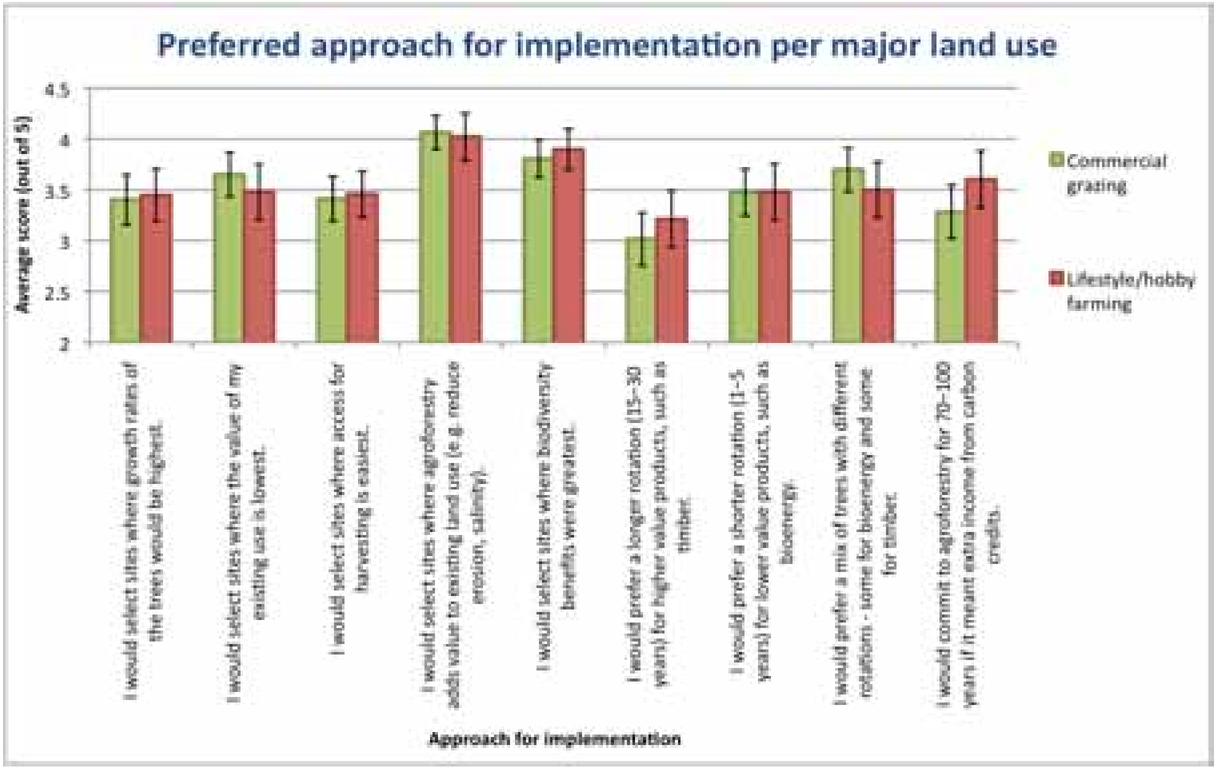


Figure 32 – Preferred approach for implementation per major land use

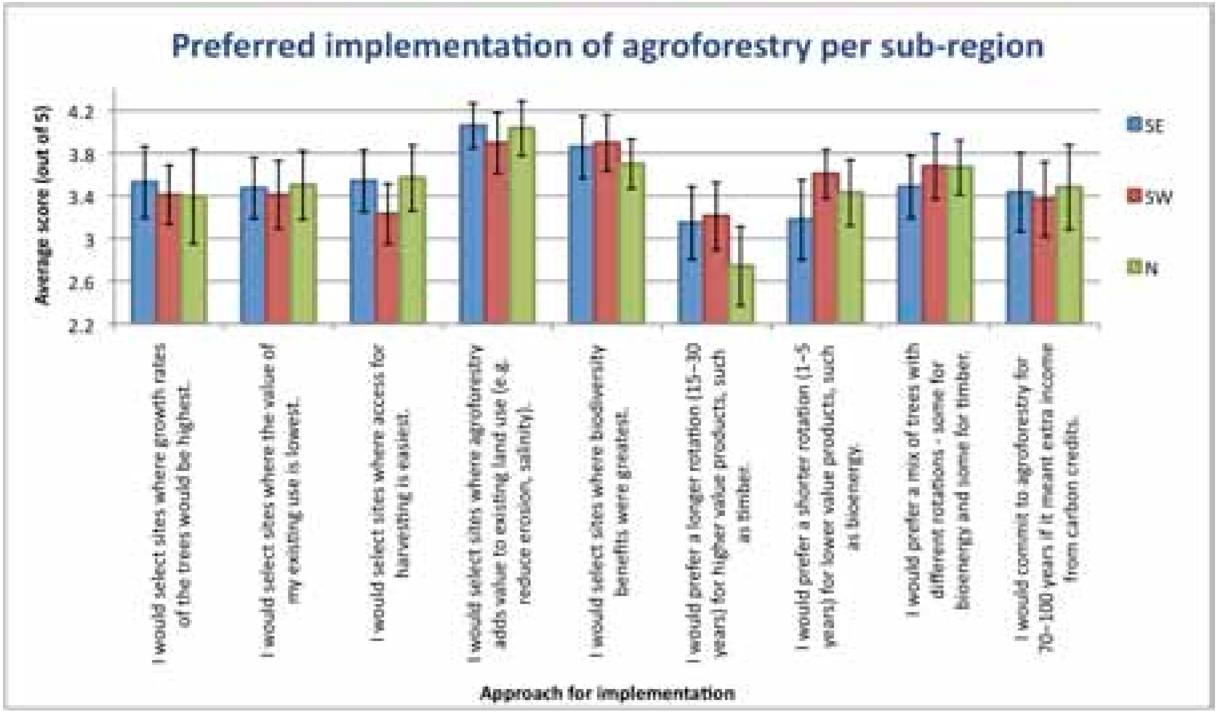


Figure 33 – Preferred strategy for implementation of agroforestry per sub-region

The PRA was useful for discussing some of the preferred options for supporting the establishment of agroforestry/bioenergy systems, and comparing these between the sub-regions. For instance, landholders in Bathurst (SW) indicated a preference for establishment support, not price support. In Mudgee/Rylstone (N), landholders were doubtful about government handouts and more interested in carbon or ecosystem payments. The survey results partly supported this (Figure 34); in the N, respondents were indeed interested in ecosystem services, but not doubtful about government support; in the SW, a preference for establishment support was confirmed, but this was actually true for the entire region.

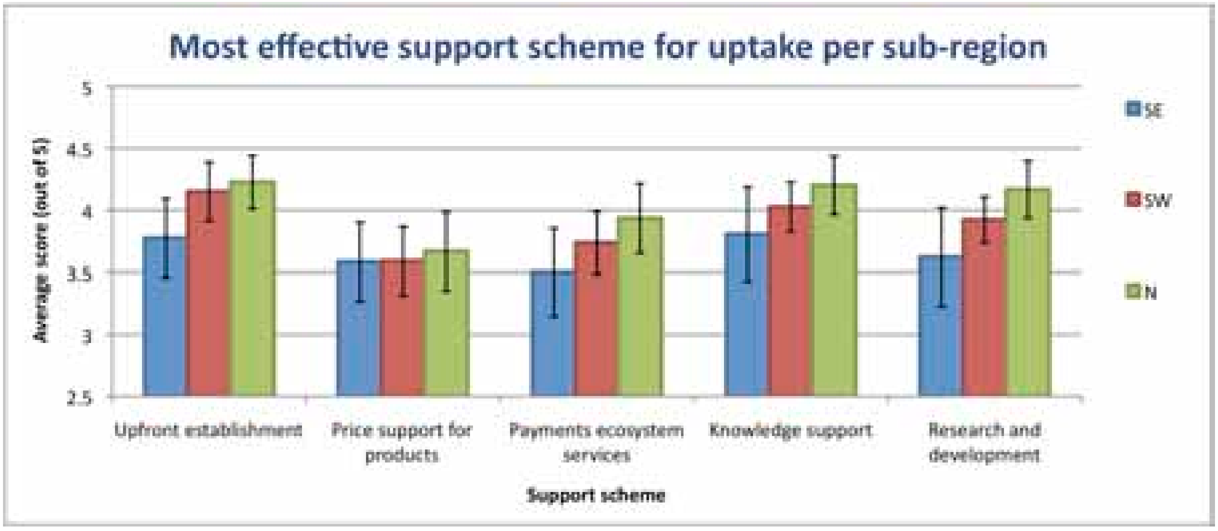


Figure 34 – Most effective support scheme for uptake per sub-region

Use of biomass and species

Previous work on community attitudes to plantations (Williams 2009) has shown that the particular end use of the biomass produced can influence community acceptance of plantations. From the survey, however, when asked whether the respondents had a preference for bioenergy, timber, woodchips, storing carbon or other end uses, only 21% said it mattered (65% said no, 14% did not answer). Some of the stated reasons as to why it mattered were: 'Forestry used for timber sequesters carbon. Bioenergy adds to carbon in the atmosphere'; 'Woodchips to make paper is wasteful'; 'Woodchips seem to be a waste of good timber'; 'Australian landscapes are generally low in nutrients and organic matter, exporting… involves exporting carbon and other nutrients, productivity is being forced down. Carbon storage on site is the only long-term option without remedial inputs'.

From the PRA, interviewees mentioned a wide range of species that could work in an agroforestry/bioenergy system. Most commonly nominated species were manna gum, yellow box, red gum, casuarina, ironbark, blue gum and silver wattle. Preference for particular species varied across the region. For Mudgee/Rylstone for example, there was interest in short-rotation casuarinas or fast growing eucalyptus. From the survey, respondents mentioned box (red, white and yellow); stringybark (yellow); ironbark; pine (radiata, cypress); gum (red, blue, ribbon/manna); carefully selected oak (willow); snow gum and Blue Mountains mallee ash; acacia (blackwood, Ovens wattle and umbrella bush); birch; goat willow; ash; Chinese elm; inland scribbly gum; mealy bundy; and agophora. Some respondents mentioned a preference for native species endemic to their local area, one respondent argued that natives take all the moisture and prefers non-natives.[6]

The interviews during the PRA indicated that potential sources of biomass varied in the region. For example, radiata pine was planted in the 1970s around Oberon, but this might not be available as input for bioenergy. Around Bathurst, there was little existing biomass waste and new plantations would be needed. In Mudgee/Rylstone, biomass resources were potentially available from past trial sites, as tree plantings were widespread for environmental non-commercial benefits (although not among the older farms).

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[6] *Eucalyptus viminalis*=manna gum/ribbon gum; *E. melliodora*=yellow box; *E. camaldulensis*=red gum; *Casuarina spp.*=casuarina; *E. globulus*=blue gum; *Acacia dealbata*=silver wattle; *E. polyanthemos*=red box; *E. albens*=white box; *E. melliodora*=yellow box; *E. mullerana*=yellow stringybark; *Pinus radiata*=radiate pine; *Callitritis spp.*=cypress pine; *Quercus robur*=willow oak; *E. pauciflora*=snow gum; *E. stricta*=Blue Mountains mallee ash; *A. melanoxylon*=blackwood; *A. provissima*=Ovens wattle; *A. cupularis*=umbrella bush; *Betula spp.*=birch; *Salix caprea*=goat willow; *Fraxinus spp.*=ash; *Ulmus parvifolia*=Chinese elm; *E. rossii*=inland scribbly gum; *E. nortonii*=mealy bundy; *Angophora spp.*=angophora.

From the survey, respondents suggested several potential sources of biomass that could be used for a regional bioenergy industry (see Figure 35). Other suggested sources from the survey were: landfill waste, pruning on rotation rather than felling, stock manure, sifton bush (native but invasive), clearings from the mining industry or clearing for residential areas.

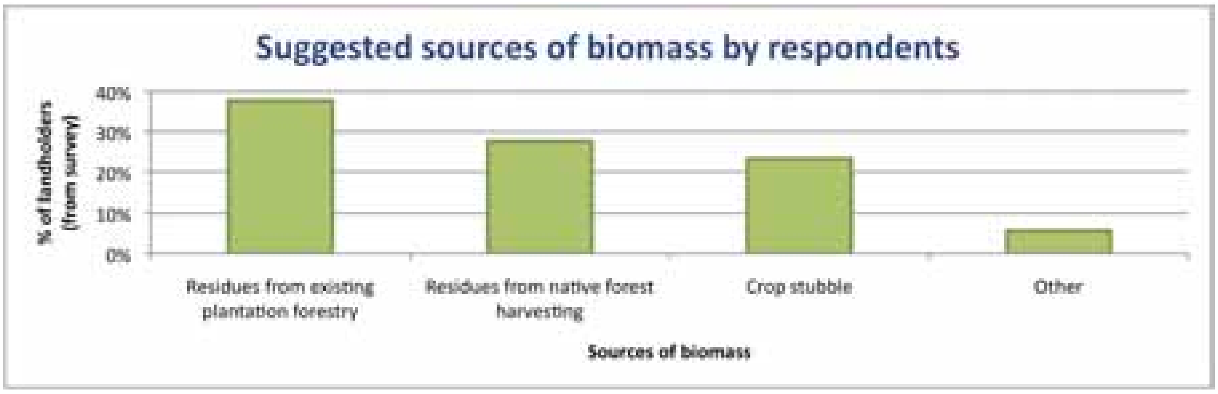


Figure 35 – Suggested sources of biomass in the region

From the PRA, it was clear that the existing and required facilities for agroforestry/bioenergy systems vary from area to area. There is very little in Bathurst, but the power plants at Oberon and Lithgow are not too distant. Mudgee/Rylstone is surrounded with mining infrastructure. The survey did not add much to the PRA results in terms of assessing existing facilities (except rail access and electricity grid access near Portland and Wallerawang). Infrastructures that would be needed included a suitable transport infrastructure, local mills and harvesters, an institution that ‘does the lot and pays the landholder’, an upgrade of existing roads and access to properties, an improved railway, new specialised bioenergy power stations, portable machinery to work on farm and so on.

Spatial Analysis

Introduction

The scenario development component of the project sought to determine four main elements:

1. the maximum available area of land for new plantations in the study area based on regulatory constraints
2. the area of private rural land in the study area that may be converted to agroforestry based on landholder interest
3. potential locations for bioenergy facilities and the impact this may have on the location of new plantations
4. the spatial distribution of natural resource management issues that could potentially be addressed through revegetation activities.

For the purposes of this analysis, the study area was defined as the Bathurst, Oberon, Lithgow and Mid-Western LGAs plus a 5 km buffer.

Maximum potential area for new agroforestry

The determination of maximum potential land available under regulatory constraints required the exclusion of each of the following areas based on regulatory restrictions hindering the establishment of plantations:

- National Parks, Nature Reserves and State Conservation Areas
- areas where forestry activities are restricted under the latest Local Environment Plans of Bathurst, Oberon, Lithgow and Mid-Western councils.
- all areas within 20 meters of a river or wetland (Photo 7).
- all areas of existing native woody vegetation.


Photo 7 - Exclusion zone around a stream.

The rivers, wetlands and native vegetation exclusions were derived from the NSW Plantations and Reafforestation Code, which was interpreted conservatively wherever possible. The Code requires different buffers around wetlands, rivers, drainage lines and drainage depressions (defined using the Strahler scale of stream order), but in order to be conservative the maximum buffer of 20 meters was applied to all wetlands contained in the Wetlands of NSW dataset (Department of Environment and Conservation 2005) and all watercourses contained in the Geoscience Australia (2006) TOPO 250K series 3 dataset.

Similarly, while the Code provides some exemptions for clearing of native woody vegetation (e.g. regrowth, irregular projections), the maximum scenario excluded all areas classed as either ‘most likely’ or ‘likely’ to consist of woody native vegetation under the NSW Interim Native Vegetation Extent v1 ‘hybrid’ map (Department of Environment and Climate Change 2008a).

Private rural land scenarios

Determining the area of rural private land in the study area required the exclusion of all National Parks, Nature Reserves, State Conservation Areas, State Forests, Vacant Crown Land and Reserved Crown Land, as well as all land uses classed as urban, transport, power generation or mining and quarrying under NSW LUMAP (land use mapping) (NSW Government 2007). The remaining area was then clipped to include only cadastral units falling wholly within the study area (using a cadastral layer provided by the NSW Land and Property Management Authority). This approach was also aimed at providing a conservative estimate of available rural private land, as around 4% of overall rural private land was excluded due to gaps in the cadastre.

Photo 8a & b – Various types of tree planting on private land

The area of private rural land formed the basis for three scenarios based on different levels of landholder uptake of agroforestry, classed as the high, medium and low scenarios (see Photo 8a & b). These scenarios were based on the results of the landholder survey, particularly the questions asking how much land respondents might be interested in converting to agroforestry for various forms of tree planting) and what level of return they would require relative to their current land uses (greater, lesser or the same). These scenarios were passed on to CSIRO for use in their related project, which involved modelling the potential amount of biomass that could be sourced from new plantations in the Central Tablelands of New South Wales.

Bioenergy facility locations and transport distances

Determining potential bioenergy facilities for the study region was based on both the PRA and the landholder survey, which included questions on what locations may be suitable and what additional infrastructure may be required. These locations were then used to calculate a maximum viable biomass transport distance by road, with roads defined as those classed as ‘primary or secondary roads or highways’, ‘dual lane highways’ or ‘connectors’ under the roads layer of the Geoscience Australia (2006) GEODATA TOPO 250K series. Estimating a maximum transport distance was difficult without knowing the price that bioenergy products might attract and the other costs involved. A figure of 85 km by primary or secondary roads (plus a 2 km buffer to account for short journeys on minor roads) was agreed upon for maximum viable transport distance (i.e. the distance most biomass would be sourced from within) based on the following assumptions:

- Average transport distances are likely to be around 50 km based on assumptions used by O’Connell et al. (2009) in their modelling of eucalypt biomass conversion to electricity and liquid biofuels in Queensland; Yu et al. (2007) in their modelling of Mallee transport distances in WA; and Hoogwijk et al. (2009) in their modelling of short-rotation eucalypts for bioenergy across a range of countries.
- Maximum transport distances are likely to be less than the 125 km maximum that softwood timber needs to be transported within the Macquarie region from Mt Canobolas to Oberon (due to bioenergy having lower value than timber).

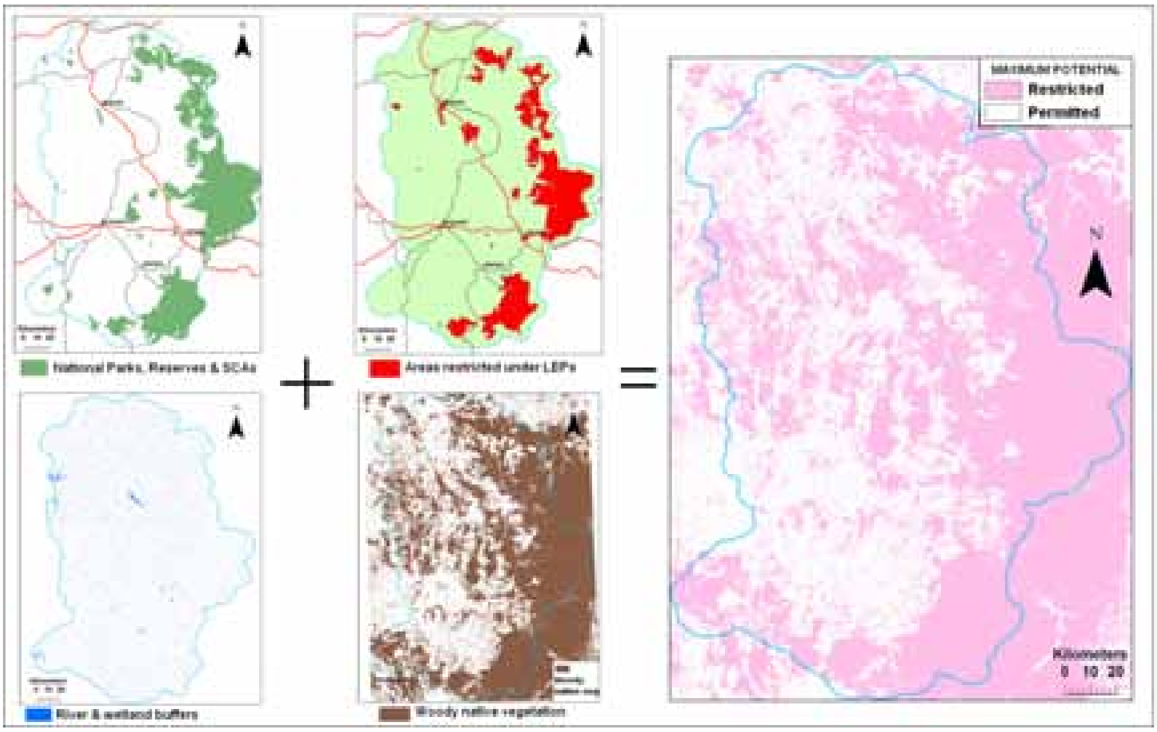
NRM and land use factors

The key NRM and land use factors to be analysed were based on the PRA and survey results. Of the potential environmental benefits that PRA and survey participants perceived from agroforestry, biodiversity, erosion and salinity were able to be assessed using spatial data provided by Hawkesbury-Nepean CMA, Bathurst Regional Council, Mid-Western Regional Council and the NSW Department of Environment, Climate Change and Water (DECCW). The top-ranked environmental benefit of agroforestry from the survey, windbreaks (Photo 9), was unable to be assessed spatially (and was assumed to have little off-property environmental benefit). Clearing levels for different vegetation communities (based on the Mitchell Landscapes ecosystem classification) was provided by Hawkesbury-Nepean CMA and these were compared to remaining woody native vegetation to identify potential sites for revegetation that could contribute to habitat corridors. Bathurst and Mid-Western councils were able to provide data on erosion rates and dry-land salinity that allowed analysis for the N and SW sub-regions. Vegetation, erosion and salinity data were then compared to the spatial distribution of landholding size (from the Land & Property Management Authority cadastre) and land capability (DIPNR 2004) to determine where the greatest synergies may be found between landholder interest in agroforestry and potential NRM benefits.

Photo 9 – Trees providing windbreaks

Maximum potential area for new agroforestry

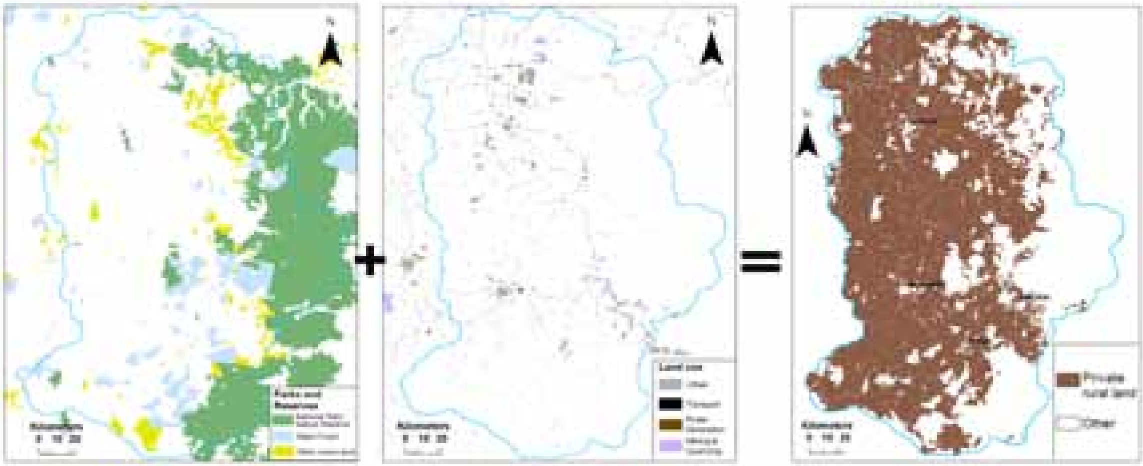
The white area on the right of Map 6 represents the maximum area potentially available for new plantations under state and local government regulations (not accounting for any economic factors such as viable transport distance or value of competing land use). Overall, new plantations would be permitted on 44% of the study region area, with the largest available areas found in the south-west and north-west. The largest concentrations of unavailable land are in the eastern part of the region (due to national parks and reserves) and across the central part (due to fragmented areas of woody native vegetation). This map was not designed to act as a plausible agroforestry scenario, but rather to indicate where in the region new plantations could occur and at what levels they would encounter regulatory constraints.



Map 6 – Calculation of maximum potential area available for new plantations under regulatory constraints

Private rural land scenarios

The area of private rural land was used as the baseline map for the 'high', 'medium' and 'low' scenarios and took account of landholder interest as reported in the landholder survey. As discussed in the Survey Results section of the report, 66% of the region was determined to be private rural land (Map 7).



Map 7 – Calculation of private rural land in the study region

The high and medium scenarios for potential new agroforestry production in the Central Tablelands (shown in Table 5) were based landholder responses to the question 'If you were to get involved, how much of your land would you think about turning over to agroforestry?'. The total amount of land nominated in response to this question was equal to 7.6% of the total area of land owned or managed by survey respondents. This formed the basis for the medium scenario (i.e. an assumption that 7.6% of all the private rural land in the study region would be converted to agroforestry). Because only 66% of the total study area was private rural land, the medium scenario represented 4.8% of all land in the study area.

The high scenario was based on a more complex analysis in which the survey data was segregated according to property size (<40ha, 40–100 ha, 100–850 ha and >850 ha). This was done because the survey data was skewed towards large landholdings (>850 ha) compared to the properties within the cadastral layer provided by the NSW Land and Property Management Authority (see rows 2 and 4 in Table 5). As these larger landholders nominated much lower percentages of their properties on average compared to those in the smaller property classes (see row 5 in Table 5), it was considered likely that the medium scenario was an underestimate of landholder interest in agroforestry. Segregating the data according to property size led to an assumption that 19.2% of all rural private land may be converted to agroforestry (or 12.1% of all land in the study area).

While the medium scenario may be an underestimate of landholder interest, the high scenario also introduces its own bias. The cadastral data is divided up according to Lot and DP numbers[7] and takes no account of situations where landholders manage more than one property unit, which was reported in the PRA to be common across the region. This bias was likely to lead to an overestimate of interest in agroforestry because some landholders classed with large properties (>850 ha) in the survey would have appeared as medium (100–850 ha) in the cadastre and thus would have been assigned a much higher land conversion percentage than they should have been (26% instead of 2.6%). Thus, the reason for using both scenarios was that the medium scenario was likely to be an under-estimate of landholder interest and the high scenario is likely to be an overestimate.

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[7] Lot and Deposited Plan (DP) numbers are unique identifiers to land parcels used by the NSW Land and Property Management Authority.

Table 5 – Land assumed to be available for new plantations under the medium and high scenario (corrected for property size)

	Property size				
	<40 ha	40−99 ha	100−849 ha	>850 ha	All properties
Total hectares in each size class from cadastre	87,261	149,270	900,484	443,338	1,580,354
% of land area in each size class from cadastre	5.5%	9.4%	57.0%	28.1%	100.0%
Total hectares owned or managed by survey respondents in each size class	578	1,946	18,486	75,581	96,590
% of total land owned or managed by survey respondents in each size class	0.6%	2.0%	19.1%	78.3%	100.0%
Land nominated for conversion to agroforestry as % of total land owned or managed by survey respondents in each size class	28.4%	22.3%	26.0%	2.6%	7.6% (medium scenario)
Hectares potentially converted to agroforestry based on survey results corrected for bias in property size class	24,809	33,274	233,680	11,407	302,395
Total hectares available based on cadastral property size distribution as % of total rural private land in study area (i.e. 302,395 divided by 1,580,354)					19.2% (high scenario)

The low scenario was developed because the high and medium scenarios were based only on the amount of land that survey respondents said they would consider converting to agroforestry and took no account of the conditions under which they would actually proceed with agroforestry. The low scenario attempted to incorporate this by assuming that only landholders who indicated that they would be prepared to take a similar or lesser return, compared to their current land use, would ultimately take up bioenergy-based agroforestry. In a narrow economic sense, this group could be seen as likely 'early adopters' because they would be prepared to adopt agroforestry without requiring a relative advantage in economic return, although in reality a variety of other factors, such as compatibility, complexity and social norms would also influence if and when they adopted (Pannell et al. 2006).

Overall, the amount of land nominated for conversion to agroforestry amongst those saying they would accept the same or lesser return was 1758 ha, or 1.8% of the 96,590 ha owned or managed by all survey respondents (Table 6). Again there was a large difference between the figures for landholders with more than 850 ha and those with less (see row 1 in Table 6), so a property size class correction was applied using the same method as for the high scenario. This produced a figure of 5.0% of total private rural land. As 1.8% is likely to be an under-estimate and 5.0% is likely to be an over-estimate, these figures were averaged to produce the final figure for the low scenario of 3.4 ± 1.6% of rural private land. This corresponded to 2.2 ± 1.0 % of the total land area of the study region.

In summary, the high, medium and low scenarios passed onto CSIRO for use in their analysis of biomass production from new plantations were based on the assumptions that 19.2% (high), 7.6% (medium) and 3.4% (low) of private rural land in the study region would be converted to agroforestry.

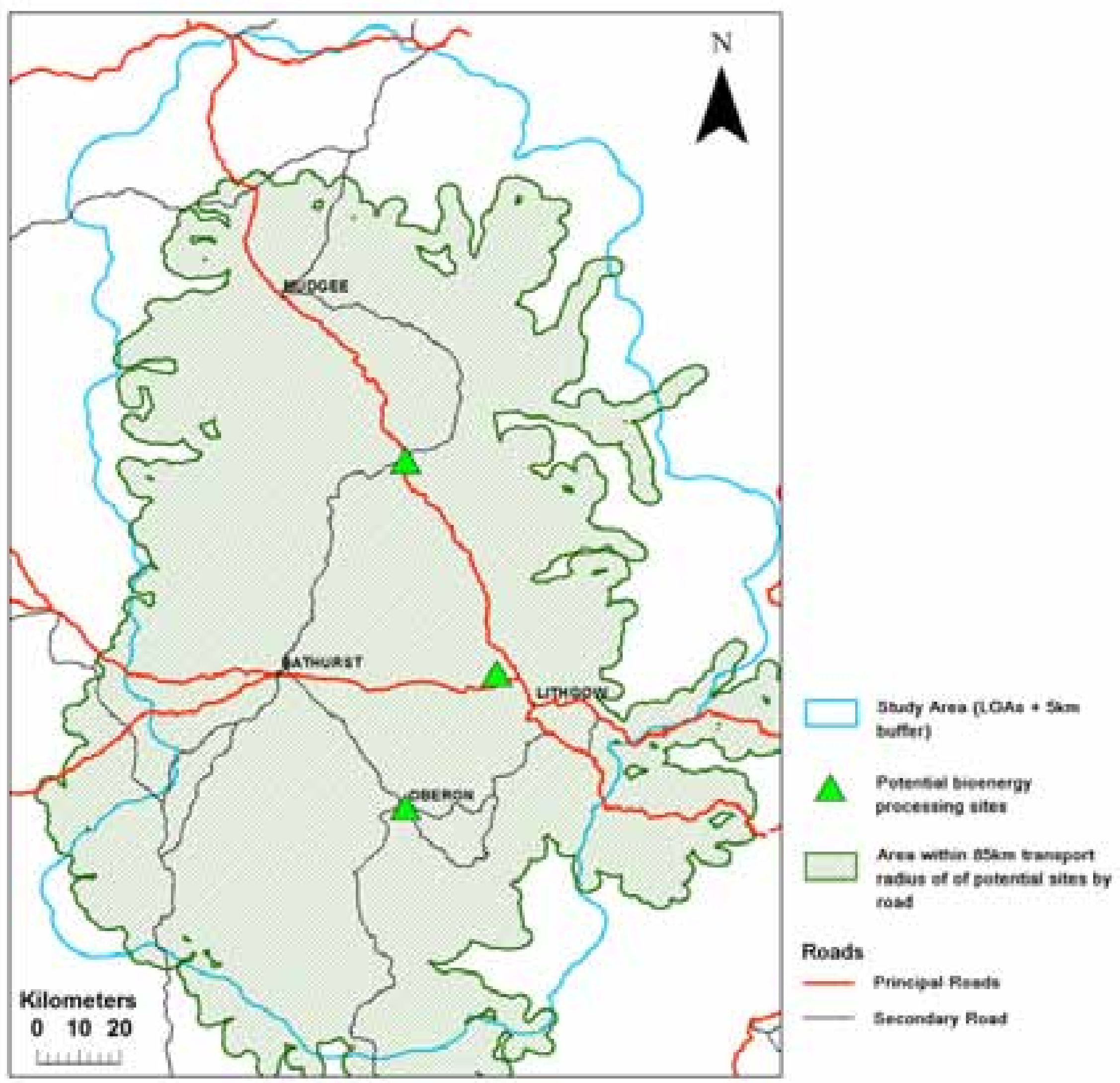
Table 6 – Low scenario

	Property size				
	<40 ha	40−99 ha	100−849 ha	>850 ha	All properties
Land area nominated by those who said they would accept the same or lesser return in each size class (as % of total land owned or managed by survey respondents)	5.6%	6.5%	7.1%	0.4%	1.8%
% of total rural private land to be converted by those saying same or lesser corrected for property size bias					5.0%
Low Scenario (average of corrected and uncorrected figures)					3.4% (± 1.6%)

The scenario analysis also sought to determine the proportion of biomass from plantations that may be available for bioenergy production. As the survey showed that a mix of rotations was most favoured, a mixed planting regime was used for modelling purposes. Such a regime could involve a complex integration of different species or could simply consist of alternating blocks, with some harvested at 5 years for 100% bioenergy and some harvested at 15−30 years for timber/pulp (with residues and thinnings used for bioenergy). Based on a 2007 study of eucalypts grown for timber in northern NSW (Cowie et al. 2007), a plausible assumption for the longer rotation blocks would be that 82% of biomass felled during thinnings and 75% of the above-ground biomass present at the time of harvest would be used for bioenergy (only 10% actually ends up as sawn timber).

Bioenergy facility locations and transport distances

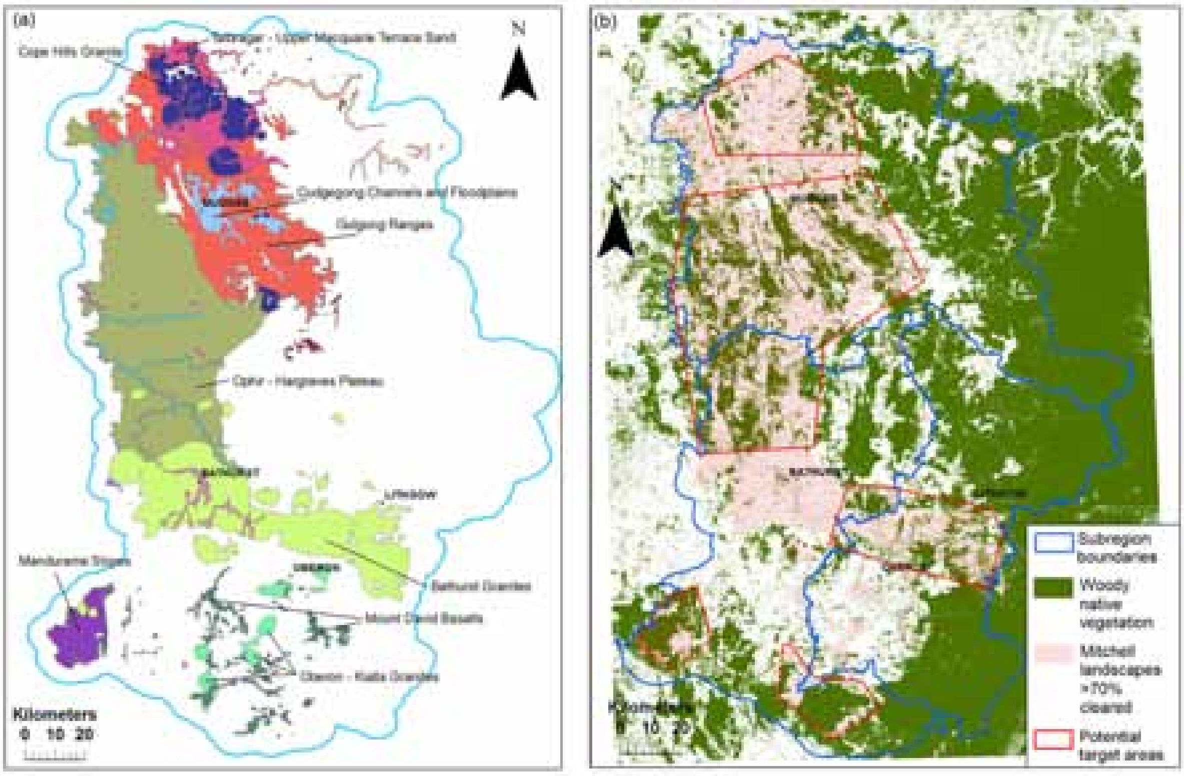
The dominant suggestions for bioenergy facility locations in the PRA and survey were the Oberon timber complex (due to proximity to existing wood processing wastes) and the Wallerawang Power Station west of Lithgow (due to previous trials with co-firing of biomass). No clear preference emerged for a site in the North sub-region so for the purposes of further analysis, a hypothetical site was selected near Ilford, at the intersection three major roads of the N sub-region: the Castlereagh Highway, Bylong Valley Way and the Goulburn-Ilford Road. Map 8 shows these three sites, along with the area that falls within an 85 km transport distance by road (plus a 2 km buffer to take into account minor road transport). Facilities at these locations could service the entire region except for the eastern and south-eastern fringes (which are mainly protected areas) and the northern fringe of the region.



Map 8 – Area within 85 km transport distance of potential bioenergy facilities by road

NRM and land use factors

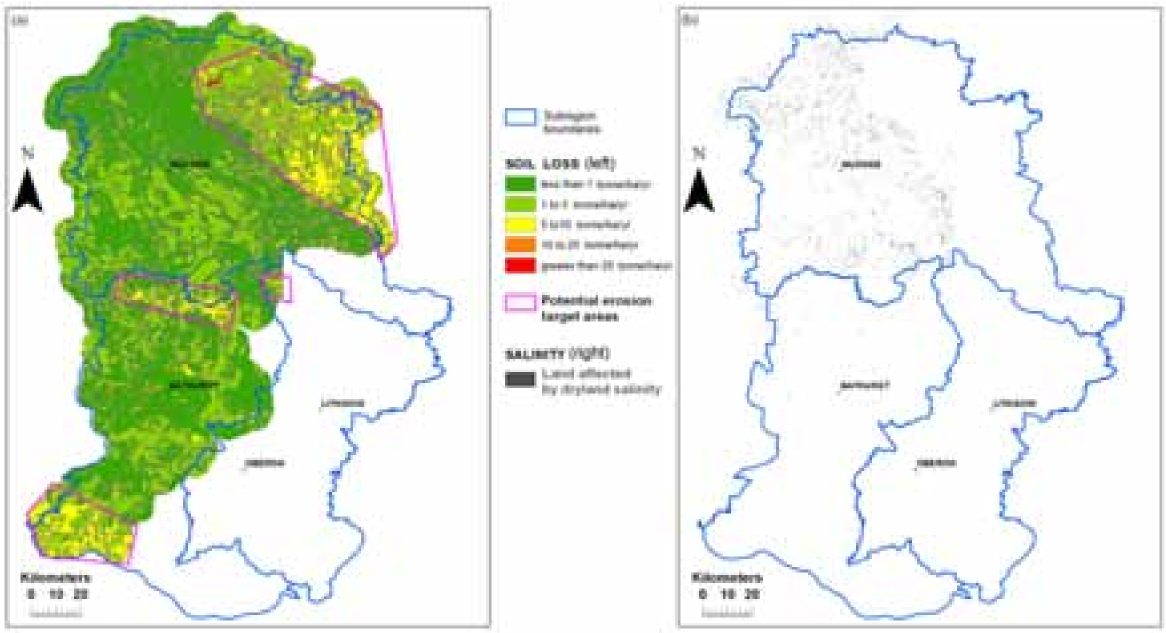
The distribution of natural resource management 'hotspots' varied between sub-regions. Map 9(a) shows the distribution of Mitchell Landscapes that have experienced a clearing rate of 70% or more since European settlement (the threshold for considering a landscape 'over-cleared' under the NSW Property Vegetation Planning system). These over-cleared landscape types were found in each sub-region, but the greatest concentrations were in found in the northern part of the SW sub-region and the western part of the N sub-region (Department of Environment and Climate Change 2008b). The major landscape types were predominantly composed of eucalyptus forest (Oberon-Kialla Granites); eucalyptus woodland to open forest (Ophir-Hargreaves Plateau, Bathurst Granites and Mount David Granites); and cypress/eucalypt woodlands (Gulgong Ranges).



Map 9 – (a) Over-cleared Mitchell Landscapes (i.e. greater than 70% clearing rates) in the study region; and (b) Over-cleared Mitchell Landscapes matched to woody native vegetation. Source: Department of Environment and Climate Change (2008b), provided by Hawkesbury-Nepean CMA.

Map 9(b) matches the over-cleared landscape types to areas of existing woody native vegetation to highlight potential target areas for improving landscape connectivity. From this analysis, a large potential target area emerged in the area south-west of Mudgee and north-west of Bathurst, with a smaller corridor evident in the SE sub-region running east-west between Lithgow and Oberon. The area around Bathurst showed very high levels of clearing, but improving connectivity in this area is likely to be much more difficult due to very low levels of existing native woody vegetation and high levels of urban and cropping land uses.

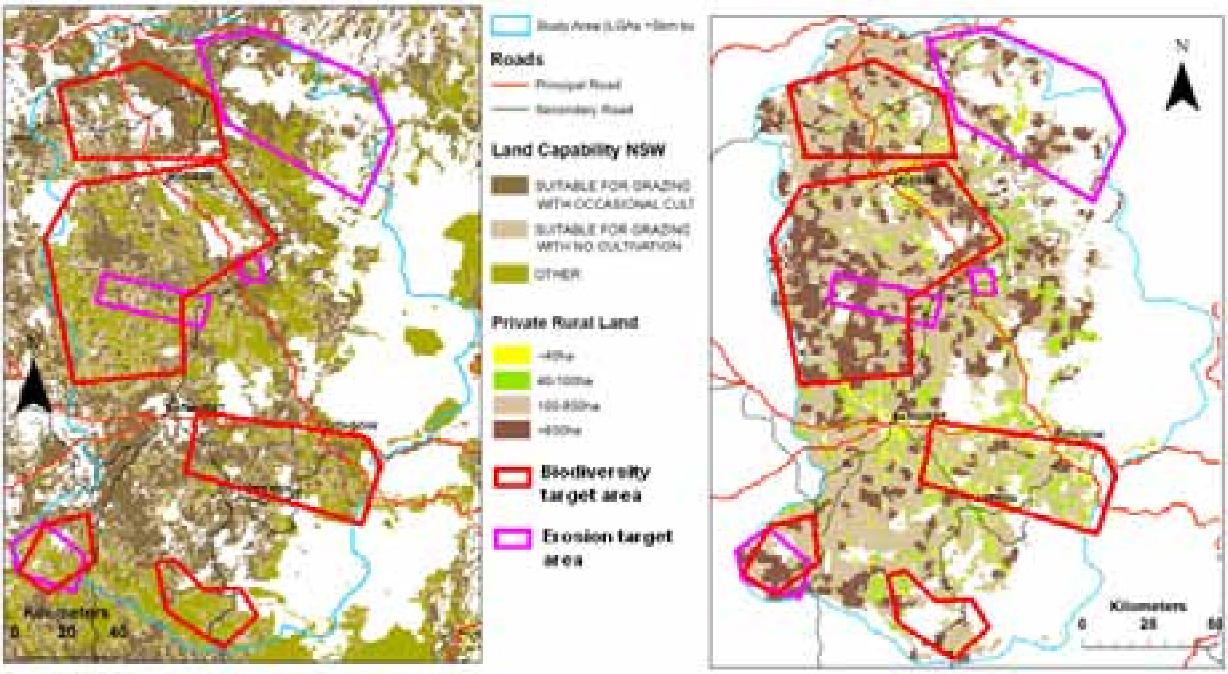
Erosion rates and occurrences of salinity also varied across the study region and analysis was only possible for the SW and N sub-regions due to data access limitations. Map 10(a) shows the location of erosion hotspots across these sub-regions, while Map 10(b) shows hotspots for salinity. Erosion rates were highest in the north-east of the study area, along the boundary between the North and SW sub-regions (i.e. between Bathurst and Mudgee) and in the far SW corner (plus some scattered areas around Bathurst). Salinity areas were found at small, scattered sites, with problems greater in the N sub-region than in the SW. Erosion and salinity data was not available for the SE sub-region, however advice from Hawkesbury-Nepean CMA indicated that stream and bank erosion is the primary issue in this area and revegetation involving plantations is unlikely to be an effective solution.



Map 10 – (a) Erosion rates; and (b) Salinity occurrences in N and SW sub-regions. Source: Environmentally Sensitive Areas data provided by Bathurst and Mid-Western councils.

Lastly, the potential target areas for biodiversity and erosion control were compared to land capability and property size distribution across the study region (Map 11). This showed that:

- The area between Bathurst and Mudgee featured an alignment of erosion control and habitat connection goals, as well as consisting mostly of low capability land (which was the preferred location for future plantations by surveyed landholders). However, this area also had the highest concentration of landholders with large properties, who nominated the lowest proportions of their land for agroforestry in the survey. Targeting the eastern part of this corridor would achieve the greatest alignment of erosion and biodiversity goals, avoid the greatest concentration of larger landholdings, and reduce transport distances to any of the three potential bioenergy facility locations shown in Map 8.
- The corridor between Oberon and Lithgow featured an alignment of habitat connection goals, low land capability and small to medium sized properties. Erosion control is unlikely to be a driver of agroforestry in this area. The SE region also had the highest levels of interest in agroforestry from the survey (as indicated by net benefit score, the percentage of land nominated and willingness to accept lesser or the same returns as current land use).
- The far northern edge of the region featured an alignment between habitat connection and erosion goals and included mostly medium-sized properties on higher capability grazing land. However, this area may face high transport costs for biomass, especially to the most commonly suggested sites of Oberon or Wallerawang.
- The far SW of the region featured an alignment between habitat connection and erosion goals on low capability land, but it also featured a concentration of large properties and relatively small areas available for new plantations amidst existing native woody vegetation.



Map 11 – (a) Biodiversity and erosion hotspots compared to land capability (left); and (b) property size distribution (right).

Discussion of Results

In this section, results are discussed based on the information drawn from meetings with stakeholders, the PRA workshop and interviews, the landholder survey and spatial data analysis. We will summarise the major findings and tie together the previous three sections (Participatory Rural Appraisal, Landholder Survey and Spatial Analysis) to the original research questions presented in the Objectives:

1. What tree crops and bioenergy technologies might be viable in the case study region?
2. What potential economic and social benefits might a bioenergy-based agroforestry industry provide?
3. How might the widespread uptake of agroforestry for bioenergy contribute to landscape-scale natural resource management goals?
4. What incentives and barriers exist for the uptake of such land uses, and what policy measures could be employed to promote and guide them?

The outcomes of this project were expected to generate an understanding of the existing and potential biomass resources from new agroforestry plantings in the Central Tablelands area. More specifically, the project aimed to provide:

A. options for enhanced and diversified livelihoods based on a local bioenergy and agro-forestry industry
B. landscape-scale revegetation and sustainable management of land in line with regional NRM priorities
C. a model for matching appropriate bioenergy production systems to local biomass supplies in line with economic development goals, community expectations and environmental targets.

This section is structured around answering the four research questions and incorporates discussions of the outcomes. Outcome A is presented partly as a result for questions 1 and 2. Outcome B is presented under question 3. A discussion of Outcome C fits better under the next section—Implications.

What tree crops and bioenergy technologies might be viable in the case study region?

There is a high level of experience with tree planting and tree cropping in the region; 21% of the survey respondents mentioned some experience with commercial agroforestry and 84% of the respondents had non-commercial experience. There were no major differences between landholder types in terms of experience, but there were notable sub-regional differences; most experience was found in the SE, followed by the N. Interviewees and survey respondents suggested a range of native tree species that would work well in their sub-regions due to their high productivity, resistance to drought and/or use in previous agroforestry trials.

The most commonly cited species were:

- *Eucalyptus viminalis* (manna gum/ribbon gum)
- *Eucalyptus melliodora* (yellow box)
- *Eucalyptus camaldulensis* (river red gum)
- *Acacia* species (particularly *A. dealbata* – silver wattle)
- *Casuarina* species (she-oak/swamp oak).

E. viminalis and *E.camaldulensis* have previously been identified as potential bioenergy species due to their high productivity (Bennell et al. 2009) and are well-suited to the climatic conditions found in the tablelands (Stirzaker et al. 2002). Tasmanian Blue Gum (*E. globulus*) is the most widespread native plantation species across southern Australia, but only rated a couple of mentions in the PRA and landholder survey as it was not generally considered to be suitable to this region. However, the subspecies *E. globulus bicostata* is considered to hold potential in drier and more northerly areas (Booth & Ryan 2008) and shows promise for bioenergy (Bennell et al. 2009). Other species that have been cited in previous studies were not mentioned at all in the PRA or survey, such as *E. cladocalyx* (sugar gum), which showed high productivity and bioenergy potential in medium-low rainfall areas in modelling by Bennell et al. (2009), *E. nitens* (shining gum), which showed medium-high productivity in parts of the Central Tablelands in modelling by Booth et al (2007) and *E. polybractea* (blue mallee), which has been trialled for bioenergy west of the tablelands (Delta Electricity 2010). Although our focus was on native agroforestry, *Pinus Radiata* (radiata pine) was mentioned regularly as a potential bioenergy species.

The preferred type of planting for agroforestry was a combination of strip and block plantings (55%). Both commercial graziers and lifestyle/hobby farmers also preferred a mix of trees with different rotations—some for bioenergy and some for timber. Lifestyle/hobby farmers showed a preference towards agroforestry for 70−100 years in order to obtain carbon credits, and a stronger preference for sites where biodiversity benefits were greatest. All sub-regions showed a preference for shorter rotation agroforestry for lower value products (such as bioenergy) over longer rotations for higher value products; however, this preference was weakest in the SE, which may reflect their higher levels of previous experience with longer-rotation timber plantations. The SW scored higher on the preference for short rotation agroforestry. The N was most negative towards long rotation times.

When asked whether the respondents had a preference for bioenergy, timber, woodchips, carbon storage or other end uses, only 21% said it mattered. This indicates that agroforestry options are likely to be judged by landholders primarily on factors other than on the products being produced, such as economic returns, length of rotation and environmental impacts. Williams (2009) found that community acceptance of plantations in southwest West Australia (WA) varied depending on the product being grown (eucalypt for timber preferred over pine for timber or eucalypt for pulp), and that these preferences were influenced by underlying factors associated with the overall production system, such as whether plantations were on good or poor soils, owned by farmers or corporations, over a whole property or only part thereof, and whether products were processed locally. In our survey, marginal land was the preferred option for agroforestry amongst both major landholder groups; the dominant vision was for partial land conversion (averaging 11% amongst those who nominated land for conversion). Based on Williams' results from WA, these factors are likely to make plantations more acceptable to the community, but other factors remain unknown at this stage, such as whether most plantations would end up being owned by farmers or corporations, or whether any significant local processing would be required.

In terms of bioenergy conversion technologies, the main options are electricity generation and liquid biofuels. CSIRO are assessing the economic costs and greenhouse gas balance of these options for the Central Tablelands region under their project 'Assessment of the environmental and economic opportunities and constraints associated with bioenergy production from forest biomass resources in two prospective regions of Australia'. UNSW provided assumptions on future landholder uptake of bioenergy-based agroforestry for CSIRO's project, but results from CSIRO's modelling are not available for incorporation into this report.

As discussed in the Participatory Rural Appraisal section, Delta Electricity has investigated a number of biomass sources for co-firing with coal at their Wallerawang Power Station west of Lithgow. Modelling by Delta suggests that biomass-fired generation costs around $55/MWh more than coal-fired generation; this gap may be able to be bridged by a combination of an increased price for Renewable Energy Certificates (RECs), making bioenergy more attractive, and the introduction of a carbon price, which would make coal-fired generation less attractive (Horner 2010a). Both of these policy options were in a state of flux during the course of the project. The Renewable Energy Target (RET) was split into separate large-scale and small-scale schemes as of 1 January 2011, with large-scale biomass electricity projects now earning LGCs (Large-scale Generation Certificates) rather than RECs. In February 2011, the Australian Government announced a proposed carbon pricing policy that would involve a fixed price from 1 July 2012 (at an as yet unknown level) before transitioning to a market-based price under an emissions trading scheme.

As the LGC market is no longer influenced by the small-scale generation sources (e.g. rooftop solar) that were seen to be flooding the REC market and depressing prices, it has been argued that the current LGC price of around $30–35 (ClimateSpectator 2011) will rise over coming years (EnergyAustralia 2011). While the carbon price is yet to be announced, prices in the range of $20–30/t$CO_2$e have been flagged. This could result in a combined LGC/carbon price that was close to or higher than the $55/MWh cost differential between biomass and coal cited by Delta (as 1LGC=1MWh of renewable electricity and 1MWh of black coal generation emits around 1tCO_2e). However, a further buffer in the LGC and carbon prices may be needed to account for development costs such as new infrastructure and plant refits. Thus, while biomass electricity appears promising, much depends on policy decisions, LGC market prices and development costs, which will emerge over coming years.

Even if biomass electricity proves viable at Wallerawang, Central Tablelands landholders could find it difficult to compete with urban wood waste and radiata pine processing residues, which have formed the basis of Delta's cost modelling to date. However, the scale of Delta's proposals for Wallerawang (20% of total generation from biomass) has led them to look beyond existing biomass residues, including trialling the production of dedicated Mallee plantations over 200 km away at Forbes (Horner 2010b). In comparison with Forbes, production in the Central Tablelands has the advantage of higher rainfall and shorter transport distances, but the disadvantage of having to compete with higher land prices and higher returns from competing land uses. Our survey found that a minority of landholders may accept lesser returns than current land uses and a majority would favour a mix of timber and bioenergy production—both factors that could enhance the feasibility of plantations.

The scale of production required to justify a switch to biomass electricity at facilities such as Wallerawang may provide a further challenge for bioenergy-based agroforestry in the Central Tablelands. Landholder adoption of innovations often follows an S-shaped curve, whereby early adopters may be followed by larger groups of landholders if the innovation proves successful (Rogers 2003). The survey results regarding land nominated, desired levels of return, perceived benefits and perceived barriers indicated that similar landholder dynamics may exist in relation to bioenergy-based agroforestry in the Central Tablelands. However, such adoption patterns can only come to fruition if the regional industry in question is scalable (able to be built up progressively over time). Scalability is likely to be challenging for an industry that is dominated by a single large buyer that requires large numbers of landholders to commit before viability is proven on the ground. Smaller facilities, potentially for liquid fuels rather than electricity, could enhance the scalability of a regional industry, but this is dependent on further advances in the development of economically viable processes for converting woody biomass into liquid fuels (Warden & Haritos 2008).

What potential economic and social benefits might a bioenergy-based agroforestry industry provide?

Lifestyle/hobby farmers gave higher scores to all benefits of agroforestry (economic, social and environmental) than graziers. Amongst both groups, economic and social benefits were generally ranked lower than environmental benefits. Based on the survey results, the strongest perceived economic benefits were those that overlapped with the environmental category, such as providing wind breaks for stock and combating erosion and salinity. Of the purely economic benefits, diversifying farm businesses scored relatively highly, while providing a form of superannuation ranked last out of all possible benefits listed on the questionnaire. This indicates that plantations may be more successful if promoted on the grounds of diversification rather than superannuation/retirement income. Agroforestry was not seen to have particularly strong benefits in terms of increasing land value or adapting to climate change, although the potential to increase land value was seen somewhat more positively in the SE than in other sub-regions.

The survey was also able to assess the relative importance of economic benefits in driving uptake of agroforestry. 50% of respondents said they would require a greater return than their current land use to take up agroforestry; this is unlikely in the near future unless there is a significant boost in the REC/LGC price or the introduction of a high carbon price. However, the other 50% of respondents said they would accept the same or lesser return, or that it would depend on other factors (e.g. where they are not dependent on the land for income or concerned more about environmental impacts). Lifestyle/hobby farmers were more likely to fall into this latter group (with 64% saying same/less/depends) than commercial graziers (45%), and landholders in the SE (63%) were more likely to say same/less/depends than those in the other sub-regions. This information could help to devise strategies for promoting agroforestry to potential early adopters.

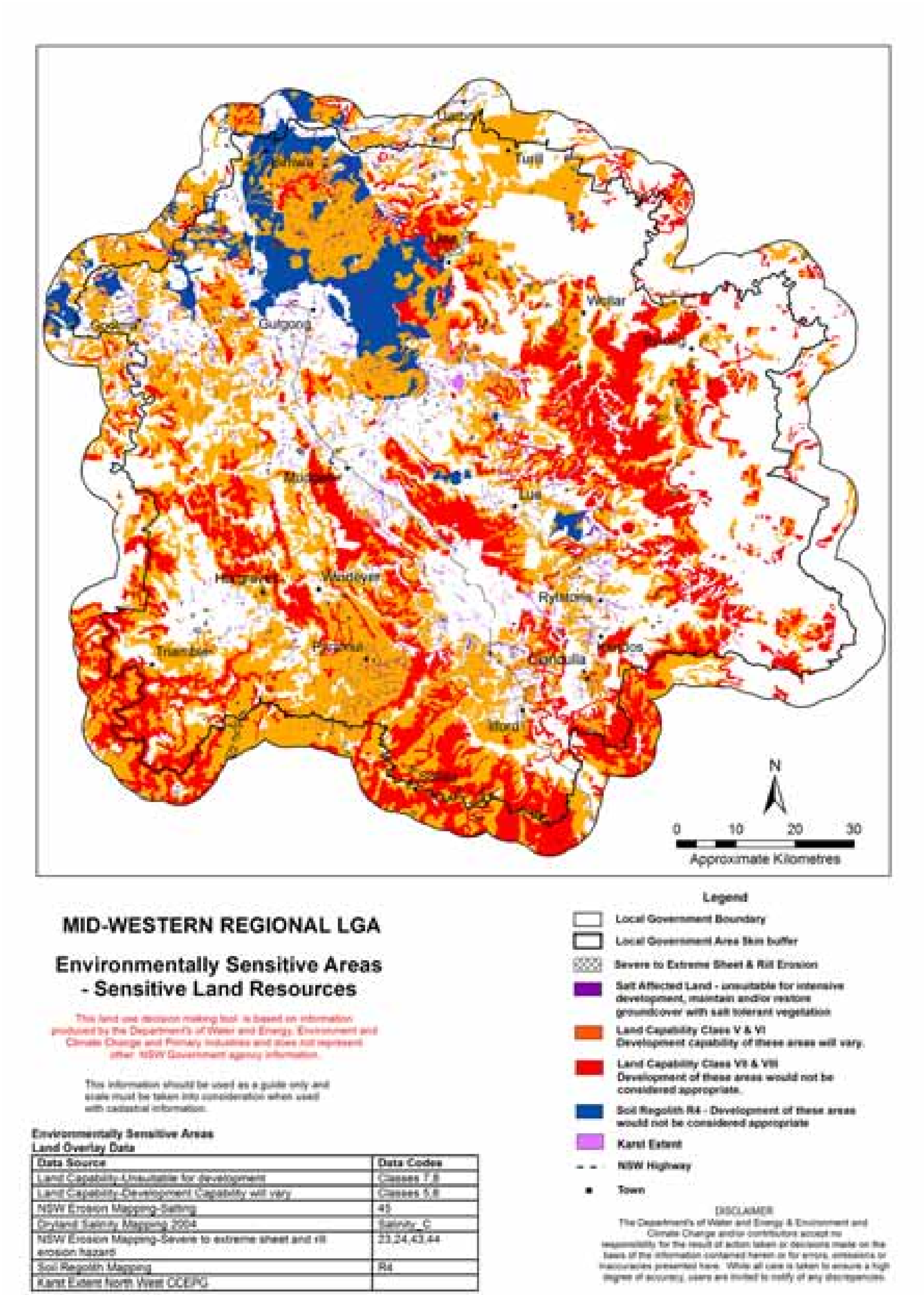
In terms of social benefits, those related to environmental factors such as attracting birds and wildlife and creating benefits beyond property boundaries, were ranked highly in the survey, particularly by lifestyle/hobby farmers. The social benefits of improved amenity and providing a legacy for children/grandchildren ranked poorly compared to other benefits, although both were rated more positively in the SE than in other subregions.

While the benefits might seem restricted to the limited options articulated by landholders during the PRA and landholder survey, as this industry grows regional development benefits such as employment may potentially emerge as new industries and infrastructure enter the region. The economic modelling being undertaken by CSIRO in their related project may shed more light on the likelihood that a regional bioenergy industry may be viable based on existing waste streams as well as new plantations. Agroforestry could also provide a buffer against income loss as grazing and cropping becomes potentially less profitable or more variable due to the more negative effects of climate change, such as more extreme drought and flooding.

How might the widespread uptake of agroforestry for bioenergy contribute to landscape-scale natural resource management goals?

Environmental benefits scored slightly higher than the other benefits. The top four highest rated benefits were all within the environmental benefits category. The spatial analysis of NRM factors in the previous chapter identified a number of potential target areas where agroforestry, for a combination of environmental and economic factors, could contribute to improved habitat connectivity and/or erosion control. The area between Bathurst and Mudgee would appear to be one of the most promising areas due to the alignment of habitat and erosion protection needs on less productive land. The eastern part of this corridor may hold greater potential for agroforestry due to the presence of smaller landholdings. The area between Lithgow and Oberon may also provide an opportunity for agroforestry that contributes to habitat connectivity, with the presence of marginal land and smaller landholdings promising higher levels of agroforestry uptake based on the survey results. The far north and far south-west of the study region could also offer possible synergies between environmental and economic goals, but face challenges due to transport distance, presence of existing native vegetation and the presence of larger properties. The potential for increased fire risk is also an important factor to be considered, especially when seeking to improve habitat connectivity, although this was not seen as a major barrier by survey respondents (ranked 8th out of 18 possible barriers).

Further work is required with CMAs, councils, state government agencies and the forest industry, to further develop agroforestry models that could contribute to NRM objectives while offering acceptable economic returns. Mixed-species plantations may be an option and have been used in other areas where landholders sought a combination of environmental and commercial goals from agroforestry (Dickinson et al. 2008). However, eucalypts (which were most commonly cited as a plantation options) are more difficult to include in mixed-species designs because of their tendency to monopolise resources (Dickinson et al. 2008). Kanowski et al. (2005) looked at mixed-species plantations in North Queensland and found no clear evidence that they supported greater biodiversity than monocultures, with factors such as age of plantation and proximity to existing native vegetation having more of an effect. Catterall et al. (2005) emphasised that trade-offs between production and conservation are likely to be required, with heterogeneity in the design and management of plantations important for generating conservation benefits (e.g. differences in patch size, patch shape and harvest cycles).



Map 12 – Environmentally Sensitive Area Mapping for Mid-Western Regional LGA.

One challenge that may need to be overcome is an apparent divergence in views regarding the development of commercial plantations on marginal land. Marginal land (rocky/steep land with little grazing value) was the most preferred location for agroforestry activities amongst surveyed landholders, which is consistent with the Central West Catchment Action Plan's suggestion that commercial plantations may be suitable for landscape protection on low capability lands (Central West Catchment Management Authority 2007). However, Environmentally Sensitive Areas mapping (see Map 12) by a number of NSW Government departments recommends that development of land in rural land capability classes VII and VIII (broadly equivalent to the description of marginal land used in the survey) 'would not be considered appropriate. This highlights a potential risk of widespread agroforestry development—if done well, it could contribute to landscape protection, erosion control and habitat connectivity, but if done poorly, it could expose sensitive lands to greater threats from soil disturbance and vehicle access.

Furthermore, a sizeable minority of survey respondents (23%) suggested they would consider establishing plantations in areas that were 'set aside for conservation'. Commercial plantation activities may be consistent with conservation objectives if they are designed in a manner that enhances biodiversity or erosion control. However, land on which such activities are undertaken would not usually be considered to be 'set aside for conservation' by CMAs or state government agencies. If such areas contained existing native vegetation, clearing for plantation establishment is unlikely to be permitted under the *NSW Plantations and Reafforestation Code*. However, the Code would allow the area to be cleared if it consisted of regrowth vegetation, potentially leading to situations where agroforestry could act as a driver to clear regenerating areas that have previously been taken out of production. These issues may require further consultation to develop agroforestry options that meet both landholder and government notions of development that are appropriate on marginal and regenerating land.

What incentives and barriers exist for the uptake of such land uses and what policy measures could be employed to promote and guide them?

The policy environment surrounding the potential land use options assessed in this project cuts across the sectors of plantation forestry, renewable energy and natural resource management (NRM). As such, the range of existing policy measures affecting these proposals is wide and the range of potential new policy measures even wider. The plantation sector features a combination of positive incentives, such as tax deductions for forestry investment, and restrictive measures such as the NSW Plantations and Reafforestation Code, that aim to prevent negative impacts on biodiversity, soils and water quality. Managed Investment Schemes (MIS) have been instrumental in promoting plantation expansion in Australia (Plantations2020 2009), allowing investors to deduct plantation investments from their taxable income. However, such schemes have come under increased scrutiny in recent years, especially following the collapse of some prominent MIS companies (Williams & Hopkins 2009) and rule changes by the Australian Government. While the Central Tablelands has not experienced substantial MIS plantation activity to date, it was mentioned by a handful of participants in the PRA as a potential option for the region, albeit one that should be approached with caution given experiences elsewhere.

As discussed above, the Australian Government's dominant policy mechanism used to promote electricity generation from renewable sources such as biomass is the Large-scale Renewable Energy Target (LRET), which replaced the previous Renewable Energy Target (RET) on 1 January 2011 (with LGCs replacing RECs as the tradeable credits). The LRET requires a steady increase in large-scale renewable electricity generation, reaching 41,000 GWh per year by 2020 (close to 20% of Australia's estimated supply at that time). Under the LRET's predecessor schemes, bioenergy (mostly landfill gas, bagasse and wood waste) provided around 22% of eligible renewable energy generation up to 2008 (Office of the Renewable Energy Regulator 2009). Liquid biofuels are promoted federally through the Ethanol Producers Grant Program (ethanol) and Biofuels Capital Grants Scheme (biodiesel), which both provide a 38.143c/l cost advantage against their respective fossil fuel equivalents. NSW is the first state to mandate biofuel supply by primary fuel wholesalers through the *Biofuels Act 2007*. These liquid biofuel measures are likely to remain relevant only for starch, sugar or oilseed production, rather than woody biomass, until second-generation technologies improve. Research and development support relating to woody biomass for energy includes the Second Generation Biofuels Research and

Development Program (focusing on processes such as cellulosic ethanol) and grants to develop new production systems such as the nascent oil mallee industry in Western Australia (e.g. Enecon 2001, Wildy et al. 2003, Future Farm Industries 2011).

NRM policy features a mix of restrictive measures, such as the NSW *Native Vegetation Act 2003*, which aims to end broad-scale land-clearing, and positive measures such as the Commonwealth Caring for Our Country program or NSW Environmental Trust, which provide funds for on-ground measures aimed at biodiversity conservation, salinity mitigation, soil conservation or other NRM priorities. Market-based instruments have also seen a rise in NRM policy, with examples including Victoria's BushTender program that allows landholders to bid for available bush protection funds (Department of Sustainability and Environment 2008), the NSW BioBanking scheme that allows landholders to sell biodiversity credits to developers wishing to clear land elsewhere (Department of Environment and Climate Change 2007) and the Commonwealth's Carbon Farming Initiative that would facilitate the trading of sequestered carbon (Department of Climate Change and Energy Efficiency 2010).

One interesting result from the PRA and landholder survey is that there appears to be a divergence of opinions, between industry and government stakeholders on the one hand and landholders on the other, regarding which policy measures are likely to be most effective in driving uptake of bioenergy-based agroforestry. Industry and government participants in the PRA interviews and workshop tended to focus on the need for a higher REC/LGC price and/or the introduction of a carbon price to drive the development of a bioenergy industry. This is further reflected in the reliance on the LRET as the main government policy measure for driving bioenergy development in Australia and the focus of companies such as Delta Electricity on REC/LGC and carbon prices as the main determinant of bioenergy viability (Horner 2010a). This contrasts with the views of surveyed landholders, who ranked price support for the products of agroforestry (such as the LRET) last out of five possible support measures, with payments for ecosystem services (e.g. carbon, biodiversity or salinity credits) ranked second last. Financial support for upfront establishment costs was ranked first, followed by knowledge support and then research and development. This pattern was consistent across different landholder types (commercial graziers and lifestyle/hobby farmers) and sub-regions.

The potential agroforestry benefits and barriers as selected by landholders in the survey and PRA may help to understand why support measures were ranked the way they were. The top four benefits as ranked by survey respondents were all environmental (windbreaks, habitat for biodiversity, off-property benefits and salinity mitigation), but notably this did not translate into a high ranking for market-based instruments such as carbon, biodiversity or salinity credits. Similarly, economic benefits (diversifying farm business) and economic barriers (capital cost too high, other options offer better returns) were ranked around the middle of the lists provided, and do not explain why upfront establishment support would be ranked first and price support last. However, the top two barriers do shed light on these issues, with 'regulatory changes could prevent future harvest' ranked first and 'the wait for returns from agroforestry is too long' ranked second. If the wait for returns is perceived as long and the risk of future regulatory and policy change is perceived as high, it logically follows that upfront support would be viewed positively and support that is dependent on future outputs and policies (e.g. price support or payments for ecosystem services) would be viewed with greater trepidation.

Concerns about regulatory and policy change amongst landholders are not unfounded, with recent history providing a number of examples to support these concerns, including:

- The collapse of the plantation MIS companies Timbercorp and Great Southern in 2009 (Williams & Hopkins 2009); the Australian Government's tightening of rules to require at least 70% of plantation investor contributions to be spent on direct forestry costs and for plantations to be established within 18 months of a scheme's commencement (under the *Tax Laws Amendment (2007 Measures No. 3) Act 2007*).
- The introduction of the NSW *Native Vegetation Act 2003* and its associated rules around clearing, Property Vegetation Plans (PVPs), regrowth and private native forestry that have created confusion amongst some landholders.

- The introduction of the *NSW Plantations and Reafforestation Code 2001*. The Code was designed to streamline the plantation approval process and provide certainty of future harvest, but there are no guarantees that future regulatory changes will not be introduced that affect the harvest and management of such plantations.
- The introduction of a ban on the use of native forest biomass for electricity generation in NSW in 2003 (under the *Protection of the Environment Operations (General) Regulation 1998*). Plantation biomass may be used for electricity under the current definition of 'native forest bio-material' but biomass harvested from old-growth or regrowth areas under private native forest may not.
- The numerous changes made to the Renewable Energy Target since its introduction in 2001. These include changes to the definition of 'wood wastes' and 'energy crops' in 2007 (separating plantation biomass from the more controversial native forest biomass), the Howard Government's decision not to expand the target (which led to a collapse of REC prices), the Rudd Government's decision to expand the target (which led to REC price rises), the inclusion of 'phantom RECs' from small-scale solar within the target (which depressed prices) and now the separation of small-scale and large-scale generation (which is predicted to boost prices).
- The continued uncertainty around the introduction of a price on carbon, including the announcement, negotiation and subsequent abandonment of the Carbon Pollution Reduction Scheme (CPRS) in 2009/2010 and the announcement of a fixed-price scheme in 2011 (with no details as yet on price, coverage or compensation).

Landholder scepticism towards price support and payments for ecosystem services does not mean that these policy mechanisms do not have a role to play in the development of a regional bioenergy industry involving biomass production through agroforestry. As discussed previously, LGC and carbon prices are likely to play a critical role in making biomass electricity cost competitive with coal. However, it needs to be recognised that the focus on economic efficiency, modelling of future returns and 'getting the prices right', that often hold sway within government and the energy industry, may be less important to landholders than factors such as risk (both financial and regulatory), trust (based on past experiences), compatibility with existing enterprises, and the ability to observe the results of a new innovation before adoption (Pannell et al. 2006). Thus, in order for bioenergy-based agroforestry to achieve significant uptake, a key area of focus should be on bridging the gap between macro-level price-based measures designed to stimulate bioenergy demand, and on-ground actions where upfront support is most valued.

There are a number of possible ways to convert price-based incentives into upfront support, each with their own pros and cons. Delta Electricity provides one such model in their mallee trial around Forbes, whereby Delta covers the costs and risks of plantation establishment and hopefully profits from the generation of LGCs if the project proves successful (Delta Electricity 2010). An MIS bioenergy scheme is another option, whereby tax deductions for upfront investment could help to offset the risk associated with a long wait for returns. Other ideas could be drawn from the solar photovoltaic (PV) sector, where householders are able to earn credits upfront at a fixed price to offset the cost of installation without having to take on the risk of future price fluctuations or regulatory changes. These ideas require further evaluation, but the clear message from this study is that price support measures are only likely to be effective if they can be translated into upfront support that addresses the goals and concerns of landholders.

Implications

From this research it is clear that for economic, environmental and social reasons, bioenergy has the potential to become a beneficial new industry in the Central Tablelands region. There are, however, a number of critical factors on which this will depend. Most of all is the preparedness of a large number of landholders in the region to take up agroforestry as part of their overall production system. The three scenarios developed as part of this research give the range of potential uptake, but there is still considerable uncertainty as to whether the volume of biomass needed for such an industry will be met. For this reason, more research and testing of assumptions and the design of incentive systems should be undertaken.

The issue of funding or support to establish the infrastructure both on farm and regionally was a major concern. There were clear differences between types of landholders in their need for support based on the extent to which they were reliant on farm-based income. As a consequence it will be necessary to generate different options targeting the different landowner interests outlined above, particularly the development of different models for large commercial landholdings and small lifestyle landholdings. Different approaches to bioenergy production have already begun to emerge to the west of the study area around Forbes and Condobolin. In an experimental project, Delta Electricity is contracting farmers in the Forbes region to grow mallee directly for the Wallerawang Power Station, and an independent group of farmers have established a cooperative in Condobolin to develop mallee biofuel products for local and regional markets (Total Catchment Management Services 2008). However, these initiatives are small-scale and experimental, and it is still unclear that market demand will be sufficient in itself to drive this industry, despite the introduction of a proposed carbon tax in 2012 and the other environmental benefits that may flow from the expansion of agroforestry in rural Australia.

A number of potential strategies for promoting bioenergy-based agroforestry in the Central Tablelands emerge from this research. The survey revealed a preference for agroforestry that takes place on marginal land or less productive grazing land, uses only a minority of a farm’s area, and involves a mix of short-term and long-term tree rotations for different products. The spatial analysis identified two target corridors where NRM objectives align with landholder preferences: one between Bathurst and Mudgee, and another between Lithgow and Oberon. The former could provide opportunities for both erosion control and habitat connection, while the latter has the advantage of being in the SE subregion, which showed a higher level of interest in converting land to agroforestry and a greater willingness to accept smaller returns.

Different incentives strategies will also be required for commercial graziers on large landholdings and lifestyle/hobby farmers on smaller blocks. Lifestyle/hobby farmers were interested in converting more of their land to agroforestry, were more likely to accept reduced returns, and had greater recognition of environmental benefits. However, the total land area nominated for agroforestry by survey respondents was dominated by commercial graziers due to their larger landholdings. For potential investors seeking to establish plantations for bioenergy across the region or to enter into supply agreements with landholders, managing a large number of small plantations spread across multiple properties is likely to carry higher transaction costs than working with a smaller number of large landholders. The importance of environmental benefits to lifestyle/hobby farmers is also a double-edged sword for investors – on the one hand it could make them willing to accept lower financial returns, but on the other it could make them more particular about how the plantations are designed and managed, or perhaps less likely to manage them well.

There were also considerable concerns from landowners over government policy in relation to land management. For landholders to move into agroforestry to support bioenergy production, they need to feel confident that whatever land is put into mixed native tree agroforestry will in the long term remain classified as a plantation and not suddenly be classified as a ‘conservation area’ or as ‘native vegetation’, which would create significant barriers to harvest and use for electricity generation in NSW. They were also concerned that they could also face major restrictions on clearing the land again in the future. This is especially the case for traditional farmers where the main motive in the move to agroforestry is diversification and the generation of a commercial return, despite other multiple environmental benefits involved. Providing such a ‘guarantee’ will have implications for existing legislation such as the *Native Vegetation Act 2003*, the *Plantations and Reafforestation Code* (approval and certainty of harvest) and the use of native species as biomass for electricity and biofuel production. Landholder fears of regulatory changes are well founded and are based on past experience with and perceptions of the shifting of rules in relation to managing native vegetation.

In terms of government support for the establishment of farm-based agroforestry production for the biofuel industry, the preferred mechanism mentioned by most landholders was for the provision of ‘establishment support’. This is, however, in marked contrast to the current popular government approach of ‘price support’ through market mechanisms, as used in the renewable energy and the carbon pollution reduction initiatives. There is a clear need for the development of an independent agency/body to address the legislative structure and the financing needed for such the industry, given the long-term investment farmers will be confronting if they are to return a significant proportion of their cleared land to mixed native forestry. Landholders have to see that there is a real and long-term market for biomass. In this their attitude and behaviour reflects not blind conservatism, but pragmatism.

One of the additional outputs of this project was the development of a framework or methodology for assessing the potential uptake of farm-based agroforestry needed for a bioenergy industry. What has become clear from this study is that in applying such a framework in similar regional assessments, there is a critical need to match appropriate bioenergy production systems to local biomass supplies in line with economic development goals, community expectations and environment targets. A regional bioenergy industry also needs a predictable yearly supply of biomass for electricity production and biofuel supply. This will require more detailed and integrated regional studies, where the specific local context is taken into account.

Figure 36 presents a model framework for undertaking assessments of bioenergy potential in other regions. In line with the focus of this project, the model is oriented towards the assessment of new agroforestry options, but it also recognises the critical importance of assessing existing biomass sources alongside any new production options. In the Central Tablelands, NSW DPI has been assessing existing sources of biomass from forestry harvesting residues in a related DAFF/RIRDC project, while Delta Electricity has also looked at wood processing residues and urban wood wastes. Our work on potential new agroforestry options ran parallel to this work on existing biomass sources.

An integrated regional bioenergy assessment could bring together the separate research strands on new and existing biomass sources, as indicated in the model’s ‘regional feasibility and impact assessment’ stage. In relation to the Central Tablelands, some of this integrative work falls within our project, particularly in relation to economic, social and environmental impacts that are more localised or specific to one form of biomass production (such as habitat creation or erosion control from the establishment of new agroforestry plantations). Other aspects of this integrative stage fall within CSIRO’s project, specifically greenhouse gas balance and economic assessment that draws on both our work and that of NSW DPI. The model also outlines stages that lie beyond the 12-month timeframe of this current project, such as returning to key stakeholders to ‘ground-truth’ the results of the assessment, and obtain a decision on whether to proceed further. If the decision is taken to proceed, development of business models and planning for the development of the industry is required. These stages form Phase 2 of our project to be undertaken from June–December 2011 under RIRDC funding.

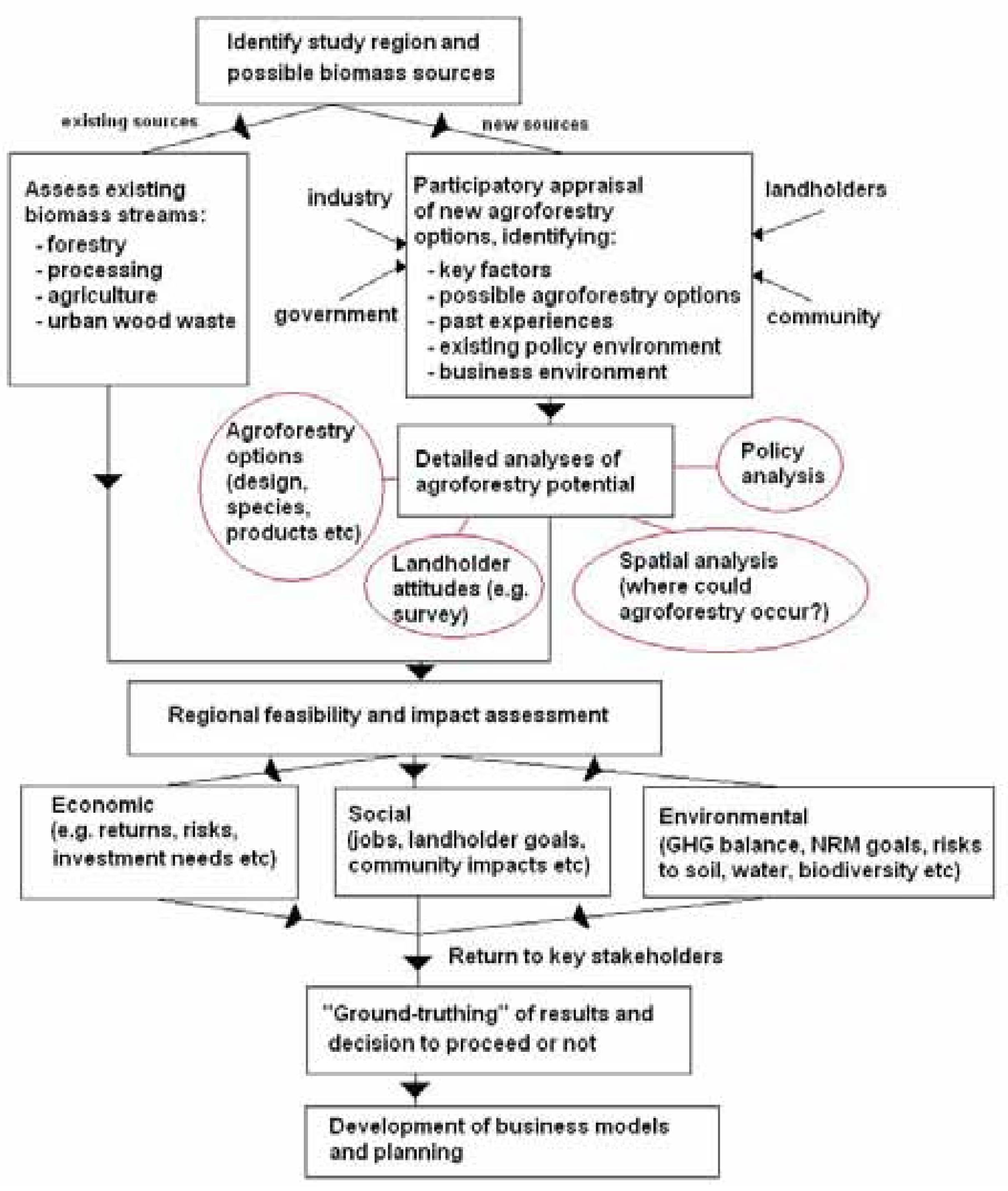


Figure 36 – Model for a transferable regional bioenergy assessment framework

Recommendations

There are a number of initiatives that flow from the discussion and finding sections of this report. If there is to be an effective and sustainable bioenergy industry in rural Australia, the following recommendations could be critical steps in its establishment. Due to the complexity and uncertainty associated with the proposed industry, as well as the multiple sectors involved (e.g. economic, legislative and social), there is a crucial role for government and industry collaboration in its establishment. To assume that the market alone could deliver a sustainable bioenergy industry is, we believe, a mistake.

1. Stimulating adoption of bioenergy plantings by landholders

Industry stakeholders, both in the forestry and energy sectors, need to devise strategies to reach different landholder types who have different attitudes towards agroforestry. They also need to consider ways in which a regional bioenergy industry can be scaled up over time, as many landholders will need to observe successful implementation before they make the decision to adopt. The matching of new agroforestry with existing biomass wastes is one way to achieve the necessary scale, and the results of related projects by NSW DPI and CSIRO should shed more light on this potential. Industry stakeholders also need to consider ways of converting government price support measures, such as the RET, into establishment support for landholders. Managed Investment Schemes (MIS), Delta Electricity’s mallee trials at Forbes and the experiences of the solar PV industry could provide possible models worthy of closer examination.

2. Co-ordinated planning for a regional bioenergy industry

Local councils also have a role to play in planning for a regional bioenergy industry, including appropriate zoning of potential plantation areas and planning for the infrastructure needed at a regional scale (e.g. roads, rail and bioenergy plants within 85–100 km of any producer). These issues extend beyond any one LGA in the region and require cross-council cooperation. Catchment Management Authorities have a role to play in identifying forms of agroforestry involving bioenergy that can complement and contribute to regional NRM goals, and target these towards identified areas of need. Appropriate opportunities for this co-ordination are an essential requirement.

3. Getting the regulatory and other policy settings right

State and Commonwealth government agencies need to explore how present incentives schemes for renewable energy can be ‘translated’ into on-ground support mechanisms that are viable and acceptable from the perspective of landholders. They also need to address landholders’ scepticism towards government regulations, considering past experiences with native vegetation clearance, earlier dismantling of price support schemes, and changes to the RET and MIS regulations. The NSW Government should also consider whether the potential for future changes to regulations around plantation establishment and harvesting, native vegetation clearing and the use of native forest biomass for bioenergy could create investment uncertainty for bioenergy-based agroforestry, due to the risk of restrictions being expanded or multiple-objective plantations being classed as native vegetation. It also needs to be considered whether a similar set of regulatory restrictions are likely to be imposed on liquid biofuels produced from woody biomass, if indeed these technologies become viable on a large scale over coming years. Ideally, if a decision is made to stimulate regional bioenergy industries, a streamlined regulatory pathway should be developed to simplify the process and to make regulatory requirements clear and transparent.

4. Need for an independent agency to drive and monitor bioenergy initiatives

Considering the cross-sectoral and cross-jurisdictional nature of these recommendations, there is a strong case for an independent agency/institution to be created that can oversee the development of a viable and sustainable bioenergy industry in rural Australia. Such an agency would need to consider each of the issues identified in relation to planning, investment strategies, NRM priorities, regulatory reform and incentive mechanisms. It would need to liaise with industry as well make recommendations to government at all levels. Considering the applicability of these issues to many different regions across Australia, such an agency may be best coordinated at the Commonwealth level or under the auspices of the Council of Australian Governments (COAG). This agency could lead the implementation of the first three recommendations.

5. Follow up in the Central Tablelands

In relation to this study of the Central Tablelands region of NSW, a follow up Phase 2 will include the design of a business model to bridge current gaps. This would also include an assessment of the number of landholders needed to commit to agroforestry to create the needed critical mass. As planned, the project will involve a regional workshop to further progress the outcomes of Phase 1 (this report) in the second half of 2011. Phase 3 will involve a pilot project in the area, but the exact form will depend on results of Phase 2. This follow-up is a critical step and should be fully funded.

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Appendices

Appendix 1: Joint summary

Research into a Viable Bioenergy Industry for the NSW Central Tablelands

Three inter-related research projects are being undertaken in 2010/11 in the NSW Central Tablelands. They are jointly looking at the potential for a regional bioenergy industry to be established based around the use of plantation biomass. Electricity generation and conversion to liquid biofuels are being assessed, based on biomass sources including residues from existing pine plantations, residues from wood processing and biomass from new plantations. Biomass from native forests is not being considered within this research.

The three projects are being led by:

- The University of New South Wales (Institute of Environmental Studies), the Blue Mountains World Heritage Institute and the University of Sydney (Faculty of Agriculture, Food and Natural Resources)
- Industry & Investment New South Wales (Policy and Research Division)
- CSIRO (Energy Transformed and Sustainable Agriculture Flagships)

Each project has received funding under the Australian Government's Forest Industries Climate Change Research Fund, with the Rural Industries Research and Development Corporation also providing support for the first two projects.

THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY · AUSTRALIA

The University of Sydney

This project will focus on the potential for new agroforestry plantations in the Central Tablelands region. The research will look into possible sites, species and plantation designs, as well as social goals and conservation objectives. Through stakeholder consultation, the project draws on the ideas and experiences of landholders, industry, Government agencies and community groups in the region. **This will also provide information for the CSIRO bioenergy resource assessment** (see overleaf).

Key Project Activities

- **Participatory Rural Appraisal** (August/September 2010): This will involve interviews conducted over 3 days by a team of interviewers followed by a stakeholder workshop to review the information gathered.
- **Data analysis:** Results of stakeholder consultation will be analysed
- **Qualitative analysis** of social drivers/barriers, ability of plantations to meet regional NRM goals). Likely to include a survey, GIS analysis and policy analysis.
- **"Ground-truthing"** of scenarios and modelling results. This will involve returning to local stakeholders in March/April 2011 for a workshop or interviews.

Project Team

John Merson and Peter Ampt (Principal Investigators), Crelis Rammelt (Project Manager), Alex Baumber (PhD Researcher) & Sarah Terkes (Administration)

Contact: Crelis Rammelt on (02) 9385 5731 or c.rammelt@bmwhi.org.au

Industry & Investment

This project aims to quantify the biomass currently left on site following harvest operations in radiata pine plantations around Oberon and Bathurst. Significant volumes of plantation biomass must currently be managed or removed to reduce fire risk, allow for re-establishment and improve forest health. Some of this material could be sustainably utilised to help meet clean energy targets. As well as assessing available volumes of biomass, this project will also assess the environmental implications of nutrient removal and reduced intensity of site preparation.

Key Project Activities

1) Select nine study sites in Forests NSW pine plantations around Oberon/Bathurst.
2) Establish plots to estimate total above ground biomass and its components.
3) Assess total residual biomass after harvest for each plot.
4) Develop inventory methods for assessing residual and recoverable biomass.
5) Perform a preliminary cost benefit analysis for a range of biomass yield and prices.
6) Calculate nutrient removal and carbon balance for different harvest intensities.

Project Team

Dr Huiqan Bi (Principal Research Scientist, New Forests), Fabiano Ximenes (Acting Program Leader, New Forests), Nick Cameron (Manager, Investor Relations)

Contact: Fabiano Ximenes on (02) 9872 0143 or fabiano.ximenes@industry.nsw.gov.au

National Research FLAGSHIPS CSIRO

CSIRO will assess the economics and greenhouse gas benefits of using existing and future plantation biomass for bioenergy. Available biomass resources will be estimated from production models and with inputs from I&I NSW and UNSW/BMWHI. Biomass resources and conversion technologies (electricity or liquid fuels) will then be assessed for their the economics and greenhouse gas mitigation benefits. CSIRO will also be undertaking a similar modelling exercise in the West Gippsland region of Victoria.

Key Project Activities

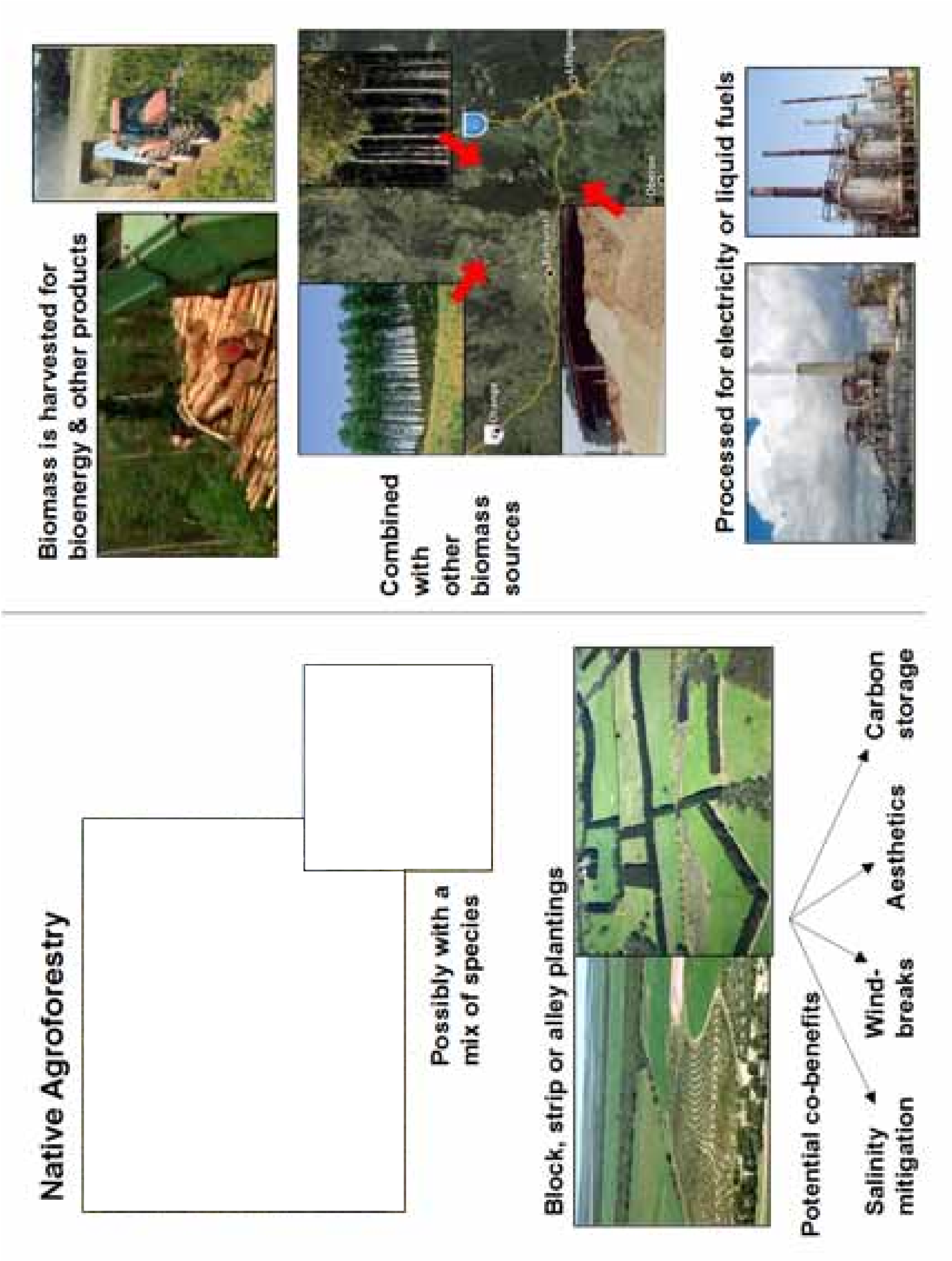
1) Estimate biomass production for each region from existing and future forests.
2) Scope prospective technologies for production of bioelectricity and biofuels.
3) Estimate GHG emissions from different biomass types for bioenergy.
4) Model the economics of various feedstock and technology combinations under different carbon and fuel prices.

Project Team

Dr Luis C. Rodriguez (Project leader), Dr Alexander Herr, Dr Deb O'Connell, Debbie Crawford, Dr. Andrew Warden, Dr Victoria Haritos, Dr Andrew Braid

Contact: Dr Luis Rodriguez on Luis.Rodriguez@csiro.au

Appendix 2: PRA interview scenario



Appendix 3: PRA interview questions

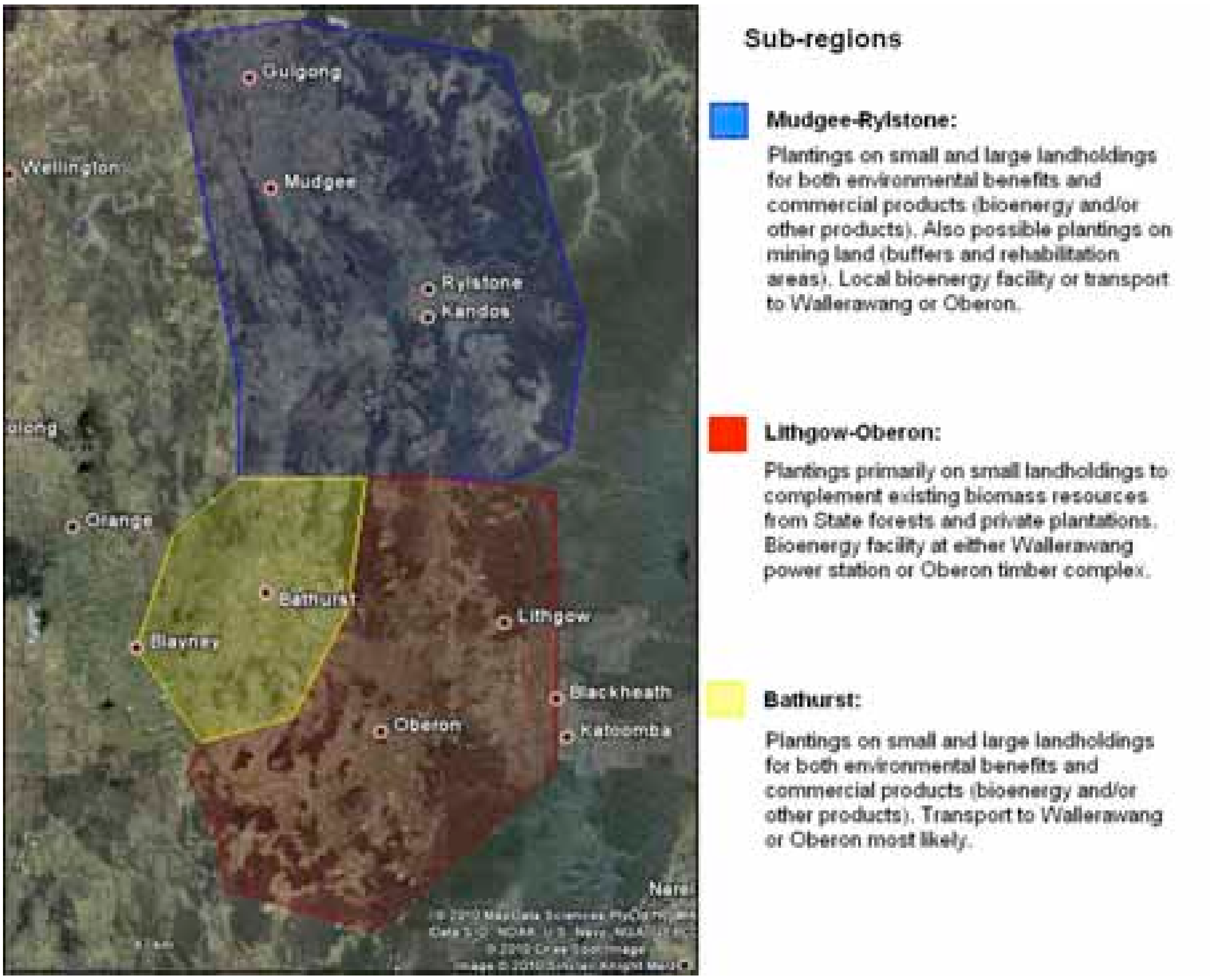
Question	***Sub-group/s***	***Comments***
1. About you		
Can you tell me a bit about yourself, such as your age, property (business) size, farming (business) activities, history on the land (in the business), dependency on land (business) for income?	Landholders and business owners	Wording may vary depending on nature of business/land use
Why do you own land? How do you use it? What is the future of how you use your land? What would you like to be able to do with it?	Landholders	
Can you tell me a bit about your organisation's role in the Central Tablelands region and the role you perform in the organisation?	Govt, community groups	
What concerns, if any, do you have about the long-term sustainability of your land/business?	Landholders, business owners	Prompt with examples if need be (climate, regulations, market prices, etc)
What is your experience or exposure to growing trees – planted or through natural regeneration, both for commercial and non-commercial reasons?	All	
2. About the district		
What do you feel are the major environmental issues in the region?	All	
What do you feel are the major social and economic issues in the region?	All	
How important is plantation and farm forestry in the area? How important is tree growing in the future?	All	
What do you think needs to happen to improve the region?	All	
3. Vision for bioenergy-based agroforestry		
Interview team will first outline a possible scenario based around plantations of native trees, managed to produce bioenergy and other products and targeted at providing a variety of environmental and social benefits. *Each team will use the script and images to outline this vision.*		
Do you have any immediate responses to the scenario?	All	
Are there any potential benefits you can see in the vision we've outlined?	All	Could prompt with "environmental, social or economic benefits"
Are there any potential threats or risks you can see in the vision we've outlined?	All	
What potential barriers could you see for landholders or industry in getting involved?	All	
If you were interested in taking this up, would you require the same average annual return as your current land use? Do you have any thoughts on what net return you'd need per hectare per year to take it up?	Landholders	
If you were to get involved, how much of your land would you think about turning over to agroforestry? Which parts of your land would you use and what sort of plantation designs would you prefer (block	Landholders	

plantings, belts along fence lines or contours etc)? What would you need to know to make these kinds of decisions		
If it were to be successful, how much land would you like to see converted over to these plantations across the region as a whole? (Is there any amount you think would be too much or any areas where you wouldn't want to see plantations?)	All	
How do you think bioenergy would fit into an agroforestry system – for example, would it be the primary product from tree-cropping, a co-product alongside other products or just be produced from the wastes left over from higher-value products?	All	
Assuming the returns and the impacts on the landscape were the same, would it matter to you what the trees were used for – timber, woodchips, bionergy or anything else?	All	
3. Making the vision a reality		
What tree species do you think could work for bioenergy production in this area? (If they name some, ask: do you know what planting times and rotation lengths would be required for these species?)	All	
What kind of support scheme do you think would be most effective in driving uptake? For example: - establishment support - price support for the products or - payments for ecosystem services such as carbon, biodiversity, salinity	All	Prompt with examples
Are there are any other types of biomass that already exist on your property or in the region that could also be used for a regional bioenergy industry (e.g. existing forestry residues, crop stubble)? If so: - what price would you need to make it worthwhile to collect and sell your biomass sources? - what other markets exist for this biomass at present	Landholders	
What locations in the Central Tablelands do you think might be good for bioenergy facilities (either power generation or processing into liquid biofuels)?	All	
What existing infrastructure do you think could be used for this new industry and what new infrastructure would be needed?	All	

Appendix 4: PRA results

In general, there was a positive response to the idea of an agroforestry/bioenergy scheme. Keeping in mind that our sample was small and biased towards the more progressive landholders, we are under the impression that commercial landholders with large properties would possibly participate with their marginal land (1–5% of the property). Smaller progressive landholders would potentially invest more of the land (15–20%). There would also be scope for larger blocks of plantations on mining land (rehabilitation and buffer areas).

The consultation resulted in the identification of key sub-regions with different characteristics (see Map 1 below showing the three most promising sub-regions).



Map 1 - Sub-regions

The boundaries for the sub-regions were set based on morphology, land use (national parks excluded and pine plantations included, for example), climate and distance to potential bioenergy infrastructure and facilities (with Oberon and Lithgow the most promising sites for bionergy facilities). We decided that Orange and areas further west (Molong, Cudal, Cowra) would not be explored in detail in this study due to their distance from existing forestry and energy activities, a lack of clear bioenergy scenarios emerging from the interviews and indications from interviewees that these areas represent separate climatic/land use zones from the rest of the Central Tablelands.

Oberon

Characteristics

There was a slight concentration of interviews around Oberon compared to other areas in the Central Tablelands.

The landholders groups have changed quite rapidly. The trend of concentrated larger landholdings that can be seen further west in NSW is not happening in the Central Tablelands, mainly because of the high land prices. These landscapes are, however, transitional from production to amenities' values. Oberon has changed over time from a rural town surrounded by large holdings to a town based around timber processing—surrounded by many landholders with small properties and few large properties. The proportion of subdivisions is constantly changing. There is a very low unemployment rate, but population is increasing. The largest employer in the area is probably the softwood industry (particularly processing).

Oberon has considerable native vegetation and the cleared areas are smaller when compared to Bathurst, for example. Because there are already a lot of trees in the landscape, some of the interviewed landholders did not see much benefit of additional plantings (including environmental benefits). On the other hand, a local tree nursery owner said that there has been a trend of buying more trees, mainly by owners of small properties. Weeds and erosion were mentioned as the major environmental issues, particularly affecting some of the small blocks that are not well managed. Pine was mentioned as one of the main weeds due to spreading from plantations.

Available resources

There are already several waste streams in the Central Tablelands region, particularly around Oberon. These potential feedstocks for a bioenergy plant include former plantations that have been harvested and are regrowing, the thinning and pruning from existing plantations and wood waste from Oberon's two sawmills, pine board factory and MDF plant (which currently has an excess of waste). Many of the smaller landholders have put in private radiata pine trees in the 1970s that are now reaching harvesting age. With lower standards of management compared to the large-scale industrial approach, the timber products from these smaller plantations might not be able to compete as timber products. They may, however, become available as a resource for bioenergy. The Oberon area could be a good place to start because it wouldn't require additional tree planting in an initial phase.

Past native forestry was fairly small scale and localised with many smaller mills. It stopped almost completely when the softwood industry started. There are large national park areas that cannot be logged. Some landholders would not want to grow more when they feel they should be allowed to harvest from existing forest resources.

The feeling was that many of the commercial landholders have subdivided and sold off their marginal land already. What still remains is better grazing land, and they are unlikely to put any additional land into tree plantations. Most of it has been sold to blockies. So land resources are likely to be found with the blockies or with those landholders who haven't sold off their marginal land and might be prepared to plant trees. Plantations that act as windbreaks for stock could also be attractive.

There was a lot of knowledge on existing species, and on which ones would grow well in what areas. The many local tree growers could hypothetically give advice to a more central management unit. On the other hand, local knowledge is currently in the hands of few nurseries that are interested in selling seedlings, and there may be issues with sharing information. There has been little measurement on the growth rates of native trees in the area, which presents an interesting potential for research.

Scenarios

In terms of possible models for agroforestry-based bioenergy in Oberon, two options arose. The first would be commerce driven where landholders could have everything done for them and could get a lease payment for the land or a share of the final product. Certain models could perhaps be coordinated by NSW DPI. NSW DPI is currently involved in softwood plantation forestry, but new data and modelling of the opportunities might encourage them to move into native tree plantations. At the moment there is not a real concern with impacts of climate change on production. The second model is a bottom-up collaborative landholder approach. Several interviewees in Oberon mentioned the large-scale industry in the area and were concerned about the profits flowing out of the communities. The agroforestry-based bioenergy system could develop as a community resource. A facility could supply firewood, or electricity, to the grid. The small-scale approach fits in with cottage high-end use, it could connect landholders with a local miller who might provide a suitable end product.

The small-scale approach might not easily link with larger scale business. One interviewee talked about people who had gone into pine plantations in the past, but never really got a good run from the mills because the mills deal mainly with state forest. The smaller players received unfavourable deals and were dictated to when to harvest and when to get thinning done. The difficulties also meant they didn’t produce high quality trees.

The issue of scale is important in both models. The viability of such an industry is dependent on scale. Agroforestry for timber implies waiting 30–40 years for a return, which many landholders would not be interested in. Landholders might not visualize the potential of a bioenergy system to provide short-term returns, because there are no examples. There is a need to demonstrate that it is economical. The major problem is that for a demonstration to work, there is a need for scale. For instance, a biofuel system requires sufficient and constant amounts of feedstock. The Oberon area offers a potential way around this chicken and egg situation by using existing wood wastes and substandard pines to start up a bioenergy industry, with biomass from new plantings coming in over time.

It would be expensive to build a local plant, so Delta Electricity's Wallerawang Power Station near Lithgow could be an option. Delta was using about 1% biomass until two years ago, but stopped because of the transport and processing costs involved. They are now exploring a number of biomass options, including local pine wastes and mallee biomass grown further west at Forbes. These options require a higher price for renewable energy credits or a carbon price to become viable. Biomass cannot compete directly with coal due to being so dispersed (meaning high harvest/collection costs). Delta will wait until such a time as policies and economics around RECs and carbon pricing are certain before investing in significant biomass use. This could discourage landholders to take a proactive approach. There is a high risk when starting without a secure long-term market. Any investment in transport infrastructure, such as rail line connections, will depend on the scale and the type of product (biofuel versus bioenergy).

Delta has assumed that growing biomass for bioenergy is likely to be less commercially viable in the Central Tablelands than further west because of the higher land values. However, co-benefits from plantings such as windbreaks or salinity control could alter this equation. Views amongst interviewees differed on the question of whether landholders would need the return on native tree plantations to be at least as lucrative as the return from current production. One interviewee believed that people would need the same return they currently receive. In fact, some might even need more than they receive from their current land use as they are so used to what they are doing that they would need something extra to make it worthwhile changing. While some said that they would need direct economic incentives, others claim that the co-benefits such as windbreaks mean it doesn't have to have the same return. One landholder was surprised that Oberon did not consider windbreaks, it being such a cold, windy area. It was speculated that blockies are probably not really concerned if the trees don’t make a profit, and they would be interested if it is something useful that engages them with the land and the community, and if it is at least revenue neutral. Moreover, if it going to take off, it won't be happening on the most productive portion of the land. Most landholders we spoke to were interested in planting, but only on marginal land. Some were concerned that planting on a slope would degrade the land. If managed/thinned badly, poor ground cover could lead to more erosion, but a thin plantation would have sufficient ground cover and would function well.

There are many blockies. A scenario that could work is one where a management group manages land across different owners. The idea of cross-property collaboration was raised in two interviews with blockies, and they both thought it was feasible. A realistic scale could be reached by aggregating small landholdings. Several interviewed landholders had a positive view on this, but others may just want to stay with cattle. Commercial landholders with large holdings could participate by assigning subplots. Land could be managed either by a collective or through ‘green leasing’ to an external company. In a cooperative, landowners could value-add with small-scale processing infrastructure. Biomass could be turned into chips on the spot, for instance. A carbon price would be a crucial element.

Risks

There were questions about how extra plantations would impact water runoff and water quality. The Oberon Council has data on this, and further information could be collected from the Sydney Catchment Authorities. There are discussions within the Department of Environment, Climate Change and Water NSW about how the drying up of catchment areas that are a source of clean water might aggravate salinity levels in the overall catchment.

If it becomes commercial, more and more people might see an investment in native tree plantations as their superannuation, thus tolerance to catastrophic events, and risks such as fire, is low. The concern for increasing fire risks from climate change will depend on the landholder's perspective on climate change. People might look at this as just another risk, but there could be a potential for thinning native vegetation instead of preemptive burning. This would provide employment and another potential source of biomass for bioenergy.

Bathurst

Characteristics

All the interviewed landholders had farms to the south of Bathurst (within 20 minutes drive from town). Bathurst is a growing regional centre that provides a high level of services for farmers who live nearby, such as those we interviewed. Rural residential subdivision has occurred around Bathurst, although this is greater to the north than to the south and the council has imposed minimum block sizes in some areas. The farming population is declining, with few young people staying on the land and many farmers managing (or sharefarming) other blocks in addition to their own. Grazing of sheep and cattle is the main activity, with some cropping (often for fodder). Regional environmental issues include habitat fragmentation (due to widespread past clearing), erosion (particularly steep slopes and gullies), salinity (in isolated areas), water use (some indicated there was over-allocation) and drought (past 8 years have been tough on farmers).

All interviewed farmers had been involved in some form of innovative farming or conservation activities such as tree planting, no-kill cropping, ‘carbon farming’ and restoration of native grasses. All but one was a commercial farmer, but they indicated that many other farmers do not think the same way they do (i.e. they are probably not typical of the region). Commercial agroforestry is not common in the area (very few sites on the list of past agroforestry trials we have obtained are in the Bathurst area). The major motivations for past and current tree planting were habitat for biodiversity, protection of gullies from erosion, windbreaks for stock and salinity mitigation (in limited areas). Sequestering carbon was also a motivation (but not for payment at this stage). Belief in climate change was widespread amongst interviewees, but they indicated that it might not be amongst other local farmers.

Available resources

Many environmental plantings exist amongst the interviewees and their neighbours. These are a mix of ages and species (manna gum, river red gum, yellow box, silver wattle, casuarinas) and are often in gullies, on hilltops or in other difficult to access areas. Legal barriers may exist for harvesting some plantings (if under CMA covenants) or native remnants (banned under the *Native Vegetation Act 2003*). There is very little in the way of timber processing residues or crop residues in this area. Thus, the potential bioenergy resources lie in new tree plantings.

Scenarios

All interviewees responded positively to the idea of agroforestry for bioenergy due to the opportunity for economic diversification and to get more native vegetation into the landscape, but also highlighted various conditions needed to make it viable. Farmers would need to see the final product use and sale pathway before investing and would need assistance with establishment (both financial and advice). Most indicated that, unless prime land was diverted to block plantings, returns would not need to be the same as current land uses. This was because there would be co-benefits (e.g. biodiversity, salinity, erosion, windbreaks) and belt plantings can actually increase productivity of surrounding areas. Regular returns would be needed rather than a multi-decade wait for harvest and, in this regard, bioenergy was seen to have an advantage over agroforestry for timber products.

The amount of land that interviewees would be willing to see converted over to agroforestry plantings on their properties varied (e.g. 1–5%, 15–20%, 30–50%). These figures included purely environmental plantings as well as those for both commercial and environmental purposes.

The most promising scenario may involve working with landholders south of Bathurst who have undertaken past environmental plantings to identify which species grew well and at different locations. These could be matched to appropriate uses (electricity, pellets or liquid fuels along with wood products). New plantings of these species could be established in areas that balanced landholder goals (for environmental co-benefits and by not diverting their most productive land) with practical considerations for planting and harvesting (e.g. size and shape, soil type, slope, accessibility).

Given the small size of properties in the area (1000–2000 acres), the small proportion of each property that might be turned over to agroforestry and the fact that many farms are managed by neighbours, some kind of cross-property leasing or sharefarming arrangement is likely to be needed to provide a critical mass of plantings. Government or large companies (e.g. forestry, energy) could play a role in leasing and managing land for such uses. Community title is also an option, as one landholder used this option to ensure environmental plantings were retained when their land was subdivided.

No obvious locations for processing and use of biomass in the region were discerned from the interviews. Bathurst could be a central point with established transport, labour and support industries, but the general public may object to a large plant. Oberon (timber processing) and Lithgow (power stations) would be better locations for a large-scale facility, while Bathurst or nearby may be suitable for small-scale production. A number of interviewees indicated new road infrastructure might be needed.

To overcome the fundamental chicken or egg situation in relation to establishing new plantings for bioenergy, some plantings are likely to require establishment some years before a viable end use has been proven. One option for support during this stage may be carbon payments, which were viewed quite positively by those interviewed (although none were actually involved in such schemes). Central West CMA has been trialling an incentive scheme for increasing soil carbon through tree planting and grazing management. Price support mechanisms were viewed less positively, as they would not help with establishment costs, are vulnerable to changes in government and, as one farmer put it ‘we don’t get price support for anything else we sell’. Managed investment schemes were also viewed unfavourable due to recent plantation forestry sector controversies and also due to a local history of absentee landholders managing grazing properties as tax breaks.

Risks

Major risks are financial, given that investment may be required before returns are certain. The risk of increasing land management complexity for landholders was also raised, resulting from the addition of a new, largely unknown land use options with different market pathways and red tape. Adding carbon trading as well as bioenergy is likely to increase this complexity further, especially if carbon trading involves locking in land management decisions for 70 or 100 years. Increased fire risk from more vegetation was also mentioned. Cross-property management also has inherent risks in that the right type of landholders are needed who are prepared to cooperate in managing plantations for common goals.

The risk of blocking out views if plantings became too widespread (i.e. 30% of landscape) was mentioned by one landholder. One interviewee also indicated a preference for seeing biomass used for timber or other high-value uses rather than bioenergy—a potential social barrier which has arisen in other policy and social studies around bioenergy from native forests and wood chips from biomass.

Mudgee/Rylstone

Characteristics

From the interviews, four significant landholder groups were identified in this sub-region:

- innovative commercial farmers who have tried new practices such as cell grazing and have undertaken tree planting for environmental objectives (most interviewed landholders were in this category)
- older family farmers with large properties and a more conservative approach to farming and land management (these are declining as part of a generational change)
- small non-commercial landholders (lifestylers, blockies, tree changers and hobby farmers)
- mining companies managing land for mining, rehabilitation and as buffers.

This area is a 'transitional landscape'. Most farmers in the area have off-farm income. Subdivision for hobby farms has occurred in the past (~15 years ago), mostly on the less productive country. Subdivision continues in some parts, mostly in the southern end closer to Sydney (e.g. Capertee and Ilford). There is a local debate about ensuring that productive land is kept in production and there are moves by council to limit further subdivision in some areas. The population is increasing, mainly due to mining and blockies/tree changers.

Salinity was not a big issue, although some examples were mentioned of revegetation to mitigate salinity in certain areas. Weeds were an issue and agroforestry could help to shade out serrated tussock. Native vegetation remnants are mostly on steeper country (probably not suitable for plantations anyway).

Tree planting was widespread amongst interviewed landholders, for aesthetics, habitat, shelter for stock, carbon storage (to be 'emission trading ready') and a general view that the area had been over-cleared. Other innovative practices were reported such as cell grazing and management to increase soil carbon. Watershed Landcare group is active (300–350 members), but funding has reduced in recent years. The local environment group has also done tree planting, but sometimes struggles to get sufficient volunteers.

Although most interviewees had undertaken tree planting or changed grazing practices, a view was also expressed that a conservation ethic is not prominent amongst many older local family farmers who go back 2–3 generations on the land and have a fairly conservative outlook regarding farming and land management.

This is not a forestry area like Lithgow or Oberon. There is also very little commercial agroforestry in the area, but some past trials. Many of these sites do not appear to have been closely monitored for growth rates or survival of different species.

New mining activity (e.g. coal near Ilford) was mentioned repeatedly as a theme. Several negative mining impacts were identified. Mines attract people off farms and make it hard to get labour, as farming can't compete with mining wages. The presence of mines may change the social structure of the local community. Impacts on the land include dust and erosion, and water use can be an issue. However, the mining sector was also seen as a significant opportunity for bioenergy-based agroforestry due to the amount of land they manage and their potential to invest.

Available resources

In terms of biomass resources, there are a number of past agroforestry trial sites in the area. An audit of available data on these sites is lacking, included species trialled, survival and growth rates. Vineyard waste is another possible resource.

Mining land may be an important land resource for bioenergy-based agroforestry, as mining companies often have to set aside large buffer areas that could be used and also the requirement to revegetate areas after mining.

The Watershed Landcare group is a valuable local resource for landholder contacts and expertise in tree planting for environmental purposes. However, relying on this group for a landholder survey will result in a significant bias in results because of their current high level of support for tree planting for multiple benefits.

Scenarios

Of the four landholder groups outlined at the beginning, each is likely to require a different scenario for bioenergy-based agroforestry. For example, more traditional family farmers are likely to require a higher level of return than current land uses and observable proof of success in order to switch to agroforestry. Small non-commercial farmers may not need a competitive return (as they don't rely on their land for income), but may need help with establishment costs and an external agent to handle all of the establishment, management and harvesting. The aesthetics and other environmental attributes of the plantings would also need to match closely with their lifestyle goals. Mining companies are unlikely to need help with establishment costs, but may be encouraged to participate via a government incentive such as carbon payments or tax breaks. They may also need to ensure that agroforestry is consistent with government approvals for using their land and that it enhances rather than detracts from their standing in the local community.

From the interviews, potential scenarios were clearest in relation to the first group (innovative commercial farmers). One scenario could involve starting with an audit of existing agroforestry resources from past trials and supplementing this resource with new plantings that provide both biomass and environmental co-benefits. One interviewee said he would be prepared to convert 5% of his land into trials purely for research without a guaranteed return. Another said the area could easily cope with 10% under agroforestry (maybe 20%) but that in order to switch he would need a higher return than from his current land use (in order to counteract the increased risk from a new venture). The level of return required is likely to vary depending on the quality of the land used, whether the plantation increases or decreases land value and whether it delivers co-benefits that are valued by the landholder (shelter for stock, salinity control, weed control, aesthetics).

Strip plantings were seen by some as the best option, as they are consistent with goals such as windbreaks. However, flexibility with planting styles and designs would make it attractive to a broader group. A common view was that an annual return is needed rather than having to wait 40 years, which suggests a short-rotation system based on coppicing species (e.g. casuarinas) or fast-growing eucalypts based primarily on bioenergy rather than timber. Local processing and/or electricity generation could occur as long as it was relatively small scale such as for use at a mine. If larger scale processing was required, biomass may be transported to Wallerawang or Oberon.

In terms of support mechanisms, assistance with the management of plantations was mentioned repeatedly. There was also a recurring theme of scepticism about government handouts or subsidies for revegetation and plantations. However, a couple of landholders who said that any agroforestry system needs to be economic without government support were also strongly supportive of carbon payments or other payments for ecosystem services. This indicated that such payments may be effective but they should be delivered in the form of a genuine and stable income available for a valid land use activity rather than being seen as a government handout that can change with political will. This anti-government view may be related to the reduced funding the Landcare group has received over time (which has also led to an interest in securing private sector funds to avoid the 'strings to government').

Risks

The general chicken or egg economic risk was discussed, as it was in other locations (i.e. landholders need the certainty of a market in order to plant trees but bioenergy facility requires critical mass to become viable). A lack of infrastructure, such as roads, may be a risk, but there is the potential for mining sector infrastructure to also be used for bioenergy production.

Traditional/conservative attitudes to new land uses may be a risk, but this is likely to subside with generational change. There is also a perception in some parts of the community that revegetation can increase fire risk or harbour feral animals.

A general view against burning wood for energy came from a local environment group. This idea that harvested trees should be put to the highest value use possible was observed in other regions in relation to both plantation material (e.g. in SW Western Australia) and native vegetation (e.g. higher-value test under the Commonwealth RET regulations). If widespread, this could lead to local opposition to bioenergy facilities or plantations.

Lithgow

Characteristics

Lithgow has quite a lot of native vegetation. Cleared areas are relatively small compared to Bathurst, for example. Large areas of the Lithgow LGA are forests or parks—over 40–50% according to one interviewee.

Farm forestry is undeveloped, but there are timber plantations. These large monocultures create weed problems, for example, with pine wildings spreading to swamps. Lithgow is included in the Blue Mountains 'save our swamps' campaign. There is water scarcity in the area (although it is not as severe as Orange). There are problems of water quality because of the warm water effluent from the power station in combination with agriculture, landfill and sewage effluent. Landcare activities in the Lithgow area are reportedly in decline as funding and other support for Landcare groups has become scarcer.

Being closest to Sydney and the Blue Mountains, the Lithgow area has experienced high levels of subdivision for lifestyle blocks. These small landholdings can present fire risks due to poor management. The council receives many complaints from new landholders about noise from mining, farming or forestry.

Employment and industry in Lithgow is very dependent on mining. Several interviewees mention that there is a need for diversification of the local economy.

Available resources

The landholder interviewees had tried various types of tree planting, so there is knowledge on this in the area. The fire management residues could provide a resource for bioenergy. Lithgow is an industrial centre and has a power station. Various previous industrial or mining sites could potentially be utilised for plantings.

Scenarios

Several interviewees mentioned that Lithgow could focus more on diversification. It was also mentioned that Lithgow is in a valley, and could be used as a test case because of its unique environment. Three years ago, one interviewee suggested to Delta Electricity the idea of setting up research substations, with Oberon supplying the biomass and Lithgow the power station.

Local processing could create local opportunities. Transporting material and products could have numerous impacts, but there are rail line connections. Lithgow has an advantage over Oberon (which has no rail connection), but this will depend on scale and the type of product (biofuel versus bioenergy).

According to one landholder, because there is already a lot of natural bushland and remnants, there wouldn't be much additional environmental benefit to the landscape. Rainfall could be another limiting factor. One landholder thought farm forestry would have more benefit further west around Bathurst but another felt that water would not be a problem. Another landholder could imagine trees as windbreaks in grazing paddocks. Block, strip or alley plantings would all be interesting, but blocks would probably need to be small, and if possible coppicing trees should be used (ironbark, yellow box). Other interviewees mentioned the potential for riparian corridors, which would protect creeks and stabilize soils on grazing land.

Current land uses were criticized by one landholder. More marginal land could be used for tree planting. It was suggested that agroforestry/bioenergy systems would not require the same returns to the landholder because it would rely on currently unused land. Moreover, trees are inexpensive to grow and not labour intensive. Pruning could be an issue. Fire, wildlife and protection issues make things complicated, but trees could be grown on rougher country. If trees are grown for saw logs, the land cannot be too rough because of difficulties harvesting.

A few things would increase the chances of success, such as advice and technical support for those who are interested, subsidies or tax breaks to employ labourers (chippers/managers), machinery assistance on hilly land and better information about what wilderness resources are actually there.

Risks

Rabbits, fire and weeds could become a problem. The land is on a granite base, which can affect root growth. Seedlings may pose a fire risk. Excessive water use could become a problem. One landholder was worried that timber would be sent overseas, and imported again as finished products. Skills to establish, maintain and harvest trees for agroforestry/bioenergy are needed in the region.

A view was expressed that Lithgow Council has generally been more focused on urban development and mining rather than rural environmental issues. One interviewee was broadly against the idea of burning wood for energy, even if it was from plantations. The idea that harvested trees should be put to the highest value use possible was observed in other areas in relation to both plantation material (e.g. in SW Western Australia) and native vegetation (e.g. higher-value test under the Commonwealth RET regulations). If widespread, this could lead to local opposition to bioenergy facilities or plantations.

Orange

Characteristics

The area around Orange was not well characterised by these interviews. The interviewees talked about the broader region of the Central Tablelands and of the Central West Catchment Management Authority area.

Subdivision has affected the quality of the land. Around Orange, because of the soil quality, production on small plots has been linked to 'boutique production', such as berries, truffles and so on. In the Central West CMA in general there is not a lot of pressure from land clearing. There are a significant number of pine plantations. Private native forests are also significant, but have been a bit undervalued and would need a small market. Seventy-five per cent of the private native forests state-wide have significant environmental issues. In the north, the land quality is good, but Central West is does have environmental issues. The environmental issues in the area are mainly weed invasion, erosion and water capture. Woody perennials and grasses affect the water flow.

An interviewee argued that the reason is bad management. The forests are underburnt and need high-level intervention. Public awareness of this is low, and people think that any type of logging is bad. Biodiversity values may be lower in unmanaged regrowth areas than in managed areas. This is something that is not well understood, and farmers have no money to invest in proper management.

Available resources

There is potential in the Central West to improve planned management of private native forestry. There is quite a large timber resource in the scribbly gum forest, of which a large part is regrowth of sub-prime quality. One interviewee argued that economic harvests have been compromised due to regulations, when it is exactly this that could help drive the management of healthier forests. A market for firewood, thinnings or biochar could drive this. However, many mills have been shut down in the area.

Scenarios

Support for landholders that are already on the frontline would encourage participation. Local farmers could take this on and promote it within the community, rather than agencies taking the lead. It would be harder to get commercial farmers interested because a strong case would need to be made to demonstrate that this is commercially viable and that there is a reliable end-market.

Farmers are unlikely to plant on prime land. They will use lower-value country or invest in alley planting on medium-quality country. The question is how to support farmers for some of the lower-value land. There is already some landholder interest in looking for ways to benefit from a carbon price.

According to one interviewee, wood from private native forestry is a cost-effective and readily available resource. Planting monocultures may not be cost-effective, but the resource already exists on farms that desperately need management support and cashflow. This could also potentially improve the health of forests.

Cash-strapped farmers may choose to subdivide land, which may cause landscape management issues. It is probable that corporate agriculture may increase in the future by taking over small family farms. Corporations often undertake blue gum farming on the land of elderly farmers. This provides benefits to the farmers who are soon to retire, because don’t need to maintain/manage the trees themselves and can collect yearly annuities. On the other hand, farm forestry may require less maintenance than traditional farming, and therefore may be suitable for hobby farmers and smallholders. Hobby farmers tend to engage in more innovative non-traditional farming practices compared to established commercial farming.

In any case, demand for the products by an industrial consumer seems necessary. The lack of a market is the biggest issue right now. Funding for R&D is essential to get any fledgling industry off the ground.

Risks

One risk could be the unintentional contamination of introduced eucalyptus with local plants. Appropriate species would need to be researched. Another risk could emerge if operators overharvest, thus regulations should be considered. Currently, if there is a breach of the code, landholders are penalized. On the other hand, there is also a fear of regulation. At the moment, it is a legal maze for landholders to go through in order to thin bush/woodland on their land. Using native vegetation for bioenergy may also run into other regulatory barriers such as the ban on using such material for electricity in NSW and the requirement under the Renewable Energy Target that the trees must have been harvested primarily for a higher-value purpose.

Planting more woody perennials for bioenergy could have an impact on the water balance of the region, which is already relatively dry. There may be public resistance against plantations for this reason. This is currently being discussed by the Department of Environment, Climate Change and Water NSW.

Outside boundaries

Characteristics

These areas were originally outside of the scope of the study but interviews were included due to recommendations from regional contacts. In both the Cowra area to the southwest and Molong/Cudal to the west, interviewees expressed the view that they were climatically different from the Central Tablelands. Around Cudal, the rainfall of 600 mm was considered to be significantly different to the parts of the Central Tablelands where commercial agroforestry may be viable. Cowra was considered to have earlier spring weather and a different growth season for crops and grasses than on the Central Tablelands. This area was noticeably different to the Central Tablelands around Bathurst, as the proportion of the land sown to crops in late August (winter wheat and canola) increased markedly along the drive from Blayney to Cowra.

These factors do not mean that these areas are not worth further investigation, but due to their climatic differences, long distance from the existing plantation areas and low numbers of landholders interviewed, they probably fall outside of the feasible boundaries for this study. A separate study could assess the viability of bioenergy-based agroforestry in these areas.

Many characteristics were similar to landholders interviewed in the Bathurst area. A lack of young farmers, rising land prices from rural subdivision and declining terms of trade were seen as issues for the areas around Cowra, Cudal and Molong. All interviewees had undertaken tree planting (most for environmental reasons, one for agroforestry trials).

Available resources

Previous agroforestry trials were undertaken in the Cowra area but commercial agroforestry has not taken off. Knowledge about the performance of different tree species may be available from these trials but it seems data has not been systematically collected. Crop stubble may also be a resource due to higher cropping levels in these areas, but a view expressed by all three interviewees was that a better use for crop residue might be to leave it in the field to protect the soil.

Scenarios

We don't have enough data to propose a viable scenario for these areas, especially given their distance and climatic differences from the core Central Tablelands area. It may be that scenarios similar to other parts of the Central Tablelands could work here but with different species. Alternatively, the kind of short-rotation mallee system being trialled at Forbes and Condobolin may be a better option.

In terms of the percentage of land converted to a new agroforestry land use with joint commercial and environmental outcomes, those who had done a lot of environmental plantings in the past said 20% and 25%, while the one who had only planted for agroforestry trials said 1–2%. Some said they would convert for less than current returns if there were environmental co-benefits, while others said they would need the same returns. Blocks were preferred over strips. Help with establishment costs was the most preferred support option, although stewardship payments were also mentioned. Views on climate change and carbon payments were mixed (some sceptical, some supportive).

Risks

Given the lack of knowledge about agroforestry in these areas, there are numerous risks. Those identified were economic risks, fire (especially if locked in to a carbon storage contract) and distance from processing centres. Further work would be required to assess which risks are most significant.

Appendix 5: Survey questionnaire

Questionnaire – Potential for Bioenergy and agroforestry in the NSW Central Tablelands

Part 1. About yourself and your farm

What is your gender? Male ☐ Female ☐

What is your age? Under 30 ☐ 30 to 49 ☐
50 to 64 ☐ 65 and over ☐

What area of land do you currently own or manage?

Land owned: Acres or Hectares

Other land managed: Acres or Hectares

What is the postcode for your property?

What are your current land-uses?

Please tick the appropriate box or boxes. You can tick as many as is relevant to your situation.	**Major use**	**Minor use**	**No use**
Commercial Cropping	☐	☐	☐
Commercial Horticulture	☐	☐	☐
Commercial Forestry	☐	☐	☐
Commercial Grazing	☐	☐	☐
Intensive animal production (feedlot, kennels, etc)	☐	☐	☐
Commercial, not production (B&B, farm stay, etc)	☐	☐	☐
Mining and quarrying	☐	☐	☐
Lifestyle and hobby farming	☐	☐	☐
Conservation of remnant native vegetation	☐	☐	☐
Environmental plantings (e.g. revegetated corridors)	☐	☐	☐
Indigenous land	☐	☐	☐
Other (please specify):	☐	☐	☐
Other (please specify):	☐	☐	☐

1/9

What is the productive capability of your land (both owned and managed)?

Please estimate the percentage of your land in each category below:

Capability	**Percentage**
Suitable for regular cultivation	
Suitable for grazing with occasional cultivation Suitable for grazing only	
Marginal land (rocky/steep with little grazing value)	
Land set aside for conservation purposes	
Other (please specify):	
Total	**100%**

To what extent do you agree or disagree with the following statements?

Please tick the box that best describes y our reaction to each statement.	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Farmers have to prioritise making an economic return over improving environmental outcomes	☐	☐	☐	☐	☐
Farmers have a responsibility to manage their land to provide benefits for the wider community	☐	☐	☐	☐	☐
Farmers should be paid to manage their land to provide benefits for the wider community	☐	☐	☐	☐	☐
Human use of fossil fuels is changing the climate	☐	☐	☐	☐	☐
The science behind climate change is doubtful	☐	☐	☐	☐	☐
Good agricultural land should grow food, not trees	☐	☐	☐	☐	☐
Tree planting is more acceptable on marginal land	☐	☐	☐	☐	☐
Planting trees should involve native rather than exotic trees	☐	☐	☐	☐	☐

What is your experience with tree-planting or tree-cropping?

☐ I have planted trees for commercial purposes (including trials)

What were the aims? Please tick all that apply.	How much grew successfully?	How did you plant the area? Please tick all that apply.
☐ Producing commercial timber	☐ None	☐ A few scattered trees
☐ Trialing timber species	☐ Some	☐ Long strips of trees
☐ Carbon sequestration	☐ Most	☐ Blocks of trees < 1ha
☐ Other (please specify):		☐ Blocks of trees > 1ha

☐ I have planted trees for non-commercial purposes

What were the aims? Please tick all that apply.	How much grew successfully?	How did you plant the area? Please tick all that apply.
☐ Rehabilitating degraded land	☐ None	☐ A few scattered trees
☐ Improving my property's looks	☐ Some	☐ Long strips of trees
☐ Increasing birds and animals	☐ Most	☐ Blocks of trees < 1ha
☐ Reducing salinity		☐ Blocks of trees > 1ha
☐ Other (please specify):		

Have you received government funding to help cover the costs of any of these tree plantings, or free materials (e.g. seedlings)? Yes ☐ No ☐

Were any of these trees planted and managed by someone other than yourself (e.g. a revegetation or forestry organisation)? Yes ☐ No ☐

Part 2. About agroforestry for bioenergy

The following questions relate to the potential for commercial agroforestry in the region with bioenergy as one of the products produced in the form of either heat or electricity from woody biomass. Bioenergy could be the major product or only produced from wastes and off-cuts. The plantations could be single species or multi-species. They could be short-rotation (harvested every 1-5 years) or longer-rotation (15-30 years). A number of possible species and plantation designs could be used. Incentives could be put in place to overcome some of the obstacles.

To what extent do you agree or disagree with the following statements?

Please tick the box that best describes your reaction to each statement. **Agroforestry…**	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
… protects land and water from erosion	☐	☐	☐	☐	☐
… protects land against salinity	☐	☐	☐	☐	☐
… has environmental benefits beyond my property	☐	☐	☐	☐	☐
… attracts wildlife and birds	☐	☐	☐	☐	☐
… improves how my property looks	☐	☐	☐	☐	☐
… increases the value of the farm	☐	☐	☐	☐	☐
… provides windbreaks and shelter for stock	☐	☐	☐	☐	☐
… creates a legacy for my (grand)children	☐	☐	☐	☐	☐
… diversifies farm business	☐	☐	☐	☐	☐
… acts as a form of superannuation	☐	☐	☐	☐	☐
… stores carbon to mitigate climate change	☐	☐	☐	☐	☐
… helps adapt to climate change impacts	☐	☐	☐	☐	☐

What barriers do you see for greater uptake of agroforestry?

Please tick the box that best describes your reaction to each statement.	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Current land uses offer better returns than agroforestry.	☐	☐	☐	☐	☐
The wait for returns from agroforestry is too long.	☐	☐	☐	☐	☐
Regulatory changes could prevent future harvest.	☐	☐	☐	☐	☐
The capital cost for agroforestry is too high.	☐	☐	☐	☐	☐
Agroforestry involves considerable ongoing management.	☐	☐	☐	☐	☐
Agroforestry has a negative impact on water availability.	☐	☐	☐	☐	☐
I've had negative experiences with commercial agroforestry.	☐	☐	☐	☐	☐
Agroforestry reduces flexibility for future land use.	☐	☐	☐	☐	☐
The labour requirements for agroforestry are too high.	☐	☐	☐	☐	☐
Markets and future prices for bioenergy or timber products are too uncertain.	☐	☐	☐	☐	☐
I don't know enough about appropriate species.	☐	☐	☐	☐	☐
I don't have the necessary machinery or expertise on how to grow trees.	☐	☐	☐	☐	☐
The risk of pest or disease damage is too high.	☐	☐	☐	☐	☐
Agroforestry increases fire risks.	☐	☐	☐	☐	☐
Land is unsuitable for commercial plantations.	☐	☐	☐	☐	☐
Trees do not establish well here.	☐	☐	☐	☐	☐
I don't like the look or aesthetics of plantations.	☐	☐	☐	☐	☐
I already have enough trees on my property.	☐	☐	☐	☐	☐
Any other barriers (please describe):					

Part 3. Making the vision a reality

What annual return would you require in order to consider agroforestry? Please tick the appropriate box:

- ☐ The same return as your current land use
- ☐ A greater return than your current land use
- ☐ A lesser return than your current land use
- ☐ It depends (please explain factors)

What net return (income-expenditure) per hectare would be needed to take it up?

AU$ per hectare.

If you were to get involved, how much of your land would you think about turning over to agroforestry? Acres or Hectares

If you were to get involved, which parts of your land would you use? Please tick one or more boxes below:

- ☐ Land suitable for regular cultivation
- ☐ Land suitable for grazing and occasional cultivation
- ☐ Land suitable for grazing only
- ☐ Marginal land (rocky/steep with little grazing value)
- ☐ Land set aside for conservation purposes

Would you prefer block or strip plantings? Please tick the appropriate box:

- ☐ Block plantings
- ☐ Strip plantings
- ☐ A combination of both

How would you implement agroforestry on your property?

Please tick the box that best describes your reaction to each statement.	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
I would select sites where growth-rates of the trees would be highest.	☐	☐	☐	☐	☐
I would select sites where the value of my existing use is lowest.	☐	☐	☐	☐	☐
I would select sites where access for harvesting is easiest.	☐	☐	☐	☐	☐
I would select sites where agroforestry adds value to existing land use (e.g. reduce erosion, salinity).	☐	☐	☐	☐	☐
I would select sites where biodiversity benefits were greatest.	☐	☐	☐	☐	☐
I would prefer a longer rotation (15-30 years) for higher value products, such as timber.	☐	☐	☐	☐	☐
I would prefer a shorter rotation (1-5 years) for lower value products, such as bioenergy.	☐	☐	☐	☐	☐
I would prefer a mix of trees with different rotations - some for bioenergy and some for timber.	☐	☐	☐	☐	☐
I would commit to agroforestry for 70-100 years if it meant extra income from carbon credits.	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐

Assuming the returns and the impacts on the landscape were the same, would it matter to you what the trees were used for (e.g. bioenergy, timber, woodchips, storing carbon)? Yes ☐ No ☐

If yes, why?

What kind of support scheme would be most effective in driving uptake?

Please tick the box that best describes your reaction to each statement.	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
Financial support for upfront establishment would be most effective.	☐	☐	☐	☐	☐
Price support for products would be most effective.	☐	☐	☐	☐	☐
Payments for ecosystem services (e.g. carbon, biodiversity, salinity) would be most effective.	☐	☐	☐	☐	☐
Knowledge support for plantation establishment and management would be most effective.	☐	☐	☐	☐	☐
Research and development support for bioenergy products would be most effective.	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐

Part 4. About your region

What tree species do you think could work for agoforestry involving bioenergy production in your region?

Do you think that any other sources of biomass in the region could also be used for a bioenergy industry? Yes ☐ No ☐

If yes, what sources: ☐ Residues from existing plantation forestry

☐ Residues from native forest harvesting

☐ Crop stubble

☐ Other (please specify):

What locations in the Central Tablelands do you think might be good for bioenergy facilities (either power generation or processing into biofuels)?

What new infrastructure do you think would be needed for this potential new industry?

Thank you for taking the time to complete this questionnaire. If you wish to add any further comments, please do so below.

9/9

Bioenergy from Native Agroforestry

– An assessment of its potential in the NSW Central Tablelands –

by A/Prof John Merson, Peter Ampt, Dr Crelis Rammelt, Alex Baumber

Publication No. 11/065

This report describes how bioenergy feedstocks could be generated using agroforestry in the Central Tablelands region of New South Wales based upon information from engagement with stakeholders, a survey of landholder attitudes and Geographic Information System analysis. The report also includes recommendations for future planning, as well as details of how the work undertaken in this case study area can be applied to other regions.

Regional and state land management agencies could use the findings of this study to develop programs that harness economic potential of bioenergy to deliver better regional Natural Resource Management and development outcomes. The report will also be of use to stakeholders in existing local industries such as saw-milling, electricity generation, furniture-making and other value-adding forestry-based enterprises. These stakeholders are critical to understanding the feasibility of bioenergy options and implementing them.

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