



# An Assessment of the Vulnerability of Australian Forests to the Impacts of Climate Change

III. Socio-economic implications of climate change with regard to forests and forest management



Image: Peter Halasz

Geoff Cockfield, Tek Maraseni, Laurie Buys, Jeffrey Sommerfeld, Clevo Wilson and Wasantha Athukorala

## **FOREST VULNERABILITY ASSESSMENT**

### **Socio-economic implications of climate change with regard to forests and forest management**

Contribution of Work Package 3 to the Forest  
Vulnerability Assessment

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# Table of Contents

Executive Summary .....	1
1 Introduction .....	4
1.1 Introduction to the Forest Vulnerability Assessment project.....	4
1.1.1 Purpose and approach .....	4
1.1.2 Definition of forests and forest uses for the purpose of the project.....	6
1.1.3 Classifying Australia’s forests.....	11
1.1.4 Climate change projections and scenario modelling.....	12
1.2 The socio-economic implications of climate change with regard to forests and forest management.....	15
1.2.1 Scope .....	15
1.2.2 From cause to responses .....	18
1.2.3 Social, economic and policy interactions .....	19
1.3 Conclusions.....	22
2 The biophysical impacts of climate change on forests .....	25
3 Impacts on ecosystem services.....	28
3.1 Forest Ecosystem Services.....	28
3.2 Services from conservation forests.....	34
3.2.1 Protected and reserved conservation areas .....	35
3.2.2 Private landscape-scale conservation forests.....	38
3.2.3 Indigenous managed forests .....	38
3.2.4 Remnant vegetation in production landscapes .....	39
3.2.5 Forests in lifestyle landscapes .....	40
3.3 Native forests with timber production.....	41
3.4 Reforestation.....	42
3.4.1 Supply of and demand for wood-based forest products .....	45
3.4.2 Policy Variables.....	46
3.4.3 Conservation plantings and regrowth.....	51
3.4.4 Large Scale Plantations .....	51
3.4.5 Small Scale Plantations.....	53
3.5 Conclusions.....	54
4 Policy responses.....	56
4.1 The policy environment.....	56
4.2 Approaches to adaptation .....	58
4.2.1 Autonomous adaptation .....	58
4.2.2 Structural adjustment assistance .....	58
4.2.3 Catalysis.....	59
4.2.4 Certification.....	59
4.2.5 Resuming and allocating property rights.....	60
4.3 Institutional adaptation .....	61
4.4 Conclusions.....	63
5 Community attitudes and responses .....	64
5.1 Background .....	64
5.2 Research methodology .....	66
5.3 Understandings of climate change.....	68
5.4 Perceptions of climate change information.....	69
5.5 Community impacts of the forestry industry.....	69
5.6 Environmental impact of forestry .....	70
5.7 Social-community impact of forestry .....	70
5.8 Climate change adaptation .....	72
5.9 Discussion.....	72
5.10 Conclusions .....	74

6	Conclusions and Recommendations .....	76
6.1	Conclusions.....	76
6.2	Recommendations: Policy .....	77
6.3	Recommendations: Further research .....	81
	Appendix 1: Indicators for forest communities and industries .....	83
	Appendix 2: Estimating carbon sequestration values .....	85
	Appendix 3: Total Economic Value .....	86
	Appendix 4: Selected Valuations of Conservation Forests.....	88
	References .....	89

## Executive Summary

The assessment of the vulnerability of Australian forests to climate change is an initiative of the Natural Resource Management Ministerial Council (NRMMC). The National Climate Change Adaptation Research Facility (NCCARF) was approached to carry out such a comprehensive Forest Vulnerability Assessment (FVA). NCCARF engaged four research groups to investigate distinct aspects in relation to the vulnerability of forests, each of which has produced a report. In addition a fifth group was engaged to create a summary and synthesis report of the project.

This report – *Socio-economic implications of climate change with regard to forests and forest management* - is the third in the series. Through a review of literature this part of the FVA project was established to identify the potential socio-economic impacts of climate change and develop a framework for thinking about coordinated responses to socially and economically adverse outcomes. This report is based predominantly on a literature review of relevant economic, social and policy studies. In addition some original work was carried out on:

- the development of a model of plantation decision-making under climate change; and
- a small-scale survey of respondents in two towns in timber growing regions with a good mix of forest types (Bombala in the Eden/Gippsland region; and Scottsdale in north-eastern Tasmania) to determine their response to climate change.

The report is organised according to a cause and responses logic, starting with the underlying cause (climate change), through the identification of the effects as problems that should or might be addressed, to the potential planned responses by state agencies and organised stakeholders, with some final consideration of engaging with the broader community. The report concludes with recommendations in regard to adaptation and future research.

The potential direct social and economic impacts resulting from biophysical impacts of climate change considered in this review include changes in:

- the production of timber, pulp and fuel and the locations of production; changes in the ranges of tree and other forest-utilising species;
- the intrinsic value of habitat quality and viability;
- the appearance, and therefore human perceptions, of some forests;
- carbon sequestration rates;
- the impact that trees have on soil salinity control; and
- water filtration services provided by forests.

The socio-economic impact of changes in the intrinsic value of habitats also needs to be considered because it can be assumed that changes in the value of natural capital, even in the absence of direct use by humans, has significant social impacts.

The flow-on impacts of these primary effects include:

- growth in some forest-based communities and accelerated decline in others because of changes in output and therefore regional income and the cumulative effect of relocation and re-establishment decisions;
- some change in the aesthetic pleasure and spiritual comfort from particular forests;
- possible changes in tourism preferences due to changes in forest appearance, composition and habitat quality; and
- increased competition between farmers, rural 'lifestylers' and forest managers for land in higher rainfall areas which could drive land prices up.

Apart from changes in regional climates and land costs, policy decisions that directly influence demand for forest-based products and sequestration will significantly influence forest/plantation establishment decisions. Incentives to establish sinks have the potential to increase the area of national conservation and production forest estates, thereby offsetting some of the adverse socio-economic impacts that flow directly from climate change. However, there are social concerns with the reforestation of some landscapes.

Given the uncertainty about the extent of the impacts of climate change and the trajectory of consequences, facilitating adaptive forest management is best approached, initially at least, by adapting existing institutional arrangements and previous approaches to major resource management issues. The broad recommendations in relation to policy include:

- Building on the experience and lessons from the Regional Forests Agreements process, especially in relation to the use of multi-criteria types of assessment, to consider ecological, economic and social considerations in landscape planning, and the development of structural adjustment packages for regions and communities;
- Building on experience in the development of planning concepts and natural resources management (NRM) policy instruments to facilitate the movement, and therefore adaptation, of species. This would include the concept of biolinks, or connections across the landscape which could be developed through: voluntary covenants (established as contributions or for-profit agreements and applying to individuals, families or groups of landholders); the creation of specific tenures, such as that for Indigenous Protected Areas; regulations in relation to vegetation on private land; and government purchasing of land to complete biolinks and to create particular reserves.

Nonetheless, some changes in forest location, viability and appearance are unavoidable and we do not see that governments and forest managers can address all issues, implying that

there will need to be autonomous adaptation. It is a critical cultural question as to whether people can accept, re-engage with, and perhaps even re-imagine our landscapes. It is here that social research and engagement are important. The survey of two forest-dependent communities found that there is much to be done to engage people with the need for adaptation, especially where they are dealing with other structural change. There is underlying scepticism about the nature and extent of climate change, or at the very least, uncertainty about the local and personal impacts of that change.



# 1 Introduction

## 1.1 Introduction to the Forest Vulnerability Assessment project

The Natural Resource Management Ministerial Council (NRMMC) identified the need for a national assessment of the vulnerability of Australia's forests to climate change and a framework for adaptation to the potential impacts. The National Climate Change Adaptation Research Facility (NCCARF) through the Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) was approached to carry out such a comprehensive assessment of the vulnerability of Australia's forests. This Forest Vulnerability Assessment (FVA) has been carried out by four research groups each of which has produced a report. In addition a Synthesis Report (Boulter et al. 2011) has been produced which summarises and synthesises the outcomes from the four narrowly focussed reports. A summary for policy makers for the whole project has also been prepared.

A Steering Committee of federal and state government and university stakeholders involved in forest management, policy and research was engaged to adopt the NRMMC brief and set the parameters for this study. Here we scope the FVA and introduce the general terms of reference for the project.

### 1.1.1 Purpose and approach

The primary aim of the Forest Vulnerability Assessment project is to provide forestry policy makers and forest managers in Australia with information that assists the sector to adapt to climate change. In particular, the project sought to provide governments, natural resource managers and the business sector with:

- *an improved understanding of current knowledge of the likely biophysical and socio-economic consequences of climate change for Australia's native and planted forest regions;*
- *an assessment of the vulnerability of Australian forests from the perspectives of both resource use and ecosystem services - identifying particularly vulnerable forests and communities in major forest areas;*
- *an understanding of what is already being done in Australia in relation to understanding and managing climate related risk in relation to forests; and*
- *guidance on key gaps to assist climate change adaptation.*

The project has sought to enhance awareness of forest managers and policy makers to climate change risk by providing up-to-date information about likely climate change impacts on forests and vulnerability to these impacts. As outlined above, the project was undertaken by a consortium of research groups with specific aspects of the project allocated to five

separate Work Packages (WP) based on four major research themes and a synthesis. Work Packages 1 to 4, through an extensive review of literature and policy from a range of sources (including peer reviewed journals and technical reports) and through engaging with stakeholders, provide a critical analysis of the vulnerability of Australia's forests to climate change impacts. (see Table 1 for a list of reports).

A fifth Work Package (Boulter et al. 2011) summarises and synthesises all Work Packages, draws some broader conclusions on regional variability and vulnerabilities, and provides a review of the legal issues surrounding forest management under climate change.

**Table 1** The Work Package reports delivered as part of the forest vulnerability assessment (Abbreviations: JCU – James Cook University, Macquarie – Macquarie University, Murdoch – Murdoch University, QUT – Queensland University of Technology, USC – University of the Sunshine Coast, USQ – University of Southern Queensland, GU - Griffith University and NCCARF, National Climate Change Adaptation Research Facility).

WP	Report title	Authors and affiliations
1	Establishing the need and consultation with key stakeholders in forest policy and management under climate change. Contribution of Work Package 1 to the Forest Vulnerability Assessment (Wood et al. 2011)	Helen Wallace, Kathleen Wood, Anne Roiko and Peter Waterman (USC)
1	The scenarios of climate change: Tools, methods, data and outputs. Supplementary Materials of Work Package 1 to the Forest Vulnerability Assessment	Richard Warrick (USC and CLIMsystems Ltd)
2	Biophysical impacts of climate change on Australia's forests. Contribution of Work Package 2 to the Forest Vulnerability Assessment (Medlyn et al. 2011)	Belinda Medlyn and Melanie Zeppel (Macquarie), Tom Lyons, Giles Hardy Niels Brouwers, Kay Howard, Emer O'Gara, Li Li and Bradley Evans (Murdoch)
3	Socio-economic implications of climate change with regard to forests and forest management. Contribution of Work Package 3 to the Forest Vulnerability Assessment (This report)	Geoff Cockfield and Tek Maraseni (USQ), Laurie Buys and Jeffrey Sommerfeld (QUT), Clevo Wilson and Wasantha Athukorala (QUT)
4	Climate change adaptation options, tools and vulnerability. Contribution of Work Package 4 to the Forest Vulnerability Assessment (Wilson and Turton 2011)	Steve Turton and Robyn Wilson (JCU)
5	An assessment of the vulnerability of Australian forests to the impacts of climate change (Boulter et al. 2011)	Sarah Boulter (GU & NCCARF), Roger Kitching (GU), Frank Stadler (NCCARF)
5	An assessment of the vulnerability of Australian forests to the impacts of climate Change. Supplementary Material: Forest resources, climate change and the law	Douglas E. Fisher (QUT)

### 1.1.2 Definition of forests and forest uses for the purpose of the project

The scope of the project is largely set by the definition of forests used. We adopted the definition in the 2008 *Australia's State of the Forests Report* (SOFR) (Montreal Process Implementation Group for Australia, 2008). This definition includes both native forests and plantations:

*A FOREST is an area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20%. This includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.*

Based on this definition, the assessment includes a large part of Australia's mallee ecosystems (defined as dominated by multi-stemmed eucalypts - any one of about 25 species depending upon location) and encompasses very large areas of tropical savannah and woodland (also referred to as rangelands), where trees are spread out in a more open landscape and grazing is the predominant landuse. Inter-tidal, salt tolerant forests, often referred to as mangroves, also fall within this definition of forests. What many people would traditionally regard as forests – expanses of tall, closely spaced trees – are a relatively small part of the country's total forest estate.

Australia's forests are dominated by eucalypt forests (including the genera *Eucalyptus*, *Corymbia* and *Angophora*) and acacia forests making up about 89% of all native forest types (see Table 3). Both these forest types support an enormous diversity of species with over 700 eucalypt species and almost 1000 *Acacia* species (Montreal Process Implementation Group for Australia, 2008) as well as other plant species. Other important forest types cover smaller areas. These include rainforest, as well as *Melaleuca* wetlands and mangroves.

The SOFR 2008 report also used the National Forest Policy Statement (Commonwealth of Australia 1992) definition of plantations:

*Intensively managed stands of trees of either native or exotic species created by the regular placement of seedlings or seeds*

which has also been adopted for the Forest Vulnerability Assessment.

In summary, Australia's forests are a continuum of large-scale industrial plantations at one extreme and native forests (including mallee, savannah, woodland and mangroves) at the other. In order to place the Australian forest estate firmly into a management context, we superimpose a set of forest type categories, reflecting the way forests are used:

- Plantation or farm forests
- Productive native forests
- Conservation native forests

- Environmental plantings

**Table 2** Total area ('000 hectares) under three of the four categories of forest type used in this report including the percentage of Australia's total area under each type. The coverage of environmental plantings has not been quantified. Source: Montreal Process Implementation Group for Australia (2008)

Forest Type	ACT	NSW	NT	QLD	SA	Tas	Vic	WA	Aus	% of forest area
Plantation/farm forests	10	345	26	233	172	248	396	389	1818	1
Productive native forests	5	21060	30994	48005	4826	1996	4332	13797	125052	83
Conservation native forests	108	5148	16	4576	4029	1121	3505	3868	22371	16
Total forest	133	26553	31036	52814	9024	3364	8233	18054	149215	100

**Table 3** Important vegetation types and their representation in the Australian forest conservation estate.

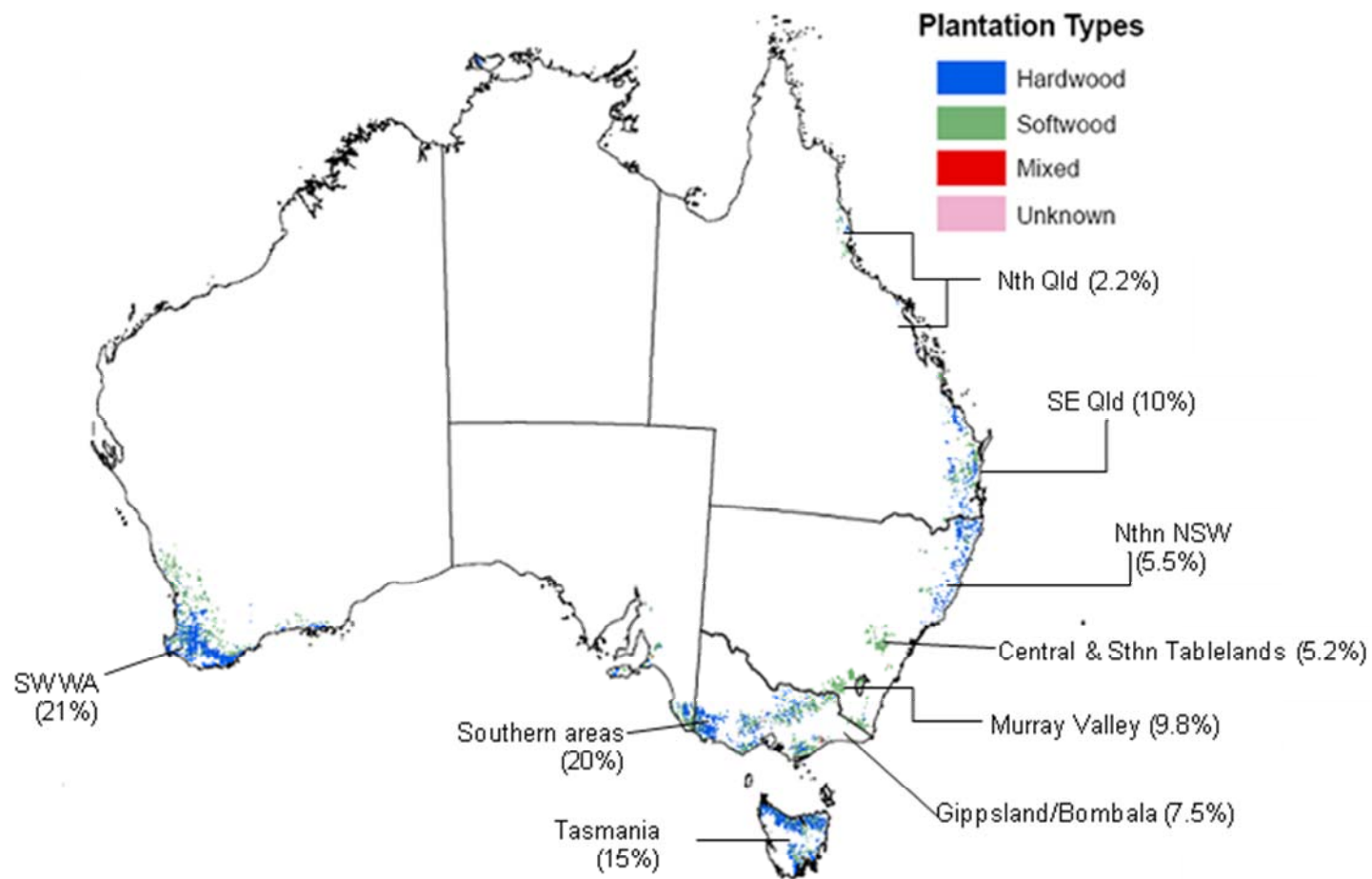
Forest vegetation type	Area ('000 ha)	Portion of forest type in conservation area (%)	Description
Acacia	10,365	5	Australia's second most common forest type; predominantly woodlands (average annual rainfall <750mm); can form open forests in wetter areas; found in all states and the Northern Territory; Mulga ( <i>Acacia aneura</i> ) dominant species in arid and semi-arid zone; Brigalow ( <i>A. harpophylla</i> ) widespread in Queensland and northern New South Wales.
Callitris	2,597	8	Found in a wide variety of climates; tolerant of temperatures ranging from below 0°C to more than 40°C; areas of annual rainfall > 300 mm, but can be as low as 200 mm; wide range of soil types, but commonly nutrient-poor soils associated with mycorrhiza.
Casuarina	2,229	39	Woodlands or open forests; all states and territories of Australia; semi-arid zone; coastal areas; Belah ( <i>Casuarina cristata</i> ) forests have the widest distribution; Belah and river she-oak ( <i>C. cunninghamiana</i> ) common inland; Coast she-oak ( <i>C. equisetifolia</i> ), rock she-oak ( <i>Allocasuarina huegeliana</i> ) and drooping she-oak ( <i>A. verticillata</i> ) form pure stands.
Eucalypt	116,449	18	Three genera – <i>Eucalyptus</i> , <i>Corymbia</i> and <i>Angophora</i> – are usually referred to as eucalypts; found throughout Australia except in the most arid regions; variety of dominant structures.

Forest vegetation type	Area ('000 ha)	Portion of forest type in conservation area (%)	Description
Mangroves	980	18	Mangroves are important and widespread coastal ecosystems in the intertidal zone of tropical, subtropical and protected temperate coastal rivers, estuaries and bays. Can form dense, almost impenetrable stands of closed forests providing coastal protection from storm and wave action.
Melaleuca	7,556	11	There are hundreds of species in the genus <i>Melaleuca</i> and many other species in closely related genera, such as <i>Callistemon</i> . About 75% of Australia's melaleuca forest occurs in Queensland, particularly on Cape York Peninsula.
Rainforest	3,280	55	'Rainforest' is a general term for a range of broad-leaved forest communities with closed canopies; do not depend on fire for their regeneration; account for most (77%) of Australia's closed crown cover forest; extend across the top of northern Australia from the Kimberley to Cape York and down the east coast to the cool temperate zone in Tasmania.

### Plantation/farm forests

In this category are those planted forests which are destined to be harvested for economic benefit at some time in the future. They include major broad-acre plantings of exotic species such as pines as well as smaller farm forestry plantings utilising a variety of species from construction to cabinet timbers.

In the 2010 National Forest Inventory update (Gavran and Parsons 2010), there were a reported 2.02 million hectares of plantations of which 1.02 million hectares was pine (softwood) and 0.99 million hectares of hardwoods of various species and mixtures. This is an increase of 49 658 hectares of new plantations from that reported in the 2008 State of the Forests Report (Montreal Process Implementation Group for Australia 2008). The area of plantation estate in Australia has continued to expand, with planting of hardwoods the greatest area of expansion (from 29% of all plantations in 1999 to 49% in 2009). There are several regions of plantation activity (Figure 1) with the largest proportion of the national estate being in Victoria and Western Australia. The majority of plantations are privately owned (62%). One-third are publicly owned and a further 5% are jointly owned (Gavran and Parsons 2010).



**Figure 1** Major Australian plantation regions. The percentage area each region makes up of the national estate is shown in brackets. Source: Bureau of Rural Sciences

## **Productive native forests**

Under this category we include those naturally occurring forests which may be periodically harvested for timber or other forest products or used for other agricultural purposes while retaining the essential ecological characteristics of their undisturbed predecessor forests. Therefore, 'productive' refers to the narrow economic use of forest resources such as timber, for example. In contrast, the much broader ecological understanding of productivity is applied to all ecological systems.

Of the 149 million hectares of forest in Australia, 147 million hectares are native forest (Montreal Process Implementation Group for Australia 2008). Under the Montreal Process definition, native forests available for harvesting (wood and non-wood products) are defined as "those native forests in which harvesting is not illegal" and some 112 million hectares or three-quarters of Australia's native forests were classified as not legally (in a strict sense) excluded from timber harvesting or tree clearing in the 2008 State of the Forests Report, (Montreal Process Implementation Group for Australia 2008). Only forests in nature conservation reserves are specifically excluded from tree removal.

For the purposes of the FVA, we have categorised those forests in which "harvesting is not illegal" as productive native forests. In practice, however, very little of this area is currently used for timber supply, with more than half (65 million hectares) being leasehold land used for grazing. In addition, in Queensland and New South Wales the clearing of vegetation is controlled legislatively (Vegetation Management Act Qld 1999 and Native Vegetation Act NSW 2003) with permits required for tree clearing and areas under remnant vegetation in "endangered" or "of concern" or "threatened" categories prohibited from tree clearing but available for other land uses such as grazing. Productive native forests, as defined here, are represented by three tenure types – multiple-use public forests, leasehold and freehold (private) lands.

Harvesting of native forests is largely restricted to multiple-use public forests with some contribution from leasehold and private lands. There is relatively limited commercial harvesting of native forests in the Northern Territory and none in South Australia or the Australian Capital Territory (Montreal Process Implementation Group for Australia 2008). The Queensland government has signalled its intention to phase out native forest harvesting in favour of hardwood plantation development (Montreal Process Implementation Group for Australia 2008) with the South-East Queensland Forests Agreement providing for the ending of timber harvesting in native State forests and timber reserves in the South East Queensland Bioregion by 2024. Although wood products can be harvested from native forests on private land, this is distinguished from farm forestry, in which seed or seedlings are purposefully planted for future harvest.

Much of the land that can be classified as productive native forests makes up the arid area of Australia commonly referred to as "the rangelands". The rangelands are those areas where the rainfall is too low or unreliable and the soils too poor to support regular cropping (Bastin and ACRIS Management Committee 2008). The area traditionally defined as rangelands includes savannah, woodlands, shrublands and wetlands that fall under the definition of forest used in this assessment. The primary use of these areas is grazing, with the trees or forests providing services such as shade

and shelter, nutrient input, salinity control, biodiversity and amenity rather than any harvestable product.

### **Conservation native forests**

Native forests on which no harvesting is legally permitted and over which conservation controls are in force are defined here as conservation native forests. This includes the many categories of forest reserves designated to serve as areas for the maintenance of environmental quality, biodiversity conservation and/or tourism. In some states this also includes forests designated as 'wilderness'. Forests in nature conservation reserves are located around Australia and cover a broad range of vegetation types. Australia has 22.37 million hectares of nature conservation reserve (Montreal Process Implementation Group for Australia 2008).

### **Environmental plantings**

This last category encompasses artificially constructed forests with a diverse set of roles from restoration and maintenance of environmental health to provision of shelter belts, biodiversity corridors, erosion control or amenity.

*Amenity plantings* are for human enjoyment and comfort and seek to provide shade, screening and windbreaks. Amenity plantings may also be used along roadsides.

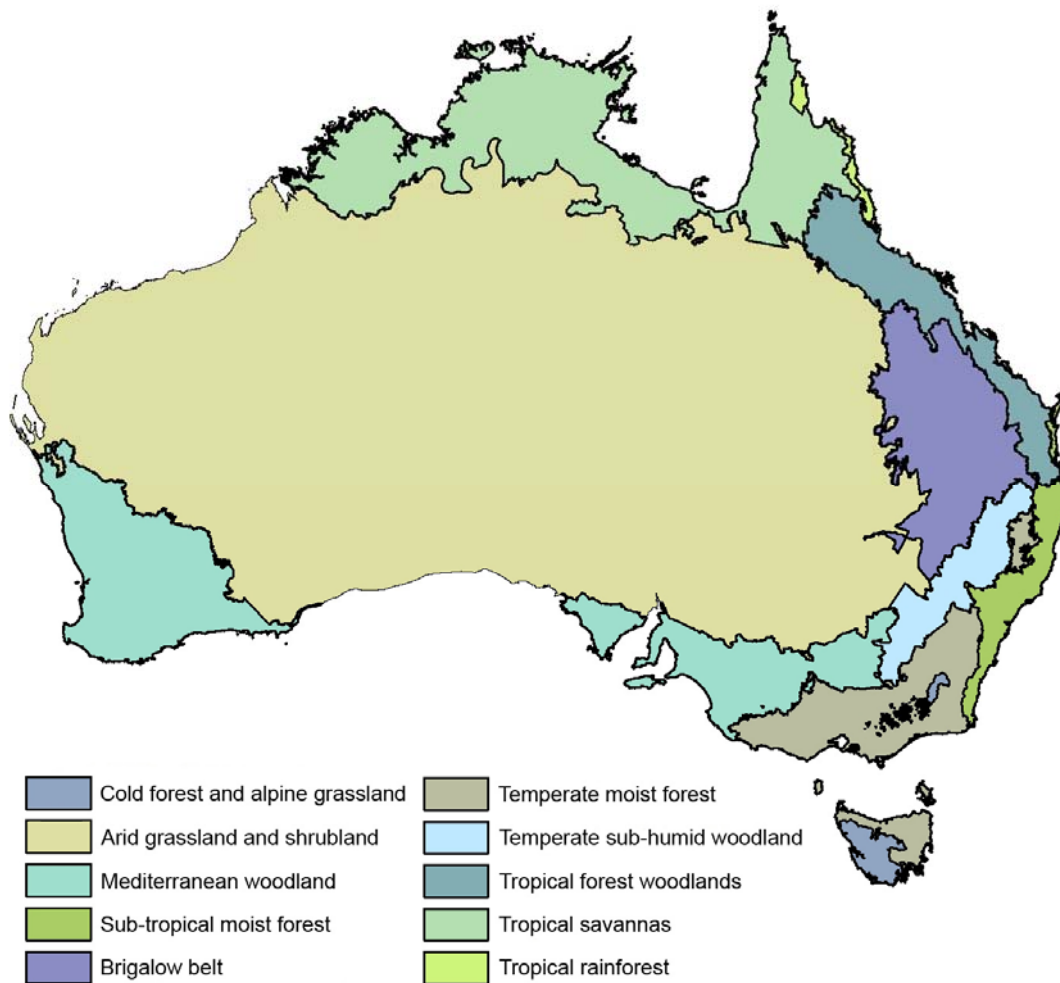
*Ecological plantings* use species local to an area (indigenous species) and provide habitat to native animals. The use of locally indigenous species conserves the character of a region both biologically and visually.

Environmental plantings may also be established for the purpose of carbon sequestration (carbon offsets) and the management of soil salinity. Environmental plantings can serve a number of these purposes simultaneously.

### **1.1.3 Classifying Australia's forests**

In addition to the forest use classification introduced earlier, the FVA applied a second layer of landscape classification using the 10 zones (Figure 2) proposed by Hobbs and McIntyre (2005). These zones were developed using both climate and vegetation. Climate was based on an agro-climatic classification incorporating a moisture index, growth index and seasonality. The climate classes were aligned to the existing Interim Biogeographical Regionalisation for Australia (IBRA) bioregions (Environment Australia 2000). Vegetation was broadly classified on the presence or absence of a tree layer and whether the understorey was grassy or shrub-dominated. A more extended discussion of these overlapping concepts of forest classification and their role in evaluating likely impacts and adaptation strategies is given in the FVA Synthesis.





**Figure 2** Agro-climatic biomes developed by Hobbs and McIntyre (2005) and used here as a framework to assess the regional impact of climate change on Australia's forests

#### 1.1.4 Climate change projections and scenario modelling

Actions to mitigate and adapt to ongoing climate change rely on modelling to predict how the climate will respond to changing atmospheric levels of greenhouse gases. There are four main areas of uncertainty in climate models (Steffen et al. 2009):

- The projected rate of production of greenhouse gases (emissions scenarios, see below)
- The relationship between the rate of greenhouse gas emissions and their atmospheric concentrations
- The rate and magnitude of the global warming for a given change in concentration in greenhouse gases
- Identifying region to region differences within global climate change scenarios.

It is difficult, if not impossible, to predict the amount of greenhouse gases that will be emitted in the future. The IPCC, the principal organisation assessing, synthesising and reporting on climate change literature, have developed four major emission scenarios (Box 1).

<b>Economic Emphasis</b>	
<b>Global Integration</b>	<b>A1 storyline</b>
	<b>World:</b> market-oriented <b>Economy:</b> fastest per capita growth <b>Population:</b> 2050 peak, then decline <b>Governance:</b> strong regional interactions; income convergence <b>Technology:</b> three scenario groups: <b>A1FI:</b> fossil intensive <b>A1T:</b> non-fossil energy sources <b>A1B:</b> balanced across all sources
	<b>A2 storyline</b>
	<b>World:</b> differentiated <b>Economy:</b> regionally oriented; lowest per capita growth <b>Population:</b> continuously increasing <b>Governance:</b> self-reliance with preservation of local identities <b>Technology:</b> slowest and most fragmented development
<b>Regional Emphasis</b>	<b>B1 storyline</b>
	<b>World:</b> convergent <b>Economy:</b> service and information based; lower growth than A1 <b>Population:</b> same as A1 <b>Governance:</b> global solutions to economic, social and environmental sustainability <b>Technology:</b> clean and resource-efficient
	<b>B2 storyline</b>
	<b>World:</b> local solutions <b>Economy:</b> intermediate growth <b>Population:</b> continuously increasing at lower rate than A2 <b>Governance:</b> local and regional solutions to environmental protection and social equity <b>Technology:</b> more rapid than A2; less rapid, more diverse than A1/B1
<b>Environmental Emphasis</b>	

**Box 1** Summary characteristics of the four IPCC SRES emissions scenarios. Source: Carter et al. (2007).

Projections of climate change vary among models. For the purpose of the Forest Vulnerability Assessment project, it was determined that the working groups would use a single set of climate change projections. The “worst case” A1FI emissions scenario was chosen because current emission trends and climate observations closely track this scenario (Allison et al. 2009). Climate modelling was carried out using the SimCLIM modelling software (Warrick 2009).

To provide the present day baseline, the SimCLIM Model uses observed monthly-mean values of precipitation and mean, maximum and minimum temperature derived from the 1961-1990 baseline period (source: Australian Bureau of Meteorology), interpolated to a 0.25 lat/long grid. For future projections, it includes spatial patterns of change for these same variables from general circulation models (GCMs). In order to capture the four areas of uncertainty already discussed, there are three points within the SimCLIM model where different ranges of data can be selected to capture different levels of uncertainty. They are:

- **Climate sensitivity** which determines the *magnitude* of global warming in response to a given change in greenhouse gas concentrations.

- **Greenhouse gas emissions** which determine the *rate* of change of greenhouse gas concentrations and associated radiative forcing (capturing uncertainties 2 and 3 from the Steffen et al. 2009, list – see above).
- **Spatial patterns of change from general circulation models (GCMs)** which determine the *regional differences* in changes in temperature, precipitation and other climate variables.
- For this project the following specifications were applied for all projections:
  - Climate sensitivity – **high**
  - Emission scenario – **A1FI** (highest future emissions)
  - General circulation model – **the median value of an ensemble of 21 equally weighted GCMs**

Two time horizons were selected for the project, 2030 and 2070, to provide a mid- and long-term scenario in each case. Projections were made for annual rainfall, seasonal rainfall (all seasons for the southern half of Australia and wet and dry seasons for northern Australia), February maximum temperatures, days over 35°C and days over 40°C and frost days (days with minimums less than 0°C).

A full description of the SimCLIM methods and a complete set of mapped projections is provided in both Work Package 1 (Wood et al. 2011 ) and the FVA Synthesis Report (Boulter et al. 2011)

### **Projected changes in climate factors**

Under current climate change projections there is a high certainty that across Australia temperatures are likely to rise in response to global increases in CO<sub>2</sub> (CSIRO and Bureau of Meteorology 2007; IPCC 2007; and Wood et al. 2010). Annual rainfall patterns and moisture availability are likely to change, but a general trend of increases or decreases is less clear and is mainly dependent on location.

The key climate-related changes that will most likely have an effect on forest system functioning in Australia are summarised below.

**Atmospheric CO<sub>2</sub> concentration:** The atmospheric CO<sub>2</sub> concentration is currently 380 ppm; estimates for the year 2099 range from 600 ppm under a low-emission scenario, up to 1100 ppm under a high-emission scenario (Sitch et al. 2008).

**Temperature:** Maximum and minimum temperatures are projected to increase in all regions and seasons. By 2030, increases of approximately 1°C are projected, with the greatest increases occurring in inland Australia. By 2070, increases of as much as 4°C could occur.

**Extreme hot days:** Increases in the number of extreme hot days are expected. By 2070, large areas of interior Australia in particular would be facing average daytime temperatures in February in excess of 39°C.

**Snow and frost:** Duration and occurrence will likely decrease across Australia.

**Precipitation:** There is considerable uncertainty around future trends. Current best estimates of annual precipitation change indicate possible increases or little change in the far north and decreases of 2% to 5% elsewhere. There could also be changes in seasonality. In Northern Australia, projections indicate that the wet season will get wetter and the dry season drier. In southern Australia, widespread decreases in rainfall are likely to occur during winter and spring. The west and southern coasts are likely to show decreases in rainfall in all seasons.

**Storms:** More severe and/or frequent storms are projected, including an increased occurrence of damaging hail and windstorms. Rainfall intensity is also likely to increase, which may lead to more flooding.

**Potential evapotranspiration:** Annual potential evapotranspiration is currently projected to increase across Australia. Best estimate projections reported by CSIRO (2007) are for an increase in potential evaporation of 6% in the south and west, and 10% in the north and east, under the A1FI scenario by 2070. However, new research demonstrating non-stationarity in other climate variables affecting the process of evaporation, particularly wind speed (see Roderick and Farquhar 2004; McVicar et al. 2008; Donohue et al. 2010) suggests that these projections need to be re-modelled using all the forcing meteorological variables (net radiation, vapour pressure, wind speed and air temperature).

**Droughts:** With decreasing rainfall, increasing potential evapotranspiration and higher temperatures, drought occurrence is projected to increase over most areas, but particularly in southwest Australia.

## **1.2 The socio-economic implications of climate change with regard to forests and forest management**

### **1.2.1 Scope**

This report includes the identification of the socio-economic implications of climate change, as described above, with these implications ordered by the forest types, also described above. Almost 15 percent of Australia's forest area (3 percent of total land area) is in forest reserves primarily for conservation purposes, and another 50 percent (more than 10 percent of land area) is under other public tenures, which includes recreational areas. Almost 25 percent of forest area (five percent of land area) is privately controlled and this includes areas with high conservation value. Forests, especially mature forests such as the eucalypt and rainforests of eastern Australia, Tasmania and south west Western Australia, occupy only a minority of the land area but they have been central to the development of environmental consciousness in Australia and as such have a high social value and political profile.

Production forestry is not a major sector in the Australian economy, contributing approximately one percent to GDP with more than \$3 billion in wages, or more than 6 percent of the wages paid in all manufacturing industries (Table 4). There is however a considerable regional concentration with

plantations mainly in southern and eastern higher rainfall areas (see Figure 5), as are the major remaining native production forests. Hence, there are forest resource-dependent communities that are highly vulnerable to changes in output.

**Table 4:** Overview of Forest Industries

		2001-2	2002-3	2003-4	2004-5	2005-6	2006-7	2007-8
<b>Vol. of log production ('000 m<sup>3</sup>)</b>	Native Broadleaved plant.	9829	10314	10090	9866	8575	8551	8940
	Coniferous plant.	1112	1594	1819	2936	3779	4052	4607
		13356	13911	14589	14196	14379	14580	14913
<b>Value (\$m)</b>	Native Broadleaved plant.	576	618	627	640	588	570	635
	Coniferous plant.	58	81	102	172	237	273	341
		703	777	839	842	847	869	895
<b>Value (\$m)</b>	Imports		4086				4271	4412
	Exports		2091				2355	2471
<b>Wages</b>	Value (\$m)	2528	2764	2902	3020	3145		
	% of all manufacturing	5.9	6.2	6.3	6.2	6.2		
<b>Employment</b>	Nos ('000)	82.8	83.3	90.6	83.5	83.0	83.4	76.8

Source: Australian Bureau of Agricultural and Resources Economics 2009

For this report, forest resource-dependent communities are those that largely rely on the extraction and/or processing of forest products (Thellbro 2006 cited in Eastaugh 2008). This includes communities that extract food and medicines from forests, which in Australia is largely confined to Indigenous communities. For the NCCARF projects, Indigenous people's vulnerability to climate change is being investigated through other designated research, so this category of forest owners is only briefly considered in this report, though we note their potential importance in landscape management. More than 20 million ha of land is designated as Indigenous Protected Areas (Department of the Environment, Water, Heritage and the Arts 2009), which is effectively held under a restricted tenure that emphasises the protection of conservation values. We also consider that there are some forest-dependent communities, such as those in the Daintree region of north Queensland, that have a high reliance on forest-based tourism, but for other regions the forests are part of a 'bundle' of tourist experiences so the degree of dependence is lessened. There are other forms of attachment to forests, notably for recreation and spiritual sustenance, and these benefits are considered important, but the term forest-dependent communities is reserved for the more direct economic and social dependencies.

Communities and individuals are vulnerable to climate change impacts on forests where there is a dependency on forest ecosystems. That is, for this study, the systems of forest ecology overlap with the socio-economic systems so that changes in the ecological system flow into the social systems. Communities are **socially vulnerable** where the biophysical impacts of climate change are amplified by the economic and social conditions (Eastaugh 2008). Vulnerability would tend to be greater where:

- Economic dependency on the resources and related industries is high and alternative sources of income are few;
- Social structures in communities are based around the resources and related industries; and
- Attachments to current occupations, places, landscapes and community structures are strong;

'**Socio-economic resilience**' is the ability of communities to adapt to change (Daniels 2004), which includes the ability to take advantage of opportunities and recover from system shocks. Adaptive capacity is the ability '... of a system to adjust to, or cope with, stress' (Parkins and MacKendrick 2007).

Adaptation is the sum of actions to 'reduce adverse effects' and 'take advantage of opportunities' (Smit *et al.* 2000), which for this report relates to the actions of people. **Autonomous adaptations** are those actions undertaken by individuals, family groups and businesses in response to changed circumstances, while **planned adaptations** involve coordinated responses. Stakhiv (cited in Smit *et al.* 2000, 239) suggested that adaptive strategies can be classified according to time frames. The creation of national-scale biolinks, for example, would be a long-range response, while spreading plantation investment across different regions would be a contingent response, with the decision-maker able to further shift investment as climate change impacts become more obvious. In a similar vein, a tactical response might be to start shifting investment at the end of a plantation cycle but this would vary with the species and resource function. For example, pulp species might be relocating in 10-15 years of an initial decision, whereas the cycle for some hardwoods might be 35 years or more and for hoop pine, 60 years.

Another way to classify adaptive responses is by the application of management measures, including:

- Structural or infrastructural change;
- Regulation;
- Institutional, administrative and organisational arrangements;
- The provision of incentives; and
- Education (Carter 1994, cited in Smit *et al.* 2000).

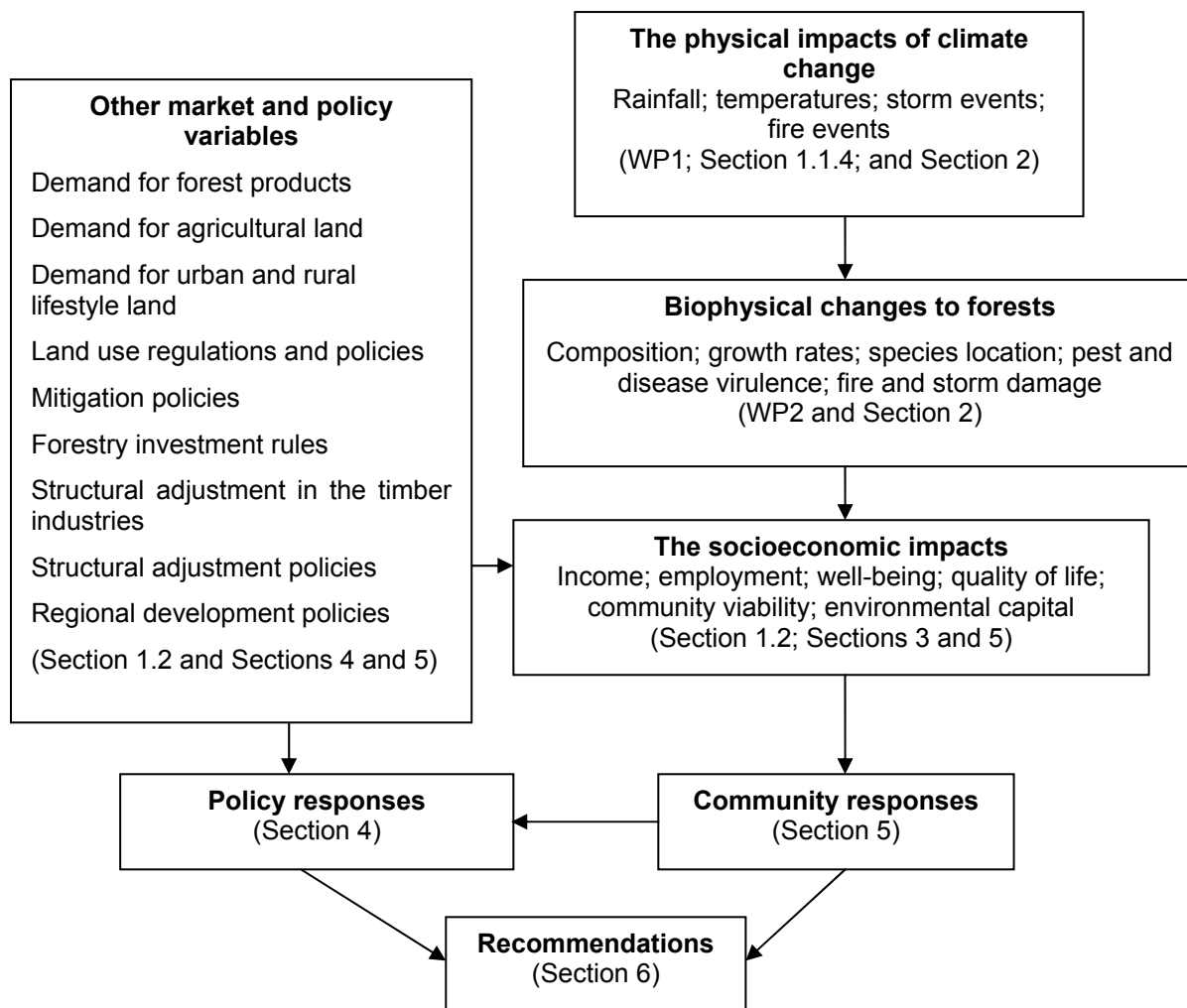
Given that industry representatives, environmental NGOs and policy-makers are primary audiences, the latter part of the report is focussed on planned adaptations and the management measures, as they relate to changes in the social and economic systems, though the inevitability of autonomous adaptations is acknowledged. The focus of the latter part of the report is on general approaches to planned adaptation, rather than detailed recommendations on how to respond to the particular social and economic impacts of climate change. This report is an early step through a complex area with a high degree of uncertainty about the underlying biophysical changes, let alone the consequent and diffuse social and economic impacts. To guide the discussion, we use a simple policy studies framework for this report, starting from the problem and working through to the responses.

### **1.2.2 From cause to responses**

This report is organised according to a cause and responses logic, starting with the underlying cause (climate change), through the identification of the effects as problems that should or might be addressed, to the potential planned responses by state agencies and organised stakeholders, with some final consideration of engaging with the broader community. Figure 3 illustrates the overall logic of this review and the report structure. In this section we discuss each of the stages but the main focus of the report is on socio-economic, state and community responses (chapters 3-5).

The underlying phenomenon is climate change, and for the characteristics of this, we work from the high warming scenarios, as generated by climate modelling. The results from this modelling are summarised in Work Package 1 (Wood et al. 2010) but in general, it is assumed that for Australia there will be a decrease in winter rainfall, which will particularly affect southern continental Australia. There may however be increased summer rainfall in north-western and central-northern Australia and an increase in summer rainfall in some of the central-eastern areas. Evaporation rates will generally increase and water run-off will decrease. Along with the expected increase in average temperatures, there will be changes in other factors that will affect the growth rates and preferred location ranges of trees. For instance, the number of high-temperature days will increase and the number of low temperature days could decrease. In addition, there will be an increase in the frequency and length of dry periods.

This report starts with an overview of the possible biophysical changes to forests, recapping some of the findings from the WP2 Biophysical Impacts report (Medlyn et al. 2010). Next, the socio-economic impacts are considered (Chapter 3), using the organising concept of ecosystem services. Ecosystem services include goods for consumption such as timber, regulation of natural systems, such as carbon sequestration and the protection and regeneration of soil, to intangible benefits such as aesthetic appeal. Since the type and extent of services varies according to the composition, extent and location of forests, potential impacts on services are considered by forest types, with several types of conservation forests and a range of production forests. Then, the discussion moves to how the various impacts might be valued so that responses can be prioritised at the level of forest, natural resources management and regional development policy communities that include government and industries. We argue, however, that community responses to climate change impacts and the resulting policy decisions are critical to any successful adaptation. We therefore consider two case study surveys of forest-dependent communities to establish a base line set of responses to the issues. The report concludes with recommendations in regard to adaptation and future research.



**Figure 3:** Thematic overview of FVA Work Packages and sections in this report

### 1.2.3 Social, economic and policy interactions

In this report, the socio-economic impacts of climate change are considered in the context of other major systemic variables (see Figure 5) that are already contributing to the determination of the size, appearance and composition of forests and the viability and resilience of forest communities. Some of the major market and policy variables are briefly summarised here and then further considered in chapters 3 and 4. While the demand for forest products will continue to influence forest management decisions, there is limited discussion in this report of possible impacts of climate change on that demand. Some possible effects might be that climate change affects demand for certain building products, or that changes in policy related to fossil fuels may increase demand for forest-derived bio-energy. On the other hand, climate change may affect competition for inputs to forestry production, and, in particular, the competition for some types of land in higher rainfall areas could increase land prices. The demand for productive agricultural land is a major threat to the size, extent and resilience of some forests and this is because of three factors.

First, trees generally affect crop and pasture yields adversely (see for example Stirzaker et al. 2000; Carberry et al. 2002) and so there is a strong incentive to reduce forest area and where this occurs



there is an increase in fragmentation and greater threat to the viability of the resulting remnants. Second, there is the incentive to suppress spontaneous regrowth in order to maintain production, further constraining the expansion and/or regeneration of forests, especially in rangelands. Third, there is direct competition for land between agriculture and the burgeoning plantations sub-sector, especially in the higher rainfall areas (see Figure 5), and in some cases, for example in south western Victoria, there is competition between grazing, cropping, forestry and amenity landscapes (Barr 2008). Another source of competition for land is the demand for urban housing, also largely in the higher rainfall areas, with the population growth in the coastal areas, especially the eastern, southern and south western regions (Hugo 2008). This results in the direct loss of forest, but also has some indirect countervailing effects in favour of forest preservation or even expansion, at the margins of the urban areas. Partly driving the movement to some coastal and hinterland areas is landscape amenity, which includes demand for forested areas. Along with this demand for amenity in some landscapes, agricultural production is decreasing as landholders become less reliant on farm income (Barr et al. 2005) and in some of these cases there is regeneration of woody vegetation and even amenity or conservation reforestation.

The impacts of land use competition are however also dependent on government regulation and policies. Most notably, agricultural, industrial and urban incursions into forests are limited in some situations by the various state and territory land legislations that restrict clearing. Further to that, governments are also seeking to preserve and enhance the ecological value of some privately owned forest areas by paying for protection (see for example Stoneham et al. 2003). There are two other potential drivers of reforestation, the demand for bio-energy (biomass fuels and electricity) and the demand for carbon sinks. A climate change mitigation program, such as an emissions trading scheme, may result in demand for sequestration offsets since the Kyoto rules require reforestation to be considered in such schemes. This will be further discussed in Chapter 3. The political uncertainties in regard to such a scheme are acknowledged but if the assumption about continued warming is realised then the pressure for governments to enact some such policy will be maintained. In addition, but even more uncertain, there might be an increased demand for fuel from forests which could increase the total value of biomass including forestry waste and be the impetus for new plantations. At present bio-fuels account for only 0.45 percent of fuel and bio-electricity is only 0.7 of the total generated in Australia (O'Connell et al. 2009) but there are pilot programs, for example in WA where mallee is used for this purpose (Wu et al. 2008).

Another driver of reforestation has been government policies in relation to the protection of native forests and the development of a national plantation estate. From the late 1980s Australian state and federal governments started to develop a set of policies for the management of forest resources broadly intended to '*... retain the character and diversity of the forested landscape*' (Commonwealth of Australia 1992, p. 3). A major strategy for achieving this was to increase the total area of plantations, thereby reducing the demand for timber from native forests and in 1996 the Ministerial Council on Forestry, Fisheries and Aquaculture set a target of 3.3 million hectares (ha) of plantations to be established by 2020 (Centre for International Economics 1997). As at 2008, there were 1.97m ha of plantations and the area of public forests available for timber production has decreased from

13.4m ha in 1998 (Department of Agriculture Fisheries and Forestry 2008) to 9.4m ha (multiple use forests in Table 1). In order to achieve the shift from native timber to plantations, a number of institutional arrangements were developed, most notably a set of Regional Forest Agreements (RFAs), which allowed for the identification of areas of high conservation value to be withdrawn from production and in return, various support mechanisms were put in place to facilitate the expansion of plantations.

The RFA process is considered in this report as providing some important data, techniques and lessons for adapting to climate change. First there is some baseline socio-economic data in relation to forest communities (Gillespie Economics 1997; New South Wales Comprehensive Regional Assessments/Regional Forest Agreements Steering Committee 1997; Rush Social Research 1997). Second, there were the techniques, and in particular the comprehensive resource assessments (CRAs), which utilised a range of approaches to identify social and economic values and some of these are discussed in this report. Third, RFAs resulted in the establishment of a Comprehensive, Adequate and Representative Reserve System, based on a set of values developed through expert advice (Joint ANZECC / MCFFA National Forest Policy Statement Implementation Sub-committee 1997) and some similar approach could be taken in relation to identifying future needs as landscapes change.

The move from native forest logging to plantations has resulted in a number of social and economic effects that are relevant in considering climate change impacts. First, some forest-dependent communities declined as logging and processing was withdrawn, making them even more socially vulnerable. This was exacerbated by the structural change that is evident in resource-based industries as mechanised production increasingly displaces labour. Further but related to that, is the general trend to depopulation of areas where the economic base and labour markets are narrow and amenity is limited (Bureau of Rural Sciences 2008; Hugo 2008; National Economics and Australian Local Government Association 2008). Outward migration from these areas is especially evident amongst young people and young women in particular (Bureau of Rural Sciences 2008).

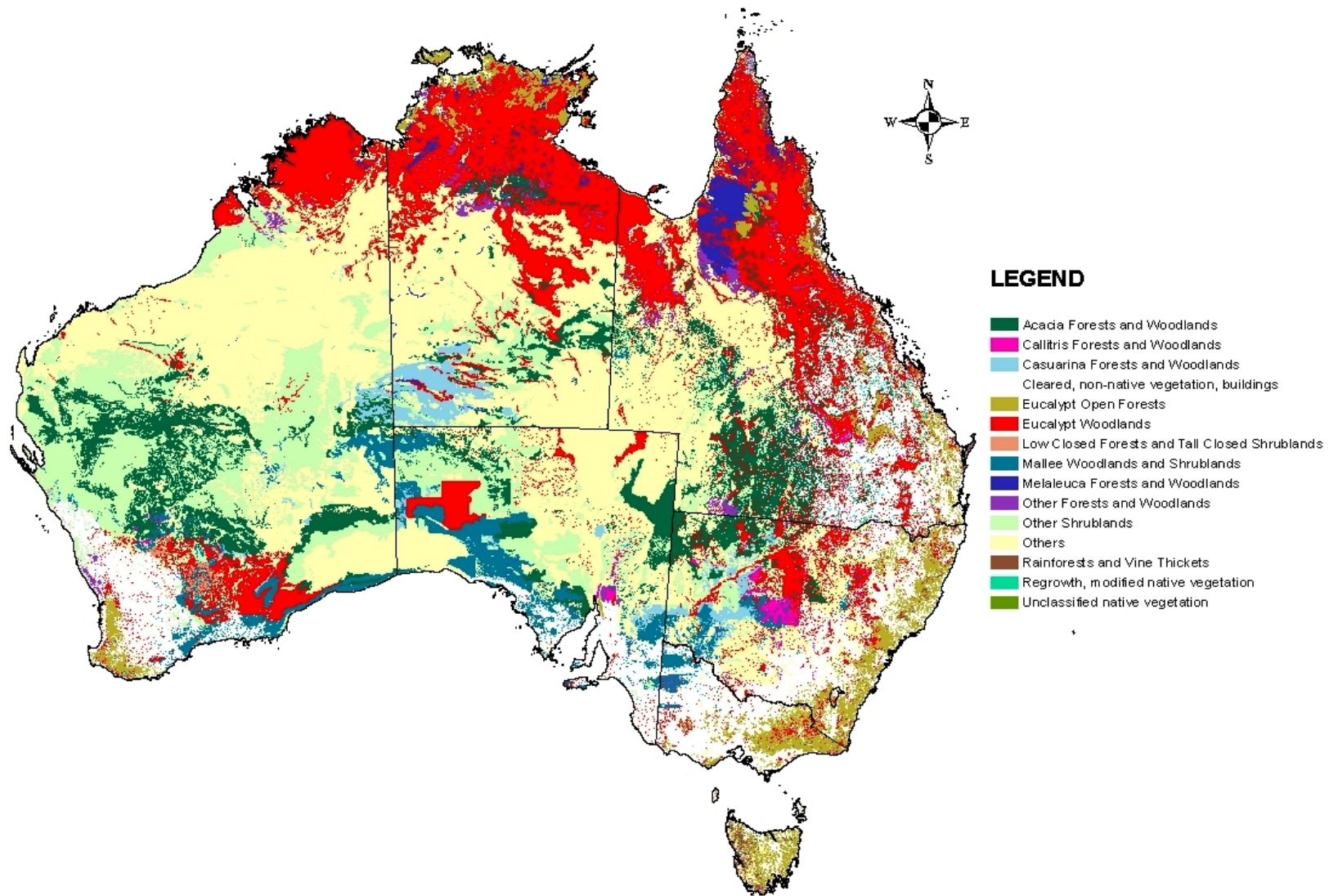
The second effect of this change in production is the resistance to landscape change amongst those more used to farm-based landscapes. The establishment of plantations, particularly those under managed investment schemes (MISs) in the southern higher rainfall areas can signify to local people, the loss of 'traditional' activities (farming and grazing) and a consequent loss of the rural cultures and local families and service industries (Tonts et al. 2001; Williams 2008; Williams et al. 2008). Hence, the longer-standing residents can be resistant to the expansion of plantations, while forest-based communities want to retain timber production. Both of these community concerns are of particular importance if the climate change impacts and consequent policy responses result in landscape changes in both settings, as is suggested as likely in this report.

Finally, we consider (in Chapter 4) some of the institutions and policy arrangements that have developed with the 'other policy and market variables' and could be adapted to include consideration of climate change impacts. These include the regulation of vegetation management, the increasing use of market-based conservation incentives, regional natural resources management (NRM)

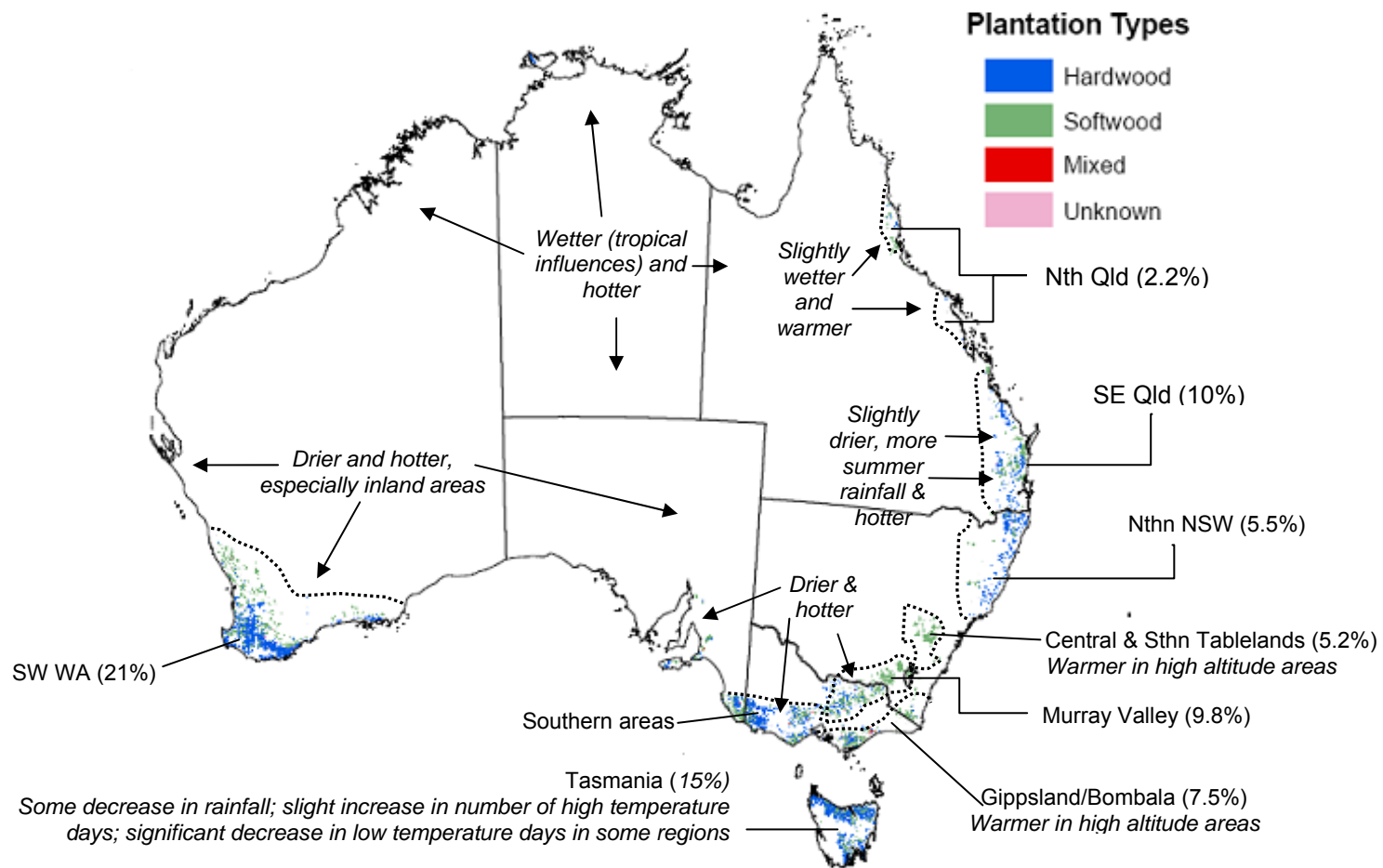
organisations and structural adjustment programs for communities affected by changes in access to forest resources. We argue that given the early stages of research into the problems and the interaction of climate change impacts with other socio-economic changes, adaptation of existing institutions and arrangements is likely to be the best approach, especially initially.

### **1.3 Conclusions**

This report is a scoping study that should be considered in conjunction with the four companion reports, with the WP5 report giving a summary of the whole FVA project. The aim here is to start to identify the potential socio-economic impacts of climate change and to develop a framework for thinking about coordinated responses. Such responses need to be considered in relation to other market and policy variables that are affecting the types, extent and composition of forests in Australia. We argue that since climate change is long term, the state of knowledge of climate change socioeconomic impacts is embryonic, the effects will be cumulative and highly variable by type and location of forests, so adaptive management is the appropriate approach for both policy-makers and forest managers. This does not mean merely defaulting to autonomous adaptation, whereby people will make changes on an individual, family or corporate basis, but the systematic building of scientific, economic and social knowledge that leads to decision adjustments and includes information and policy feedbacks.



**Figure 4:** Major Vegetation Group in Australia. *Source:* National Vegetation Information System, Major Vegetation Groups 2008



**Figure 5:** Major Australian plantation regions and broad indicators from climate scenarios (proportion of national estate in brackets). Sources: Bureau of Rural Sciences 2006; CLIMsystems Ltd 2009.

## 2 The biophysical impacts of climate change on forests

This section summarises the possible impacts of climate change on timber production and ecosystem health. The aspects of climate change that will lead to the biophysical changes in forestry are discussed more fully in WP1, 2 and 5 but the main elements are:

- changes in total rainfall, frequency of rainfall events and seasonal distribution of rain that will affect moisture availability. This will generally result in a decrease in water availability in the southern areas, while in the north and north-west, the outcomes will depend on the interaction of increased rainfall and higher temperatures (greater evaporation).
- temperature increases that will change the viability of species in particular locations, either because of the increase in the number of high temperature days, or reduced frosts and low temperature days. Growth rates may also change with higher temperatures, depending on where trees are within the climate envelope and the capacity to acclimate.
- increased concentrations of CO<sub>2</sub> which may have a fertilizing effect in stimulating photosynthetic activity. High CO<sub>2</sub> concentrations can also increase the water efficiency of plants. On the negative side, CO<sub>2</sub> concentrations are known to affect plant tissue with potential detrimental effects on the metabolism of plants.

Indirect, but nevertheless critical effects include the increased frequency and intensity of bushfires (Flannigan et al. 1998; Flannigan et al. 2000) and changes in pest and disease location and virulence.

In relation to impacts on timber production the WP2 report concludes that:

- There is little evidence that increased levels of CO<sub>2</sub> will result in universal or significant increases in tree growth rates with the possible exception of sites with more rainfall and fertile soils (Department of Environment and Heritage 2006). There may however be increases for some species in particular regions where the combination of warmer conditions, fewer frosts and, perhaps, additional CO<sub>2</sub> suit a species. Battaglia *et al.* (2009) conclude that the following plantation species and region combinations are predicted to increase in production with little increase in risk or uncertainty:
  - *Eucalyptus globulus*, *Eucalyptus nitens* and *Pinus radiata* in Tasmania;
  - the mid to lower northern regions of the hybrid pine estate; and
  - *P. radiata* and *E. globulus* plantations in East Gippsland and higher altitude parts of central and north-east Victoria. Although East Gippsland will generally receive less rainfall, the higher yield could be due to effects of carbon fertilisation and increased temperatures in high altitude areas.
- The following plantation species and region combinations are predicted to increase in production with an increase in risk or predictions associated with high uncertainty based on model assumptions:

- part of the Western Australian *E. globulus* and *P. radiata* estate in the high rainfall zone (>1000mm) where soils are fertile and deep
- plantations of radiata pine in northern and central New South Wales/ACT
- *E. nitens*, *P. radiata* and *E. globulus* plantations in Victoria and the Green Triangle.
- The following plantation species and region combinations are predicted to decrease in production (unless significant adaptation occurs), with an increase in risk or predictions associated with high uncertainty based on model assumptions:
  - *P. radiata* plantations in southern NSW, and possibly at the western edge of the southern and central estates
  - the eastern and northern extents of the Western Australian *E. globulus* and *P. radiata* estates.

As to the time frames, Booth and Jovanovic (2005) found that changes in the preferred range of most commercial plantation species by 2030 were projected to be minor but there will be some range restrictions in some species by 2070. For environmental plantings, a more critical issue may be the degree of genetic diversity. The issue of in-breeding depression caused by using local seed with too narrow a genetic base has already been found to be a problem in some revegetation projects for some genera (Broadhurst 2007).

In relation to ecosystem condition, some likely impacts include:

- Changes in ecosystem boundaries which, without intervention, could result in accelerated habitat loss and fragmentation where habitat is bounded by production activities natural adaptation of species through an ability to relocate is constrained (Fischlin *et al.* 2007).
- The suitability ranges of some invasive weeds will change, impacting on forest habitats.
- Pathogen and pest impacts on forests could increase with changes in temperatures and rainfall patterns.
- Disturbances such as fire and storms will accelerate these changes to ecosystems (see Cayan *et al.* 2008). Also, increased fire frequency and intensity of fires and storms could change species composition and ecosystems processes (Hughes 2003).
- Woody thickening in some areas might be stimulated by an increase in CO<sub>2</sub> levels (Gifford and Howden 2001) but this will also be dependent on land management, especially the use and control of fire.
- Deforestation and the degradation of forest ecosystems will increase the vulnerability of water resources (Iverson and Prasad 2001).

Dunlop and Brown (2008) conducted a qualitative assessment for each of ten agro-climatic zones in Australia. The analysis identified the 'Temperate cool-season wet' and the 'Temperate subhumid'

zones as likely to experience the most significant ecosystem-level changes, including marked changes in vegetation composition, structure and function, and increases in fire frequency and changes in land use. In addition, the impacts of these changes may be amplified in these zones because of previous high levels of disturbance and fragmentation. The Dunlop and Brown (2008) analysis differs<sup>2</sup> from “standard” assessments of the most vulnerable terrestrial regions that typically identify Queensland Wet Tropics, the Australian Alps, and southwest Western Australia (IPCC 2007b; Hennessy *et al.* 2007 cited in Dunlop and Brown 2008) (see Figure 4 for forests in those areas).

In the alpine areas, for example, changes in herb, shrub and tree competition will lead to structural and functional changes (e.g. changed tree lines, microclimate, hydrology); and changes in the composition and ecology of grazers (e.g. expansion of mammalian grazers to areas previously dominated by insect grazers) may have very significant impacts on the composition and structure of vegetation (Hughes 2003; Pickering *et al.* 2004). In Queensland and New South Wales rainforest may be converted into eucalypt forest and grassland, mainly due to changes in land use, fire regimes and climate change (Hughes, 2003). With small changes in climate (e.g. 1°C warming), large changes in rainforest-woodland ecotones have been predicted in north Queensland, for example (Hilbert *et al.* 2001).

In conclusion, as argued by Aber *et al.* (2001); Dale *et al.* (2001); and McNulty and Abe (2001) future climate change will significantly affect the distribution, condition, species composition, and productivity of forests, but the precise causes, extent, magnitude, and timing of such effects remain uncertain. Further to that, native forests may be subject to greater fragmentation as remnant areas decline because some species cannot adapt to the new conditions or lack the capacity to autonomously re-establish in areas that become more favourable for them. The next section considers how these biophysical impacts might flow through to the social and economic systems.

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<sup>2</sup> This study was based on ecosystem-level information rather than the more traditional species-level information.



## 3 Impacts on ecosystem services

This section is a summary of the potential impacts of climate change on forests, where those forests are ordered according to types based on the predominant ecosystem services they provide, according to composition, scale, landscape location and tenure. The major types of services from forests are categorised and then used as the starting point to show how climate change might affect each of the major services. There are three reasons for the categorisation: one is to illustrate the range of services beyond a simple list; the second is to show that the services will be different in different types of landscapes; and the third is to disaggregate the forests into types that might be better targeted by different adaptive responses. The need for disaggregation will be more fully discussed in Chapter 4. Ecosystem services provide social value and in this chapter that value is discussed in general terms only. Values are highly site dependent and while there are means of estimating the economic value of changes in ecosystem services, there is as yet little detailed work relating to climate change. Some relevant valuation techniques that could be adapted to this purpose are described in the appendices. In this chapter, ecosystems services provide the organising framework.

### 3.1 Forest Ecosystem Services

According to the Millenium Ecosystem Assessment, ecosystem services are those things provided by natural systems that yield benefits to people (Island Press 2007). This is an anthropocentric framework and it has been widely argued that natural systems also have intrinsic value, most notably by deep ecologists (Naess 1973) and so we present a slightly modified framework, which includes a specific service to other species, as in Table 5. There are broad services types that provide different sorts of benefits. Some can be directly consumed or traded such as fuel wood, timber for building and foods and medicines, while others, such as recreation and spiritual experiences are generally may or may not have a commercial component. . Where there are marketed goods, the commercial activities generate flow-on income in the form of wages to workers, which then circulate in other economic sectors and expenditure on production inputs, which then pays more wages and so on. The more indirect benefit of knowing of the 'existence' (existence value) of forests and forest habitats does not require actual contact so it cannot be easily marketed but is nonetheless an important value in the age of environmental awareness.

Then there are the regulatory services that beneficially affect other systems and so enable the further provision of services from that second system. For example, a forest on a recharge area that lowers the water table and keeps surface salinity under control in another area, can allow that other area to be used for agriculture (Heaney et al. 2000). Similarly, riparian forests help to filter water that is used downstream for consumption or irrigation. Of particular relevance here, forests help regulate

**Table 5:** Overview of forests ecosystem services

Type of service	Service	Direct consumption	Direct income	Flow-on income	Enables other system services
<b>Consumption goods</b>	Timber	✓	✓	✓	
	Bio-energy	✓	✓	✓	
	Food*	✓	✓	✓	
	Medicines*	✓	✓	✓	
<b>System regulation</b>	Carbon sequestration		✓	✓	✓
	Water table		✓	✓	✓
	Flood control**				✓
	Micro-climate**				✓
<b>Filtration</b>	Water quality	✓	✓	✓	✓
<b>Protection</b>	Soil *				✓
<b>Regeneration</b>	Soil**				✓
<b>Psychogenic services</b>	Recreation	✓	✓	✓	
	Spiritual sustenance	✓	✓	✓	
	Existence value	✓			
<b>Services to other species</b>	Habitat	✓	✓	✓	✓

\* Very limited further discussion of these services. \*\* No further discussion of these services. *Source:* adapted from Island Press 2007.

the level of greenhouse gases. Traditionally, regulatory services have either been provided voluntarily or acquired through legislation, for example through clearing regulations, which place a cost on the landholder even though the benefits might be enjoyed elsewhere. Since the 1980s, however, a range of programs have been developed whereby governments or their agencies pay for the provision of services, though to date these have been limited in scope and geography (see for example the summary in Action Salinity and Water Australia 2002 and later discussion). An emissions trading scheme (see later section) could result in private payments for the sequestration service.

Similarly, habitat services which include food, water and shelter for other species were often non-market 'goods', supplied by landholders voluntarily maintaining remnants or by governments acquiring and managing reserved areas. In the last decade however, a number of schemes have developed whereby governments pay for those services. Program examples include the Victorian BushTender scheme, the NSW Environmental Services Scheme, the Western Australia Auction for Landscape Recovery and the Queensland Nature Assist Program. The major Commonwealth schemes to date are the Tasmanian Forest Conservation Fund and the Environmental Stewardship Program.

There are some services that are not further discussed, or only briefly considered in this report. Flood control is a possible benefit but there is considerable debate about the role forests can play and most research is focussed on other more vulnerable (to floods) regions than Australia. Even there, the Food and Agriculture Organisation (FAO) is cautious about the mitigating value of forests (Food and Agriculture Organisation 2005). In contrast, a team of researchers that includes Australians argues that deforestation 'amplifies' flood effects (Bradshaw et al. 2007) but this study is global. Climate

change may contribute to the loss of trees in areas where forests do regulate flood effects, though on the other hand there are countervailing pressures for reforestation, as previously foreshadowed and further discussed below. Similarly, micro-climatic effects may be very important but the evidence for benefit, let alone studies of the extent of these, is also very limited. Soil regeneration, the process whereby litter degrades to build up soil in forests, is not further considered because of the long time frame for soil replenishment and because realising this benefit, say for agriculture, would require clearing of the forests. We note however, that forests which are set aside would likely increase in future agricultural value, though this would depend on the relative clearing costs. Food and medicinal benefits are briefly considered but are to date a very minor part of forest services in Australia.

In relation to the other major services, if as a result of climate change, forest composition changes, threatening processes accelerate and/or there is a direct loss of forests then there could be a loss of ecosystem services. These losses will however vary by type of forest. We have therefore divided the forest types according to the FVA framework, and then sub-divided them to capture some important differences. The forest categories are summarised in Table 6.a and then explained in the remainder of this chapter. There is also a basic comparison of possible relative value of each of the services from the particular forest type. This is an illustrative generalisation of what might be expected and, as will be discussed, there is much to do before more meaningful relative values can be applied. Table 6.b includes some additional descriptions where there are multiple characteristics that determine the forest values.

Environmental and ecological economists have developed a number of means of estimating or attributing value to the services from forests. Where services are directly used by humans a 'use' value can be estimated, either through the prices revealed in markets, such as those for timber, biomass for energy and commercial tourism, or through some form of equivalent value. For example, non-market forest food might be valued according to the cost of the processed foods which it replaces, or gathered firewood might be valued against what it would cost in a market. There are overseas studies that have considered the impact of climate change on use values (see for example Howard et al. 1996; Perez-Garcia et al. 1997; Burton et al. 1998; Sohngen and Mendelsohn 1998; Irland et al. 2001; Sohngen and Mendelsohn 2001; Bjornstad and Skonhoft 2002; Lehtonen et al. 2003; Cramer et al. 2004; Sohngen and Sedjo 2004; Leppanen et al. 2005; Hui et al. 2007; van Kooten 2008; Kallio 2010) and some of these will be considered later when global timber production is considered in more detail.

**Table 6.a:** Forest types and ecosystem services

Ecosystem services	Conservation forests					Native Production (Timber)	Conservation plantings <sup>±</sup>	Plantations	
	Protected/reserved areas	Private large-scale	Indigenous managed	Remnants in production landscapes	Forests in lifestyle landscapes			Large-scale	Small-scale
Timber						√√		√√√	√
Bio-energy						√√		√√√	√
Food*			√						
Medicines*	P	P	√						
Carbon sequestration	√	√	√	√	√	√	√√	√	√
Water table	√*	√*	√*	√*	√*	√*	√√**	√**	√√**
Water quality	√*	√*	√*	√*	√*	√*	√√**	√**	√√*
Soil protection	√*	√*	√*	√*	√*	√*	√√**	√**	√√**
Recreation	√√		√		√√	√			
Spiritual sustenance	√√√	√	√√√	√	√√√	√√			
Existence value	√√√	√	√√√	√	√√	√√	√		
Habitat	√√√	√√	√√√	√	√√	√√	√√**	√**	√**

<sup>±</sup> Includes regrowth with conservation value, √ number of ticks indicates relative potential value (Illustrative only - actual values would be highly site dependent), \* Benefits are highly dependent on location, \*\* Benefits increase over time, P Possible but no data

**Table 6.b:** Elements of selected ecosystem services values

Service	Elements
Recreation	Individual values; ease of access; co-recreational activities; relative cost of access
Spiritual sustenance	Individual values; ease of access; relative cost of access
Existence Value	Individual values; cultural norms; knowledge of forest characteristics
Habitat	Number and maturity of key tree species; rarity and viability of non-tree species in forest; understorey complexity; hides and roosts; litter; recruitment; size of forest; shape of forest (edge effects); proximity to other forests; connectivity to other forests; presence of exotic species; feral animal impacts; disturbance impact history (fire, clearing)

In addition to direct economic value, there are also various means of estimating the flow-on impacts, whereby income from forest-based industries circulates through the economy as production inputs are purchased and forest industry workers spend income on consumption goods. Input-output (I-O) models that track such income flows from forestry, either nationally or regionally have been used to:

- assess the impacts of eliminating or downsizing the forestry sector (Munday and Roberts 2001), which is relevant where plantation investment ceases or decreases growth rates of native timber; and
- anticipate the impacts of changes in environment policies, in relation to the substitution of agriculture by forestry (Thomson and Psaltopoulos 2005) and estimate the impacts of changing land use to forestry (Eiser and Roberts 2002).

I-O models can be used to generate economic (expenditure and value added) and employment multipliers that can be applied to similar cases. In the case of conservation plantings, only the establishment (of the plantations) impacts would be considered, whereas production forests include harvesting and processing impacts. The estimation of employment multipliers starts to move beyond just considering income, for employment levels can also be an indicator of social capital. That is, employment contributes to individual well-being and the development of social networks. Employment multipliers have been derived, for example, by the Bureau of Rural Sciences (2005) for the Greater Southern Region of WA and South West Slope of NSW and by Schirmer (2009a; 2009b) for WA and Tasmania.

Analyses of the local economic and employment impacts of changes in production were a particular feature of the Regional Forest Agreements process, from the mid-1990s to 2000 (see for example Rush Social Research 1997; Powell *et al.* 1999) so there is both data and expertise for this sort of work. In addition to direct and indirect income measures, researchers have also developed a range of indicators for assessing forest-dependent community viability and health and some of these are summarised in Appendix 1. Hence, if there is a change in production related to climate change, then some direct and indirect economic effects related to that production can be relatively easily estimated.

For direct use services, where there is no market price, most notably for forest-based recreation where there are no or low direct charges, other methods of implied value have been developed. For unpriced or underpriced recreation, the travel cost method is used (Ward and Beal 2000). This method is essentially an opportunity cost estimate that

sums the total cost of visiting a forest, including fuel and accommodation and the value of time away from work. Total value is then the average individual/family cost multiplied by the number of visits. Iconic but remote forests may have relatively few visitors but the private costs expended may be relatively high. This would however be a difficult method to use to estimate the discreet impacts of climate change, given that changes to appearance and perceived value may be incremental and very long-term.

In relation to the 'regulatory' services, such as carbon sequestration, water table control and water filtration, some markets have been created by government regulation and these can provide a monetary value but generally such services are indirectly estimated. Sequestration markets are developing and since mitigation programs are considered to be a critical variable in the future, these markets and the resulting prices are discussed more fully later in this chapter. In the absence of 'carbon' markets, it is also possible to estimate the value of both the rate and stock of sequestration in a forest and one method is described in Appendix 2.

'Markets' for watershed protection have also been created by government regulations. As a result, nutrients trading schemes in the US have resulted in payments of \$US12-25/ha for reforestation (Scherr *et al.* 2004). Alternatively Avalalapati *et al.* (2004) have used resources protection values to estimate filtering effects in a US agricultural zone as being \$US30/ha for five years. Resources protection services can be valued by estimating the avoided cost or the cost of alternative preventative expenditure. For example, if the amount of soil erosion prevented by having a forest cover can be scientifically determined, then the value of the benefit could be the equivalent of the cost of the nutrients that have been preserved on site, or the equivalent of the cost of soil engineering that would be required to achieve the same soil protection outcome. Cockfield (2005) estimated the soil protection benefit of small-scale plantations as the equivalent of lost grain production resulting from soil erosion as a result of a lack of forest cover. Similarly, water filtering effects can be valued according to the avoided cost of mechanical filtering of that water or the equivalent value of nutrients saved. In Australia, forests have additional potential value in protecting water quality through salinity control, though the extent of the benefits is dependent on location in relation to the local topography (Heaney *et al.* 2000). That is, trees planted in the recharge areas generally have the greatest effect (Stirzaker *et al.* 2000).

Most difficult is the estimation of non-market services that contribute to human well-being, such as spiritual sustenance, aesthetic enjoyment and existence value. These depend on individual preferences, though social, cultural and political discussions are influences. One method of aggregating these non-use values is to undertake a contingent valuation (CV), usually comprising a survey that elicits the willingness to pay to preserve a natural feature such as a forest. A major criticism of this method is that saying you are prepared to pay is no real test of whether you actually would pay. An alternative approach is choice modelling to construct an experiment whereby participants, representing some broader population, are asked to make choices between different courses of action or different sets of outcomes This

method reduces the problem of 'over-promising' (Mallawaarachchi *et al.* 2001) because something has to be given up to 'pay' for conservation and this reveals the implicit value of conservation. The CV/CM studies can elicit the value of particular features, such as the appearance of a forest, or they can be used to try and determine a range of non-market and intangible values within a total economic valuation (TEV). The concept of TEV is explained in Appendix 3, while some examples of efforts to value all or some services are summarised in Appendix 4. Forest values are however highly site specific (Pearce and Pearce 2001) and can change over time (Bengston 1994) so these should be considered as examples only.

In this section, we showed that it is possible to identify the ecosystem services from forests and it would also be possible to apply monetary values to those. Therefore, if forest managers and policy-makers were able to measure the relevant bio-physical changes, then it would be possible to compare the costs and benefits of climate change on forests. There are three qualifications to this. First, there would be the extensive effort and time to measure changes across different types of forests, especially where such changes were incremental and long-term, in order to make valid value estimates. Second, some of the techniques used to estimate non-market values are subject to significant criticism on methodological and ethical grounds, and these will be discussed later in the report. In particular, some people object to the monetisation of non-market values. On the other hand, it can be argued that all investment and policy decisions always have an implicit relative value in that there is always an opportunity cost which can be estimated in monetary terms.

Third, there is the problem of bias towards the measurable, which could in this case lead to more of a concentration on production than conservation forests. For example, it is easier to estimate changes in growth rates and consequent regional output than to estimate all non-use values in conservation forests. It was certainly the case with this review, that studies of production effects from climate change are generally more developed and are starting to include quantitative estimates, as summarised above and discussed later, while the non-use impacts are only being identified. Thus, this report may seem to favour production forests but that is not the intention.

### **3.2 Services from conservation forests**

This section considers forest types where there has been no direct human intervention in the establishment of those forests. Dominant species are native and indigenous to the particular region and hence the services for biodiversity are likely to be generally of higher value than for mono-culture plantations or for recently established conservation plantings because of the maturity of the habitat, ground cover and biomass. The extent and mix of ecosystem services does however vary according to scale and management and this is why some sub-categorisation has been undertaken. Major potential biophysical impacts compounded by climate change and common to all of these sub-categories, though different in degree, are the fragmentation and isolation effects. In particular, where forests and forest patches are

surrounded by other forms of land use and the ranges of forest systems change, there is limited scope for system adaptation through spontaneous migration across the landscape of tree and faunal species.

### **3.2.1 Protected and reserved conservation areas**

This category includes state-owned protected or reserved forests and private conservation areas that allow public access. Primary ecosystem services include habitat for other species, recreation and leisure activities and psychological/spiritual benefits. We might expect that protected and reserved areas tend to have high existence values, especially those that are considered iconic, such as the Blue Mountains, Kakadu and the Daintree areas. Conservation forests also tend to have high amenity value for visitors and those residents who value the appearance of a forested landscape. It is the iconic areas that are typically studied to identify non-market values (see Appendix 4).

Climate change risks to large-scale conservation forest areas include changes in the extent and composition of forests resulting in changes in habitat, exacerbated by more frequent and intense fires and pest and invasive species impacts. For example, in the Blue Mountains (near Richmond), there are on average 13.3 days when the Forest Fire Danger Index is 'very high' or 'extreme'. This is predicted to increase to 13.8–16.3 days by 2020 and 14.5–23.6 days by 2050 (Lucas *et al.* 2007). The bushfire season may also lengthen from the current duration of early October to mid-January to late July to mid-February by 2050 (Lucas *et al.* 2007). A 7–35 percent increase in the frequency of unplanned fires could cause significant ecological damage (Bradstock *et al.* 2008). Soil conservation and other work needed following fires will also have cost implications for managing agencies, and society as a whole. In contrast, in Kakadu National Park, higher intensity rainfall may be a problem, resulting in floods and damage to infrastructure (including roads, bridges, accommodation) and a decrease in visitors. Such a downturn would largely affect the livelihood of Aboriginal people (Cooperative Research Centre: Sustainable Tourism 2009).

In summary, the changes in forest ecosystems and appearance, along with fire and pest damage may result in:

- Loss of rare and vulnerable species;
- Reduced existence and spiritual values;
- Reduced visitor numbers with consequent loss of direct tourism income in some regions;
- Reduction in secondary expenditure benefits for local businesses; and
- Accelerated population decline in vulnerable (to loss of tourists) communities, in turn accelerating the decline of available financial and social capital.

Hence, in terms of the ecosystem services, given no policy or management interventions, climate change could result in a decline in habitat value (discussed in WP2, Medlyn *et al.*



2010), a decrease in carbon storage, due to fires and changes in growth rates, a decrease in existence and spiritual values, and in the long term, some economic losses from tourism.

### *Tourism in conservation forests*

A recent study covering five key tourist destinations in Australia: Kakadu National Park, the Cairns region (including the Great Barrier Reef and Wet Tropics rainforest), the Blue Mountains, the Barossa Valley and the Victorian Alps (Cooperative Research Centre: Sustainable Tourism 2009) shows that the impacts of climate change are not distributed evenly across tourism destinations and depend on the degree to which a destination is reliant on tourism and the impact of climate change in that region. Some regions do not have obvious alternative opportunities for economic activity. For example, in the Victorian Alps regional tourism output is 25 percent of the total output produced by the region and the Tropical North Queensland share is 13 percent (Cooperative Research Centre: Sustainable Tourism 2009). Kakadu may be most affected with biophysical changes but when flow-on effects are considered, Alpine Victoria and Tropical North Queensland (Cairns) may be the most affected regions (Cooperative Research Centre: Sustainable Tourism 2009). In addition, there might be indirect deterrents (or attractants) such as changes in temperature, precipitation and frost (U.S. Global Change Research Program 2009). For example, high temperatures may discourage forest/bush hiking, national parks visits due to fire danger or physical discomfort, although warmer winter conditions in some areas may encourage additional activity.

There are some baseline studies of the value of tourism in conservation forests. Gillespie Economics (1997) estimated expenditure on recreation and tourism visits to forested lands in the Eden Regional Forest Agreement (RFA) region in the range of \$10-\$15 million/yr based on a 'macro' approach. Similarly, Tobias and Mendelsohn (1991) and Maille and Mendelsohn (1993) have estimated a positive consumer surplus associated with ecotourism in tropical forests where there are strong regional tourism sub-sectors, notably the Wet Tropics areas. The tourism industry is relatively labour-intensive (Cooperative Research Centre: Sustainable Tourism 2009) and so there could be increasing structural unemployment in tourism-based regions. For example, in Kakadu National Park, the largest number of jobs is provided by tourism followed by conservation and recreation (Bayliss *et al.* 1997).

The potentially mitigating effect here is that prospective visitors might psychologically adapt, so that tourism levels are maintained, especially as changes in appearance may be over a long period. In effect prospective visitors will adapt autonomously to changes in the appearance of forests and still find value in them. This was eloquently expressed in a stakeholder workshop conducted for this project, in which one participant argued that climate change means people will need to 're-imagine' the landscapes. Thus the two critical areas for research related to tourism effects are the likely changes in the appearance of popular forests and the reactions to those changes. Such research might be usefully undertaken using

visualisation techniques, so that anticipated changes are included in images and reactions sought (Sheppard 2005).

### *Existence value and climate change*

Similarly, there needs to be research to understand the psychogenic values of major forests as these will be critical in generating, or not, support for planned adaptations. Winter and Lockwood (2004) have developed a scale to measure four values for the natural environment: use; non-use; recreation and intrinsic values. The scale was later extended to include a particular type of spiritual value, that was associated with religious beliefs (Winter 2007). This later modified scale has been applied to native forest management issues in Tasmania (Ford *et al.* 2009). This study found that people with stronger use values for nature judge practices such as clearfelling in native forests acceptable, whereas people with stronger non-use and intrinsic values were concerned about protection of the natural environment and found clearfelling of native forests unacceptable.

Another way existence and other non-use values are measured is through computer content analysis of electronic media. Xu and Bengston (1997) found that a gradual shift has been occurring in the structure of forest values in the USA since the early 1980s, at least among forestry professionals and mainstream environmentalists. Most significant was the decline in the relative frequency of expression of economic/utilitarian value and an increase in life support value among forestry professionals and environmentalists. This suggests that conservation forests are effectively increasing in value. Other trends included an increase in expression of moral/spiritual value among forestry professionals and a decrease in aesthetic value among environmentalists. We might therefore suppose that major threats to the habitat and aesthetic value of forests, if they are known and understood, will result in demands for adaptation.

Strict economic valuations of intangible values (see Appendix 3) need to be treated with care. The fragmentation and loss of habitat quality of forest areas would lead to an increase in the per hectare value of some of the remaining areas, simply through further changes in social values, combined with the increasing rarity of high quality, large-scale forests. Thus, the total value of the national conservation estate has to be considered, not just each forest. Regular measures of value of a particular forest could reveal increasing value suggesting that climate change impacts are nothing to worry about, whereas the problem is contributing to the value change through the creation of scarcity.

### *Planned adaptation for public conservation forests*

In this final sub-section, we briefly consider the flow-on impacts for some planned responses to the biophysical changes discussed in WP2, especially related to the management of viable habitats. The responses could include:

- Research, development and extension expenditure to anticipate and manage a range of specific impacts;

- Purchasing or contracting for the protection of suitable refugia within anticipated 'new' habitat suitability ranges (see next chapter);
- Purchasing or contracting for extensions to existing reserves, through a biolink development strategy to facilitate migration of species to suitable climate zones and habitats (see next chapter);
- Enhanced fire controls; and
- Enhanced pest and disease controls.

This implies that there would need to be an increase in the workforce devoted to land use research and management, which would have some specific regional benefits through increased employment and local consumption. The state and national flow-on economic benefits of such redeployment are less certain because in a conventional I-O analysis, such a development merely draws resources from other possible uses unless the end result is an increase in the total labour force.

### **3.2.2 Private landscape-scale conservation forests**

This category includes areas where landscapes are dominated by forests and the tenure or some other conservation contract, limits development. The potential values are similar to those for the protected and reserved forests with the significant difference that there is likely to be limited direct expenditure generated by tourism and hence changes in forest composition and appearance will not necessarily result in major negative flow-on effects into local economies. It might also be presumed that psychogenic 'losses' due to reduced amenity will be less than for the previous category because there will be fewer visitors directly experiencing these forests. Further to this, existence value could also be presumed to be somewhat lower given the higher levels of awareness of, and interest in, public and private conservation areas, though this would need further testing.

There is however, a further reason for differentiating this category of forests related to potential planned responses. This category might be particularly important for future corridors, buffers or sites for relocation of species as ecosystem boundaries change. The issue is that ecosystem transition may be from public land (previous category) to private land. This will involve additional costs, either through acquisition of land or through payments to landholders to provide particular habitat types. The potential roles for private conservation forests in adaptation will be discussed further in the next chapter.

### **3.2.3 Indigenous managed forests**

Some forests managed by Indigenous peoples have similar values to the public conservation forests and may even include tourism, especially where designated as conservation forests. Others, where a range of activities are possible, are generally similar to other privately managed forests. Around 21 million ha (13 percent of total estate) of forest is managed by Indigenous people (Department of Agriculture Fisheries and Forestry 2008). There are three

major factors that warrant separate consideration of forests managed by Indigenous communities: dependence on non-timber forest products (NTFPs) for sustenance and quality of life; particular spiritual and cultural values; and vulnerability of the communities to climate change. Studies in Australia, New Zealand and USA suggest that Indigenous people are more vulnerable to climate change than non-Indigenous people because of reduced employment opportunities and levels of training, making for limited scope to adapt (Climate Action Network Australia 2006).

First, there is the vulnerability to a loss of key species used for food or medicine. Studies from overseas show the dependence of some communities on NTFPs (see for example Peters et al. 1989; Anderson et al. 1991; Knowler and Canby 1998; Mallick 2000). Chopra (1993) estimated the total present value of NTFPs from a deciduous tropical forest in India at US\$ 219-317 per hectare annually. Reviews by Godoy *et al.* (1993) covering a cross section of countries have observed the net economic values from NTFP extraction to vary between US\$ 1 and US\$ 420 per hectare per year. Values vary with the estimation techniques used and differences in biological and economic diversity between the sites. In Australia, NTFPs may be very important for some Indigenous communities.

More than 80 percent of adults living in discrete Indigenous communities fish or hunt for their livelihood. While returns from (non-market) wildlife harvesting are not reflected in standard social indicators, a loss of access to resources could further impoverish Indigenous people. Although utilisation of wildlife for livelihood is more common in remote Australia, it can also be of economic significance in more settled regions such as coastal New South Wales (Garry et al., 2005 cited in Altman and Jordan 2008). If particular and important traditional food sources were lost, they may be replaced by processed foods which could increase the costs of living and contribute to increased rates of obesity, diabetes and hypertension where these are related to consumption of unhealthy processed foods. This would not only reduce Indigenous communities' general health, but it would also make them less resistant to future diseases (Climate Action Network Australia 2006). Second, there is the potential loss of spiritual value, though there is as yet little research to base this on.

Finally, Indigenous communities could be especially vulnerable to climate change impacts on forests, noting in particular that many remote communities are in the north and north-west, where it is likely to become hotter but also wetter, so the outcomes from this could be critical. As noted earlier, Indigenous communities are largely outside the scope of this research but will be considered in other NCCARF work and we note the need for particular research.

#### **3.2.4 Remnant vegetation in production landscapes**

This category is a variation of the private conservation forests but is considered separately because of the scale and landscape context of forest remnants. Strictly speaking these remnants may not be protected from development, though we presume they are at minimum subject to restrictions on clearing under state laws. These are generally smaller patches

located in landscapes dominated by farming or open pasture grazing. These remnants in production landscapes may be highly vulnerable to climate change and yet may not attract the research and policy attention of the previously considered forest types. Because of the landscape context, climate change impacts could adversely interact with existing threatening processes, such as clearing, agricultural intensification, intensive grazing, herbicide and pesticide damage and pest and disease susceptibility, to reduce the size and viability of remnant areas, while attention is focussed on the larger forests that support rare and endangered species and tourism. Hence, the remnants will generally have a lower existence value and therefore will receive less political attention.

Remnants in production landscapes may however be examples of rare ecosystems and provide important food sources, particularly for birds (see for example Maron and Fitzsimons 2007). In addition, the aesthetic value is limited except as part of mosaic farm landscapes. There are those who appreciate a mosaic landscape that includes trees, but the media and political focus has generally been on large-scale forests, so in terms of conventional economic and social values, the number of people and the strength of their interest works against remnants in production landscapes. Nonetheless, the loss of remnants could have a range of negative social and economic impacts, including:

- Loss of refugia for bio-control agents such as birds and predatory invertebrates,
- A reduction in livestock welfare and production due to increased windchill and heat exposure.
- Increase in soil salinity, where further trees are removed from recharge zones.
- Increase in wind erosion and wind irritation to humans.

On the positive side, remnants can also provide a base for forest expansion and enhanced viability. There are areas in farm landscapes, where agricultural production intensity is decreasing due to declining fertility, soil degradation, climate change and economic pressures. For some species in some regions, peripheral recruitment (regrowth around remnants) is possible. This means that the value of remnants could increase as they recolonise farmed areas, although this will depend on which species regrow, fire regimes and woodland density. The potential for regrowth forests is further considered later in this chapter.

### **3.2.5 Forests in lifestyle landscapes**

This category is in some ways an extension of the areas just discussed, where agriculture has declined and given way to rural residential or lifestyle settlement. Through a combination of remnants, regrowth and amenity or conservation plantings, some of the lifestyle landscapes can have increasing conservation values, especially where forest patches are aggregated across holdings, connectivity is higher and other land uses such as grazing are less intensive or absent. These forests also have significant psychogenic value since the forests are perhaps an important reason why people choose to live in an area. The psychogenic values are expressed in 'shadow' prices, these being the premium that residents are willing to pay, or

the acceptance of additional living and travel costs, to be in forested landscapes. The problem is that climate change will increase the intensity and frequency of fires, which detracts from the overall value of these forests.

The adaptation scenarios for such fire-prone areas are therefore:

- Regulatory constraints on vegetation management (clearing for fire protection) and an acceptance of the private risks, so that the costs from loss of life and property will increase with the frequency and intensity of fires, as well as the loss of a range of ecosystem services; or
- There will be depopulation in high-risk rural residential areas, leading to some regional economic decline and either, increased costs from urbanisation or increased prices for tree change areas where fire risks are lower. There will be two drivers of depopulation. First after major fires, people will not return to damaged areas and second, the publicity from major fire events in other regions will encourage people to leave as a precautionary measure. Again, with limited additional protection measures, fires will be more frequent and intense so habitat value will also be affected; or
- Regulations and fire protection practices will change to allow more active vegetation management. This may reduce human and property costs but there will likely be a trade-off between loss of trees (fire breaks etc) and reduced fire risk for the remaining areas; and the cost of building near forests will increase due to new building codes and insurance premiums will increase in bushfire prone areas. The costs for fire prevention and suppression in these areas will increase.

Extreme events, which generally have higher impacts, are more likely to lead to adaptations than the more general and slower changes in the climate (Parson et al. 2003) and some adaptations are currently being made in response to the Black Saturday bushfires in Victoria. This is a major social issue, since it raises questions as to where in the landscape people should be located and such decisions will affect regional economic output and more or less demand for urban services.

### **3.3 Native forests with timber production**

These forests include those on state-owned and private land where some degree of logging is expected to continue. These forests have the potential to produce the broadest range of ecosystem services, from timber through to existence value, depending on location and appeal. Therefore, the relevant impacts of climate change are similar to some of those from the previously considered categories so that changes in composition and distribution could include:

- Loss of habitat value;
- Loss of amenity value; and
- Lower recreational value.

In addition, there will be changes in growth rates, flowing on to:

- Employment and all its associated benefits;
- Regional income; and
- Regional services and the viability of communities.

As noted in the introduction, the general trend is for a reduction in the use of native forests for timber production. While this may increase the sequestration value of forests, depending on the type and extent of logging, it will also result in fewer people living in or near these forested landscapes. Hence, climate change impacts on growth rates could compound the social effects of increasing constraints on native forest logging.

As an example, the Allen Consulting group (The Allen Consulting Group 2006) estimated that for Victoria, a 10 percent reduction in the 1.8 million cu. metres of annual wood products output (2004 figures) would result in the loss of 190 direct forestry jobs and 450 jobs in total, along with a decrease in gross (Victorian) state product of \$100 million. This estimation was in the context of increasing restrictions on harvesting, rather than climate change, but it gives some idea of potential effects. On the other hand, if governments opt to increase the number of conservation managers to manage pest and fire threats (see later discussion and recommendations) then there may be some offsetting increase in employment.

Native forests, even with timber production, can also have some recreational, spiritual and existence values, though these would vary with accessibility, landscape context and the extent, type and frequency of logging. Hence, some of the same changes in composition and appearance, as described for the conservation forests, may be evident in these situations.

### **3.4 Reforestation**

This section considers those forests that have recently been or will be established for either conservation or production purposes, including those that are allowed to regenerate. As an introduction to this section we develop a model of reforestation<sup>3</sup> decision-making, considering climate change impacts, with the main variables likely to affect such decisions, summarised in Figure 6. We start with a brief discussion of demand (bottom right of Figure 6 and shaded blue) for wood and biomass. There is then some discussion of supply, especially considering the impact of climate change on the global supply of timber. We then consider the impact of climate change on growth rates (top right) which will in turn partly determine the preferred locations for plantations in Australia and contribute to enhanced competition for land uses (soils in Figure 6).

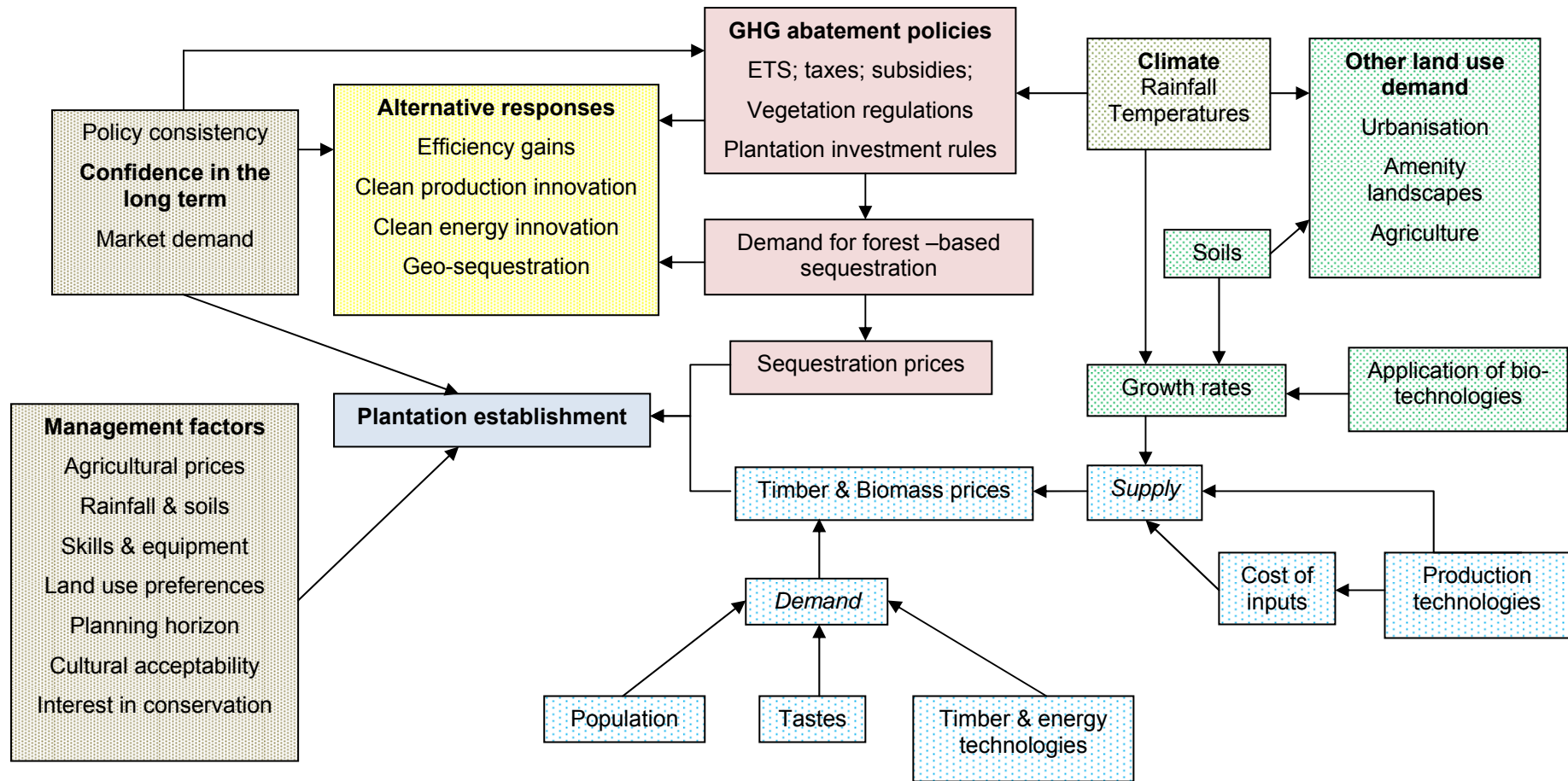
There is then a discussion of the policy variables, of which the main one is presumed to be an emissions trading scheme, with the example drawn from the Carbon Pollution Reduction

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<sup>3</sup> The term reforestation is used to cover both reforestation and afforestation (no previous forests on this land) for the sake of brevity.

Scheme (CPRS), as proposed in 2009. This discussion starts with a brief review of CPRS plantation establishment scenarios developed by the Australian Bureau of Agricultural and Resources Economics (Lawson *et al.* 2008; Burns *et al.* 2009). It is then argued that the demand for carbon sequestration will be a function of the policy design (top centre of Figure 6) in combination with the form of responses to policy that emitters choose. In relation to property-level decision-making three factors are considered: landholder attitudes to government policy-making; attitudes to conservation; and the type of landholder, as identified in previous studies (e.g. Harrison *et al.* 1996; Herbohn *et al.* 2005; Emtage *et al.* 2007). These factors are perhaps more pertinent to the small-scale plantations than to the large-scale plantations where the more important policy decisions relate to investment rules and security, but we argue that a CPRS offers the possibility of renewed interest in small-scale (farm) forestry.





**Figure 6:** Plantation establishment decision-making with greenhouse gas abatement policies

### 3.4.1 Supply of and demand for wood-based forest products

Starting with demand for timber and biomass (bottom centre Figure 6), we assume that mainstream demand trends for timber are largely unaffected by climate change. That is, climate change has no impact on preferences in building materials or pulp products though there may be an increasing demand for biomass for energy production, given for example the Australian target of 20 percent of renewable energy by 2020. As an example, Sedjo and Sohngen (2009) have estimated that for the USA, if the Energy Act (2007) target of 36 billion gallons of biofuels by 2022 was to be solely met by wood then 71 percent of the U.S. 2005 harvest of wood is required. In such a situation, the U.S. and world prices for raw wood would be about 15 percent higher in 2015 and 20 percent higher in the early 2020s. In Australia, there is some small-scale experimentation with particular eucalypts (notably types of mallee) grown under coppicing systems for bio-fuels (Wu *et al.* 2008) but Australia starts from a very low base with bio-fuels as noted earlier. Perhaps a more immediate outcome will be greater efforts to use waste from timber and pulp production which could add value to those enterprises.

In relation to the supply side and growth rates in particular, we refer to the work of our colleagues who investigated the biophysical impacts of climate change on forests and concluded that there is evidence from overseas and Australia that in particular cases increased levels of CO<sub>2</sub> could result in increased growth rates but this might be limited to the most fertile soils (Medlyn *et al.* 2010). With hotter and drier conditions, holding other factors constant for the moment, the tendency over the long-term (towards and beyond 2070) would then be for plantations in the major zones of south-west Western Australia and the southern and Murray Valley areas (see Figure 5) to shift towards the more favourable climatic conditions (nearer the sea or higher altitudes) and better soils. This would, however, likely lead to an increase in the cost of production because of competition for land for agricultural, urban and lifestyle uses. More than 85 percent of the population live within 50 km of the coast, as at 2006 (Hugo 2008) and predominantly the populated areas are on the coastal side of the major plantation areas. Then there is the 'tree change' movement, whereby people move to semi-rural areas near the coast or in near-inland higher altitude areas (Hugo 2008), which includes the major plantation zones. Further to that, in some areas such as southern Victoria, recent decreases in rainfall have seen crop production increase in what were formerly pastoral areas to create additional competition with industrial-scale plantations for land (Barr 2008; Schirmer *et al.* 2008). Thus, there are urban pressures pushing inland and agricultural demand pushing on the inner side of the plantation zones.

Plantations might be competitive with agriculture if there was to be a decline in agricultural productivity. For example, Cline (2007 cited in Australian Bureau of Agricultural and Resources Economics 2007) suggests that Australian agricultural productivity will decrease by 17 percent, the second greatest decline of a suite of developed and developing countries and regions. This does exclude carbon fertilization effects and adaptation measures, such as the development of crop varieties with differing growing periods (see for example Peng and Parton 2008 in regard to wheat). Gunasekera *et al.* (2008) propose that while the rate of increase of agricultural productivity might

decline it could still be positive. Studies from other countries (see for example Alcamo *et al.* 1997; Alig *et al.* 2002; Sohngen 2008) have examined the combined effects of climate change on agriculture and forestry and suggest that there will be little substantial change in overall land use shares, given CO<sub>2</sub> effects on crops and demand for food. In Australia, even if overall production declines because of dry conditions in the inland cropping zones, this will only exacerbate the competition for 'soils' (see Figure 6) within the current plantation zones where cropping will become increasingly possible as water-logging becomes less of a problem.

On the other hand, little conversion of crop land to plantations and hotter conditions might suggest an overall decrease in timber supply in Australia and therefore higher prices, but many studies have concluded that global timber production is instead likely to increase (Sohngen *et al.* 2001; Schjolden 2004; Boisvenue *et al.* 2006; Sohngen 2008). Boisvenue *et al.* (2006) reviewed global literature on forest productivity and concluded that climatic change seemed to have a generally positive impact on forest productivity where water is not limited. Perez-Garcia *et al.* (1997) and Sohngen and Sedjo (2004) predicted increased timber supplies and falling timber prices. There will however be regional differences. Irland *et al.* (2001) conclude that forest production could decline during this century in the Southern U.S. and increase in the Northern U.S. Sohngen *et al.* (2001) show that tropical and sub-tropical regions may become relatively more productive, since timber rotation ages are shorter in these regions than in temperate and boreal regions so producers in the tropics and sub-tropics can quickly take advantage of the gains from climate change.

In addition, there are two factors that may lead to an increase in the area under timber production. First, some of the northern cold areas may become more hospitable for forestry, so the potential area expands without any necessary reduction in agriculture. For example, Schjolden (2004) estimates that with 0.5° C warming more than 3.1 million ha of land in Norway, currently above the tree line will become forested and with a 1° C warming this would increase to 5.5 million ha. Second, if most countries adopt some form of emissions pricing, then there could be an increase in demand for sequestration, which may encourage additional reforestation. Tavoni *et al.* (2007), for example, estimated that there will be an additional 500 million ha of land that will be forested in 2050 compared to the (2007) baseline and approximately 1 billion hectares additional to the current baseline by the end of 2100. The net change in forests relative to today would then be 600 million ha (after deducting an expected 400 million ha of losses) by the end of the century. Hence we argue that while timber production in Australia may decline, there may be no offsetting increase in timber prices and as well, land costs may increase. Therefore, it may come down to demand for sequestration services to induce additional plantings.

### **3.4.2 Policy Variables**

There are two sets of policy variables with one relating to the design of a scheme and the other relating to attitudes to that scheme (see Figure 6). In late 2007, the Australian Government committed to reducing Australia's GHG emissions by 5-25 percent, based on 5 percent unconditional and 25 percent if the world agrees to a global deal to stabilise levels of GHGs in the atmosphere at 450 ppm

CO<sub>2</sub>e (or lower) by 2020 and 60 percent below 2000 levels by 2050. In attempting to meet these targets the Government proposed in 2009 a Carbon Pollution Reduction Scheme (CPRS). The legislation to enact this scheme did not pass through the Australian Parliament and was later postponed for consideration until 2013 but the CPRS remains on the agenda. The CPRS as revised for the parliamentary debates is therefore used to illustrate the potential impact of a carbon price on plantation establishment. Given recent policy debates, we also note that subsidies could also be used to encourage the establishment of forest-based sinks, but the CPRS discussions were developed so as to provide some speculation on prices.

The proposed CPRS was to include over 75 percent of Australia's GHG emissions (Department of Climate Change 2010), which is relatively wide coverage. Reforestation<sup>4</sup> activities are proposed to be eligible from the beginning of a CPRS. Four carbon pools were to be considered: aboveground biomass, belowground biomass, dead wood and litter, but soil C would not have been included (Department of Climate Change 2009a). Managers could have forests for harvest (both short and long rotations) and/or environmental plantings with the latter getting a higher emissions unit value than the former (Department of Climate Change 2009b). There would also have been a tax incentive for carbon sink forests under tax legislation, though only the plantation cost is tax deductible (Department of Climate Change 2010). The owner can clear forests at any time but would need to hand back any emissions units they had received to cover the emissions that are released back into the atmosphere. This obligation would remain in place for 100 years (Department of Climate Change 2009b). Nonetheless, such a scheme could still encourage plantations, since the early payments for sequestration would somewhat offset the initial establishment costs and then the payback occurs when timber income is imminent.

The Australian Bureau of Agricultural and Resource Economics (Lawson *et al.* 2008; Burns *et al.* 2009) generated three reforestation scenarios based on differing reduction targets, as summarised in Table 7. The assumptions include: no other regulatory interventions in regard to land use; net present value as the financial indicator of land use choice; a discount rate of seven percent; and a terminal biomass potential for all trees at 45 years of age. With no payments for environmental services (PES) or any other policy intervention, it is estimated that the area of timber plantations would increase over 40 years to about 611,000 ha, or an additional 0.1 percent of agricultural land. With a target of 5 percent reductions, a starting price of approximately \$20 per tonne (carbon equivalent) of sequestration in 2010, increasing at 4 percent per year (Lawson *et al.* 2008), there is assumed to be an increase in both timber and environmental plantations establishment rates. Environmental plantings are assumed to attract a higher payment rate because they would grow to maximum

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<sup>4</sup> 'Reforestation' is formally defined as forests established by people since 1990 on land that was clear of forest on 31 December 1989. Australia's definition of a forest for Kyoto Protocol purposes is: a forest of trees with a potential height of at least two metres and crown cover of at least 20 per cent; and in patches greater than 0.2 hectare in area.

sequestration potential and there would be no release, assumed to be 100 percent, of carbon at harvest.

**Table 7:** Area of agricultural land economically competitive for forestry 2050

Scenario	Timber plantations '000 ha	Environmental plantations '000 ha	Forested area as proportion of farmland %
No PES	611	0	0.1
CPRS-5	3047	2740	1.4
CPRS-15	4514	21,812	6.2

Source: Burns et al. 2009.

Planting rates are assumed to accelerate from 2030 with the higher price for sequestration being driven by fewer credits being available, since the CPRS is a cap and trade system with the cap decreasing over time. The new timber plantations are projected as being overwhelmingly within the current plantation regions, especially in the southern region, Tasmania and near Adelaide, currently a relatively small plantation zone (Lawson *et al.* 2008). The plantations would mainly displace grazing rather than cropping. With a higher abatement target (CPRS 15), the starting price is \$29 per tonne, increasing at four percent per year. This would lead to a big increase in environmental plantings and these would be overwhelmingly in central NSW and Queensland (Lawson *et al.* 2008, 20), inland from the plantation zones of Figure 5, displacing extensive grazing activity.

The intention here is not to take these results literally or to critique the modelling, which is necessarily general and reliant on a range of assumptions subject to considerable regional variation. For a start, in an effort to get the CPRS accepted, the starting price was to be lowered to \$10 per tonne and additional exemptions were granted, both of which would decrease the returns to forest owners. Site suitability and the availability of processing infrastructure were not considered (Bellamy 2009) and no transaction costs for monitoring and verifying carbon credits were included, and these might be relatively high (per ha) for small-scale producers. The point of reviewing the first such attempt to anticipate the impact of pricing greenhouse gas emissions on forest establishment was to show the potential incentive and some of the tendencies in relation to new plantings.

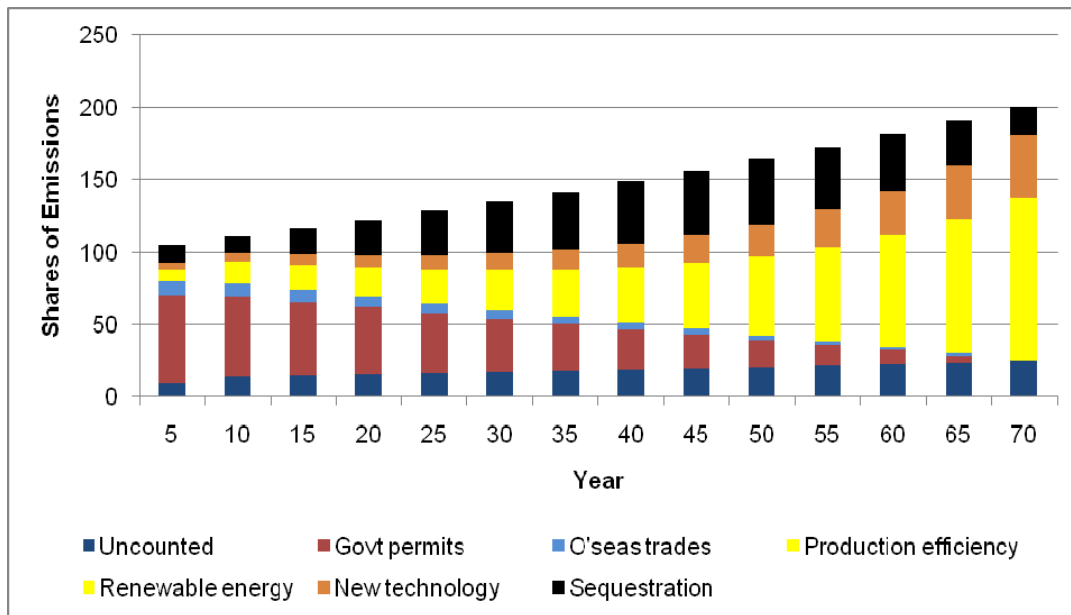
As an indicative example, we compared the estimated returns from carbon sequestration over 30 years for a site at Dorrigo, in the higher altitude part of the northern NSW plantation zone. The assumptions were a \$10 per tonne starting price for sequestration with a four percent annual price increase and a seven percent discount rate, the latter two being the assumptions used in the ABARE modelling. The tree scenarios were generated from case studies from the FullCAM model (Richards and Evans 2005). Under the CPRS, FullCAM was to be the standard model for estimating sequestration rates, though this would have been most likely a later version than the one used here, which has relatively limited data. This simple example suggests that sequestration returns are somewhat similar to a standard gross margins estimate for a beef production enterprise and that environmental plantings gain a financial advantage with regard to sequestration over the longer time, as the carbon release from harvesting takes effect.

**Table 8:** Sequestration value of different species at Dorrigo, Northern NSW. *Sources:* FullCAM model (Richards and Evans 2005); \*Beef enterprise gross margins (NSW Department of Industry and Investment 2010).

Land Use	Returns \$/ha Annualised NPV	
	30 years	36 years
Slash pine	\$175	\$176
<i>E. Grandis</i>	\$178	\$179
Environmental plantings	\$222	\$282
Growing out steers*	\$190-224	\$190-224

Nonetheless, in the medium term, the plantations with timber production could have some financial advantage over some forms of agriculture, where the timber production yields a positive NPV, which is not always the case in the more marginal areas (see for example Cockfield 2005; Venn 2005). Indeed Cockfield (2005) has shown, for sites just inland from the south east Queensland plantation zone (Figure 5), that the NPVs for plantations based solely on timber are almost always negative, though this is highly site dependent. Hence, outside the current recognised plantation zones, sequestration payments or subsidies would need to comfortably exceed the financial performance of current land uses. Even if this was the case, there are two final sets of policy variables to be considered. There are the responses of landholders to an emissions trading scheme itself, as opposed to just the sequestration prices on offer, and the responses of those producers of greenhouse gases who are within the scope of an emissions trading system (ETS) such as the CPRS (top left of Figure 6). In particular, their demand for substitutes for forest-based sequestration needs to be considered.

Emitters may choose alternatives such as production efficiency gains, adopting alternative energy sources, buying credits from others or perhaps buying geo-sequestration, if that was to be developed as an approved offset. The adoption of substitutes for forest-based sequestration depends on permit prices and various technological innovations. Figure 7 is a hypothetical illustration of how the original trajectory of increasing greenhouse gas emissions might be accommodated. In this scenario, without intervention, GHG emissions would keep increasing at about 1 percent per year over 70 years of an emissions trading scheme. Initially demand for sequestration would be low, as producers purchased permits and assessed their options. As permits became scarcer and more costly, producers would start to seek emissions reductions through internal efficiency and/or an increasing demand for sequestration. In the longer term, new technologies would be introduced and there would be a switch to renewable energy.



**Figure 7:** Hypothetical changes in emissions shares.

To conclude, sequestration may acquire a market value which could then stimulate reforestation of agricultural and pastoral land. The limits to this incentive could include:

- Global emissions reduction targets and the seriousness of major players (whether targets are legally binding or voluntary);
- Competition from alternative land uses;
- Transaction costs;
- Concern about the inconsistency of government policy into the future; and
- Substitution for offsets (efficiency, geo-sequestration, renewable energy etc).

If an ETS or similar works, then by definition demand for offsets will likely decline as the cap on allowable emissions decreases and new methods of production (substitute inputs) are developed. The period of prices being sufficiently high enough to induce reforestation will then be determined by the rate at which the emissions cap decreases against the rate of innovation for substitute inputs, including renewable energy, energy efficiency and clean production technologies.

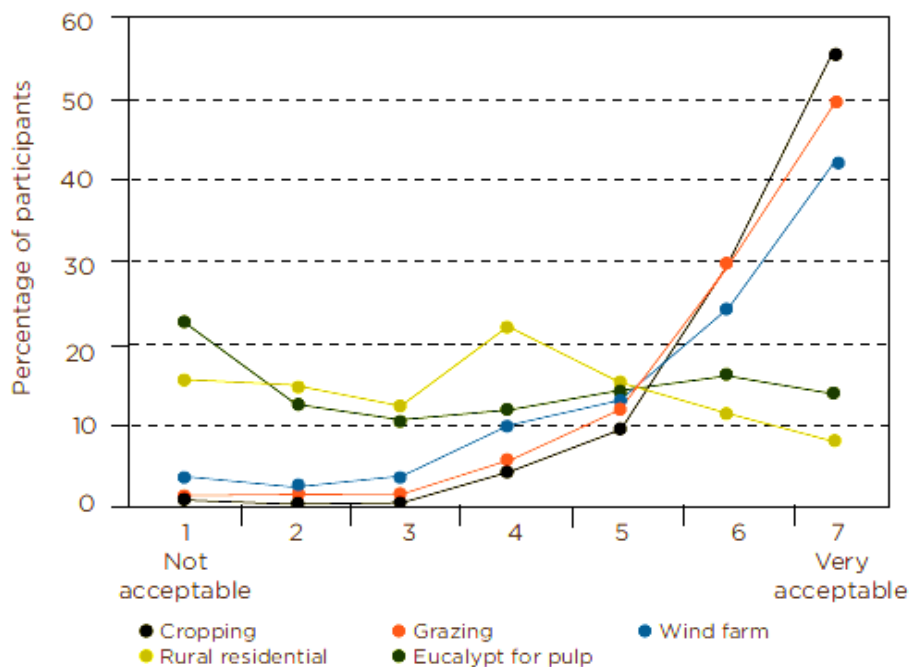
The ultimate decision on an emissions trading scheme (ETS) or subsidy program, while considered possible centrepieces of mitigation policies, may also be a critical decision in offsetting some of the socio-economic, and perhaps biophysical, impacts of climate change. That is, this would be an incidental adaptation (Smit *et al.* 2000). There would be incentives to expand the production plantations sectors, including possibly for bio-fuels, and these could help maintain profitability in the marginal areas. In addition, an ETS could stimulate the establishment of conservation forests that would provide additional habitat and eventually the other non-use benefits.

### 3.4.3 Conservation plantings and regrowth

New conservation plantings or regeneration for conservation purposes would eventually produce similar benefits to those discussed in section 3.2, in terms of habitat, existence value, protection of soil, water filtering and so on. From an economic point of view though, the future is usually heavily discounted and these would be long-term gains. Then there is the uncertainty about the later environmental value of the new forests, given the complexity of old growth systems with a long history. Reforestation projects might however have particular additional value where they form corridors between or are extensions of, current high-value conservation areas. In effect, these areas could facilitate adaptation and in some cases species migration.

### 3.4.4 Large Scale Plantations

In general large-scale plantations have high direct impacts, some limited habitat and resource protection value, but the amenity and existence values can be highly variable, and in some communities, plantations are considered to detract from landscape amenity. A social survey by Williams (2008) in Tasmania shows that cropping and grazing landscapes and activities were considered very acceptable by the majority of participants, while plantations are the less preferred option. For example, 93 percent of participants considered cropping to be acceptable at some level; wind farms acceptable at some level to 80 percent of participants; and eucalypt plantations for pulp acceptable at some level to 43 percent participants (Figure 8). It is large-scale plantations that seem to generate the most resistance (Sinclair Knight Merz 1999; Capill 2000; Tonts *et al.* 2001), so if they disappeared from the landscape as a result of decreasing profitability due to climate change, then there would be little reduction in amenity and existence values, depending on what replaced them.



**Figure 8:** Community attitude to plantations and other land use systems in Tasmania. Participants rated each land use on a 7-point scale ranging from 7 = very acceptable to 1 = not acceptable. *Source:* Williams 2008.



Part of the poor image of plantations may relate to the perceived low conservation value of monocultural stands but this does not mean there is no habitat value. There is evidence that eucalypt plantations, for example, have habitat value above that of pasture land (Borsboom et al. 2002; Lindenmayer and Dobbs 2004; Loyn et al. 2007; Haslem and Bennett 2008), though less than for remnant vegetation (Haslem and Bennett 2008). Hobbs *et al.* (2003) suggest that the habitat complexity of eucalypt plantations, one indicator of habitat value, is only 15-25 percent of that assessed in native vegetation.

On the other hand, it is large-scale plantations that generate the largest direct economic activity and consequently have the greatest regional economic impacts. Given a likely shrinking of some plantation suitability ranges, some significant local and regional effects are expected, as production winds down. Hence, climate change might accelerate the economic adjustment processes already underway in timber regions. In some regions, there could be fewer employees and the loss of processing businesses would particularly affect gross regional product (GRP). In the Great Southern region, for every \$1 million spent by the plantation sector, an estimated 17.15 jobs are created (Schirmer *et al.* 2008c). This includes both direct employment by the plantation industry and flow on employment as a result of demand of goods and services for plantation forestry. In the South West Slopes for every \$1 million spent by the plantation sector, an estimated 8.3 to 15.7 jobs are created (both direct and flow-on employment). In WA each 100 ha of hardwood plantation industry created 0.45 jobs and each 100 ha of softwood plantations created 1.44 jobs (Schirmer, 2009a).

Anticipation of the effects of climate change might also have a dampening effect on managed investment schemes (MIS). These have funded over 80 percent of new plantations in the last 6 years (Department of Agriculture Fisheries and Forestry 2008). Until 2007-08, forestry MIS investors faced the same tax rules as all Australian businesses – they claimed eligible expenses as a tax deduction in the year the investors incur the expense and they paid tax on their income from timber sales at harvest. Plantation growers can now claim a tax deduction for the expense of establishing trees in a carbon sink forest but if they have incurred the expenditure under a managed investment scheme (MIS) they do not get tax deduction. Moreover, the 2007 taxation arrangements require 70 percent of investor funds to be directly allocated to forestry costs such as land rental, plantation establishment, tending and harvesting, which aims to discourage promoters from charging excessive fees and commissions.

A MIS company has a potential tax disadvantage as it must pay tax on investors' funds in the year of collection but may not incur any expenses to offset that income until the following year when the plantation is established. MIS companies don't buy land with investors' funds. They finance their land acquisitions by borrowing, by raising equity in the capital markets, or by using up their after tax reserves (Thomson 2008). Thus, this form of investment is financially exposed, as suggested by recent problems with major corporations. These provisions would seem to favour small-scale private carbon-based plantings, rather than large-scale MIS plantations, however since the MIS investment system is a major driver of plantations industry, any changes in the perception of MIS stakeholders

due to climate change (and related government policies) could have serious impacts on plantations industry.

### 3.4.5 Small Scale Plantations

In the original Vision 2020 view of plantation establishment, 'farm' forestry was to comprise up to 390,000 ha (12 percent) of the target area (Centre for International Economics 1997) with plantations established beyond the high-rainfall areas (Centre for International Economics 1997; National Forest Inventory 1997). Further to that, the 2000 Low Rainfall Forestry Strategy (National Farm Forestry Roundtable 2000) included a proposal for an incremental extension of plantations from coastal/hinterland areas into nearby regions dominated by agriculture. While these plantations in agricultural areas were not expected to be as profitable as the large-scale plantations in the higher rainfall zones they could provide a range of environmental benefits (AACM International 1996; Binning *et al.* 2002; Buffier and The Allen Consulting Group 2002). A number of reviews proposed that the development of a farm forestry sub-sector could best be facilitated by a system of supplementary payments for environmental services (PES) (Hassall and Associates 1999; State Forests of NSW and Commonwealth Bank 1999; Pritchard and Donaldson 2000; van Bueren 2001; Binning *et al.* 2002; Buffier and The Allen Consulting Group 2002), following schemes such as those operating in Costa Rica (Pagiola 2002; Pagiola *et al.* 2004). The early enthusiasm for such schemes was never realised, as Federal governments did not really move beyond funding research and development, demonstration plantations and regional planning activities for small-scale plantations. Incorporating sequestration values may re-invigorate this vision.

Small-scale plantations provide similar ecosystem services to those from large-scale plantations, except that these woodlots have the potential if placed appropriately in production landscapes, to provide higher value resource protection. For example, salinity control benefits increase markedly if trees are established in catchment recharge areas, as noted earlier, while riparian plantings contribute to improved water quality, both locally and system-wide. As an example, the Centre for International Economics (1997) cited various estimates of the annual savings from the reduction in the water table from each hectare of trees. Using the repair cost method, the value of reducing the infrastructure costs, inflated by salinity-induced corrosion and damage, was estimated to be \$30/ha of plantation/year. The saving in downstream water treatment costs was estimated to be \$27/ha/yr and the value of increased availability of potable water was \$30/ha/yr, for a total of \$87/ha of plantation/yr. A NSW State Forests and Commonwealth Bank report (1999) estimated the value of a salinity 'credit' by estimating the area of trees needed to offset the costs of salinity control by the Murray Darling Basin Commission (MDBC), based on the transpiration rate required to sufficiently lower water tables. The 'cost' of salinity control was estimated at \$55-60/Ml of water taken up by trees (State Forests of NSW and the Commonwealth Bank, 1999, p. 37). It was estimated that the transpiration rates in the Central West of NSW averaged (over 10 years) 5-6 Ml/ha/yr (State Forests of NSW and Commonwealth Bank 1999, p. 19). This translated into a salinity credit value of \$275-\$360/ha of plantation/year. In a quasi-market situation, NSW irrigators have paid approximately \$60/ha/yr for five years to NSW forests in one pilot trading scheme (Scherr *et al.* 2004, p. 31).

As with all harvested plantations, there will be an increasing contribution to carbon sequestration during the growing period and a release at harvest time, with the net amount dependent on the end use. If there was to be a market for sequestration, the issue of scale could be important as the transaction costs of trading small amounts would be relatively high. These costs could be managed somewhat if small producers were able to work through some cooperative arrangement where an agent aggregated small lots into a saleable bundle (Buffier and The Allen Consulting Group 2002). Small-scale plantations, especially with supplementary carbon payments could then contribute to regional economic diversity, even if the timber component was not especially profitable at the property level, the production and processing would still generate economic activity. While climate change may reduce timber production in marginal (medium to low rainfall and low fertility) areas, small-scale forestry in such areas could be stimulated by sequestration payments

The second set of responses to any policy change is that of the potential forest owners, which in the case of small-scale forestry would generally be the landholders. Studies of attitudes to small-scale forestry have shown that lack of profitability is considered by landholders, especially those more dependent on agriculture for income, to be a barrier to establishing plantations (Harrison et al. 1996; Cockfield 2005; Herbohn et al. 2005; Emtage et al. 2007). Hence, at face value, additional payments for sequestration starting immediately after establishment might offset some of these concerns. The problem may be that there will be limited faith in a scheme seen to depend on government decisions. Some of these same studies have shown that one of the highest rated barriers to establishing plantations is concern that government regulation will prevent the realisation of timber returns (Cockfield 2005; Herbohn et al. 2005). Previously this was fuelled by regulatory restrictions on clearing and logging but there could be scepticism about government's likely constancy to an ETS over 45 years.

On the other hand these studies also show that one of the main reasons for establishing plantations is the environmental and aesthetic benefits (Harrison et al. 1996; Cockfield 2005; Herbohn et al. 2005; Emtage et al. 2007), though the environmental drivers are more apparent amongst people with a lower dependency on agriculture (Cockfield 2005) and more specifically, those who tend to be 'lifestyle' landholders rather than commercial farmers (Emtage et al. 2007). The larger-scale commercial crop farmers see forestry as a possibility on unused parts of the farm but are reluctant to give up the flexibility of land use based on annual crop and livestock production (Cockfield 2005). Hence, areas that might be first brought into consideration for new plantations include lifestyle properties, low-intensity grazing areas and unused parts of crop farms, where the landowner is open to considering the environmental benefits of forestry and is not hostile to government interventions in land use (Cockfield 2005).

### **3.5 Conclusions**

The socio-economic impacts of climate change on forests are diffuse and vary across landscapes and time. Since the focus of this research is on adaptation, which is to some extent treating symptoms not the root cause, there is a need to disaggregate the larger 'problem' of climate change into its effects

on different types of forests. One major threat is increased fire risks which could affect almost all the forest types, though somewhat differently. For Indigenous managed forests, major fires, as opposed to traditional controlled burning, would not only change the appearance of the forests but could destroy food sources. In all forests with conservation value, major fires could destroy native fauna and non-tree flora and allow accelerated soil erosion. In addition, in rural residential areas, there is the additional threat to human life. While remnants in production landscapes are sometimes better protected where surrounded by cultivation and green crops, fire could be especially damaging if there is limited capacity for regeneration. This could also mean the destruction of isolated but important habitat and food sources. Finally, in production forests, fire would reduce total potential output which would flow on into regional and national economic losses.

Another major potential impact, which is a threat in some regions, is a change in growth rates. There are three socio-economic effects from this. First, in some areas, there could be a decline in production, leading to a decrease in regional economic output. Second, in the absence of interventions, the locations of plantation production could, as growth cycles end, change. This means there will be regional winners and losers. Third, there will be increasing competition for higher rainfall, fertile land and therefore some increase in input costs, with little obvious prospect of commensurate increases in timber prices because of global production trends. The demand side is however partly dependent on decisions relating to renewable energy requirements and the relative costs of renewable energy.

The final major threat, especially for those with strong connections to forests and forest communities, is that there will be a change of perceptions, whereby forests have lower existence, cultural and aesthetic value because of changes in composition, scale, landscape context and appearances. This may be long term and there may commensurate perceptual adaptation to allow for a 're-imagining' of the landscape. There might however be limits to this positive re-imagining if there was an accelerated loss of habitat for rare and endangered species and a noticeable change in the extent and composition for iconic forests, for example tropical rainforests. Thus, planned adaptations may be important and in particular it is a potential mitigation policy (incentives for carbon sinks) that has the potential to offset a number of socio-economic impacts. In the next chapter, we examine other potential planned responses that could ameliorate the negative impacts.

## 4 Policy responses

This chapter contains a discussion of some broad policy frameworks and institutional arrangements for the management of forests in Australia. There are two main themes for this chapter: that there should be an effort to identify policy and program synergies that provide co-benefits or multiple ecosystem services; and the initial general approach should be one of adaptive management, even though there is a general case for treating climate change as a problem that eventually needs more fundamental changes in social behaviour and policy responses. In particular, we argue that there are a range of natural resource management institutions and policy instruments, developed over the last 30 years, that could be adapted to manage climate change effects on forests.

### 4.1 The policy environment

The general argument for policy innovation<sup>5</sup> might be that climate change is so extensive and pervasive, with such major impacts on forests, that new and sometimes radical approaches are required. We argue however that there are a number of factors that will constrain major innovation or paradigmatic change. To illustrate this, we start with a concept (Table 9) as adapted by Cashore and Howlett (2007) and used to explain forest policy developments in the north-west of the US. Essentially, if there is a rapid change of policy in which decisions have the cumulative effect of moving to a new approach, then this is a classic paradigmatic change. Examples might be the deregulation of the Australian economy or, if it had succeeded, the introduction of the CPRS. In the case of climate change impacts on forests, this could, as a speculative example, see government rapidly increase the degree of public ownership of land or increase expenditure through major national programs to acquire services through purchasing conservation services from private landholders (see below for further discussion).

**Table 9:** Taxonomy of policy change by tempo and direction change. *Source:* Cashore and Howlett 2007.

		Tempo of Change	
		<i>Fast</i>	<i>Slow</i>
Directionality of change	<i>Cumulative</i>	Classic paradigmatic	Progressive incremental
	<i>In equilibrium</i>	“Faux” paradigmatic	“Classic” incremental

The opposite of classic paradigmatic change is classic incrementalism which is policy-making by incremental adjustments as needed with no real change to the underlying institutions and policy instruments, for example making adjustments to government spending in response to short-term economic fluctuations. In the context of this review, this would mean largely using existing institutions and policy instruments to respond to symptoms as needed. An example might be governments buying new habitat sites once similar areas appear to be irreversibly deteriorating. Given the current state of

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<sup>5</sup> Usually implies both new institutions and new policy instruments.

knowledge of biophysical and socio-economic effects, some degree of incrementalism is inevitable but such caution can have its limits if symptomatic problems compound and the pace of adverse changes keeps increasing. Faux paradigmatic responses involve an apparent major shift but the underlying approach stays the same. The example might be governments making one large purchase of additional reserves, but then the management of conservation areas and tenure management programs remain much as they are.

The final category, and one we consider to be worth further consideration for this policy field, is progressive incrementalism. Here, the policy direction is towards a general change in approach, but achieved through a series of steps. While the underlying problem of climate change can be cast as a threat that needs a classic paradigmatic change, such as in the pricing of emissions and energy, this urgency is not so easily translated to managing the socio-economic impacts of changes in forests. The reasons for this include:

- The gradualist nature of climate change, at least regarding the obvious manifestation of effects and this apparently gradual onset will tend to induce incremental responses;
- Uncertainty about the nature, extent and severity of the biophysical impacts, as discussed in the WP2 report and the even more uncertain social and economic impacts, as discussed in this report, which suggest the need for adaptive policy (see later discussion);
- Issue competition, whereby decision-makers will find it difficult to drive major change over a long period as their attention is drawn away to other 'crises' such as economic downturns;
- Difficulties in prioritising actions, given uncertainty about the relative value of forests due to variations in scale, location and composition;
- Difficulties in bringing a diverse range of stakeholders along with any proposed changes in policy and institutions. Complicating factors include:
  - The economic interests tied to current practices and resource locations;
  - The social ties to current forest uses, communities and landscapes;
  - The influence of popular and political discourses of climate change 'scepticism' (see next chapter);
  - The psychological barriers to accepting the personal impacts of large-scale issues;
  - Community attitudes to climate change and adaptation (see next chapter); and
  - The complexity of the policy domains and state institutions in that responses to changes in forest value and perhaps even locations, involve industry, environmental and regional policy and cut across the levels of government. As an example, forest management can involve 6 major Federal legislative frameworks and 21 at a state level (Victoria) (Australian Forestry Standard Ltd 2007).

We note that accelerating impacts may lead to classic paradigmatic change but the need for 'adaptive governance of social-ecological systems' (Folke *et al.* 2005) is more likely to be associated with classic and progressive incrementalism. This adaptive governance requires multi-level and multi-sector co-management of resources, given the federal system plus a set of regional natural resources

management organisations. Hence there are at least four levels of 'governance' involved, cutting across a range of policy domains, as will be described below.

## **4.2 Approaches to adaptation**

This section briefly describes some general responses to the socio-economic impacts of climate change on forests and those people with economic and psychological investments in forestry.

### **4.2.1 Autonomous adaptation**

The first approach, presented here as something of a reference point rather than a recommendation, is for governments to do little or nothing and to allow forest managers and those living in forest communities to autonomously adapt to the changed conditions. Autonomous adaptation occurs in all industries and communities, with people leaving industries and regions in response to economic, social and short-term climatic conditions. Under this approach plantation investors would, for example, accept all responsibility for finding information about climate trends and production and then make decisions about the locations of future plantings. This approach fits with the broad policy trend in the Anglo-American countries to encourage self-sufficiency in individuals and business managers which in turn is thought to result in the efficient allocation of resources. A second argument for this *laissez faire* approach is that governments have little hope of managing complex policy systems (Anderson and Leal 1999) and with a global phenomenon that has local effects and diffuse social and economic consequences, this would indeed be working with a complex system. The issue for policy-makers is the degree to which they engage in planned adaptation.

### **4.2.2 Structural adjustment assistance**

Even where governments have withdrawn from direct industry and community support, such as in agriculture, fisheries and production forestry, they may provide various forms of structural adjustment. If plantation or tourism investment was to decline in a particular region, then previous policy instruments, such as retraining schemes and new business and community enhancement grants could be used. Again, this is industry and regional policy, rather than environmental policy, aimed largely at the tangible economic and social impacts. Structural adjustment assistance is usually a by-product of decisions where structural change is seen as necessary (see for example McGuffog and Western 1993 in relation to forestry on Fraser Island).

Given the generally incremental impacts on timber production and tourism, there is unlikely to be an immediate case for adjustment packages solely addressing climate change effects. These effects may however add impetus to the provision of adjustment packages where there are other changes, such as the continuing reduction of native forest logging in some areas. So, we would generally expect that adjustment packages would be an extension of existing approaches and for situations where there were other forces for regional change. In general, governments prefer structural adjustment packages to be time limited, with the exception being the series of programs for

agriculture (Cockfield and Botterill 2006). Hence, we would expect such assistance for forestry to be highly targeted and time constrained.

### **4.2.3 Catalysis**

The 'catalytic' approach would involve governments and NGOs undertaking activities that would enable and encourage people to adapt. In the forest sectors this includes:

- Research in relation to species characteristics, species ranges and production inputs and methods. Therefore, adaptive responses could include consideration of climate change impacts within existing programs. Similarly, there are programs for research on conservation forests which could similarly be adapted.
- Research on and modelling of, the economics of forests. Again, current work could be extended to include consideration of climate change impacts. In particular research into the economics of non-market values in forests is rather fragmented since the winding down of the Regional Forests Agreement processes (see below).
- Extension and demonstration activities that promulgate the findings from economic and biophysical research.

This approach is again a variation of current arrangements but the two issues to consider are: whether or not to merely extend the work of current research arrangements to more explicitly consider climate change, or to create specific research institutions; and, whether or not to increase funding into the impacts of climate change on forests. Given that lack of knowledge of impacts is a key constraint on policy responses, there is a case for increased funding and some cross-cutting activity.

### **4.2.4 Certification**

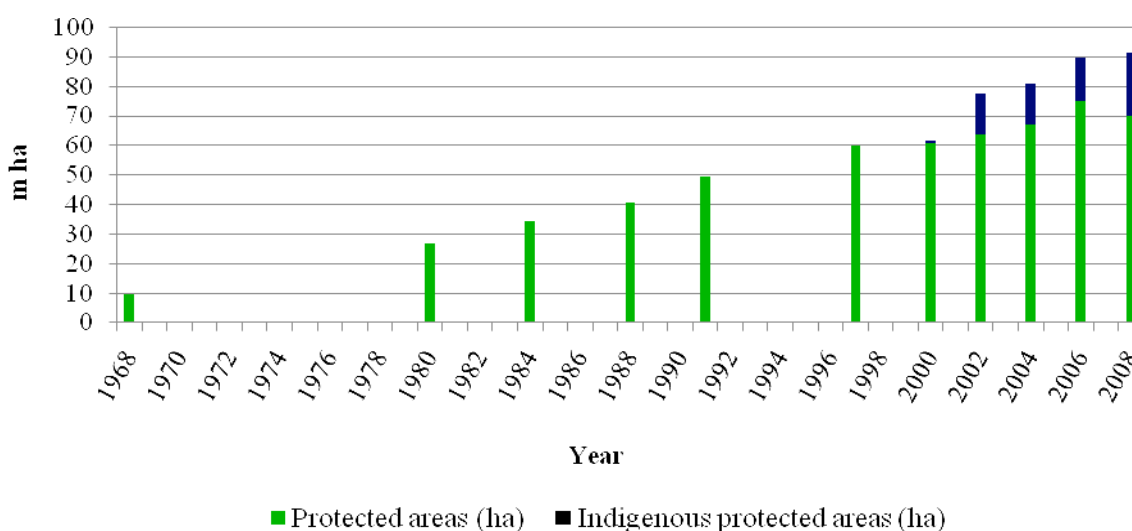
Another form of governance that could be adjusted to include consideration of adaptation measures is voluntary forest certification. Arrangements such as the Australian Forest Certification Scheme (AFCS) and the Forest Stewardship Council scheme are being taken up for both plantation and native forests (Department of Agriculture Fisheries and Forestry 2008). In 2008, under the broad umbrella of the Montreal Process Criteria and Indicators (C&I), Australia developed a Sustainable Forest Management Framework of C&I for assessing the sustainability of forest management through the national-level Montreal Process Implementation Group for Australia (MIG), comprising representatives of the Australian, state and territory governments. With that, the AFCS already contains commitments relevant to the various forms of value discussed in the previous section, including undertakings to consider ecosystem health, biological diversity and regional development (Australian Forestry Standard Ltd 2007). It also requires public participation (see later in this section and next chapter). It might therefore be possible to add requirements for consideration of the impacts of climate change. This means of governance depends on voluntary participation and conformity to the standards but it appears to be gaining momentum both here and overseas. Hence, it could be argued that certification runs parallel with market-based responses (see below) in moving away from direct government intervention and oversight.



#### 4.2.5 Resuming and allocating property rights

A fourth broad approach is for governments to change land tenure arrangements, or in economic language to change the allocation of property rights. This includes governments purchasing land outright (acquiring all property rights) and then managing that for particular outcomes. The most direct approach is for governments to own and manage forests for particular outcomes, whether for timber production or the provision of other ecosystem services. The impacts of climate change as described above and in the WP2 report, could include the isolation and declining habitat value of conservation forests and remnants. In response government agencies could purchase land to facilitate the movement of species, either or both as buffer zones around existing conservation forests, or as biolinks connecting remnants and larger areas. As noted above, this would be something of a paradigmatic change, or at least a reversion to an earlier approach. There are however at least four impediments to an expansion of government ownership of land:

- The policy trend against direct government ownership. As noted in the introduction, state agencies have been moving out of the plantations and native forestry sub-sectors. In addition, as shown in Figure 9, the reservation of areas by governments may have peaked, as control of some areas is handed to Indigenous peoples and there is increased emphasis on conservation measures for privately owned land;
- The adverse perceptions that result from governments acquiring land and the buffer/corridor scenarios could require targeted and compulsory acquisitions;
- The need for skilled land management staff, especially with the ability to manage climate change impacts; and
- The cost of purchasing and managing additional land. One possible offset would be for state agencies to be trading in land, selling the areas that have lower environmental value due to the climatic changes.



**Figure 9:** Area of government reserves in Australia. *Source:* (Cresswell and Thomas 1997; Department of the Environment, Water, Heritage and the Arts 2009)

To address the issues of purchasing costs and the direct management of land, governments could also regulate to change the conditions of existing tenures so as to exclude direct threatening processes, effectively removing some property rights. This is the effect of state-based land clearing policies. The two limitations here are: even more virulent reactions to the loss of property rights without compensation; and, second, there is no incentive for landholders to actively manage forest areas to maintain or enhance values, for example by combating weed or pest invasions, or to prevent fires, except where these might impact on other parts of a property.

To offset the compensation issue, governments, NGOs or private individuals or companies could purchase the relevant property rights, such as the right to conduct agricultural activities. There are programs that could be adapted or serve as the model for this purpose, most notably the Tasmanian Forest Conservation fund and the Environmental Stewardship Program, as discussed earlier. In these cases, the purchase of property rights, requiring refraining from certain activities, is usually supplemented with a management agreement that involves the landholder in adding value in the provision of ecosystem services, such as supplementary plantings and pest, weed and fire control. The advantage of this is the potential for the landholder to become more engaged and competent in conservation land management, and some may then provide additional value above the required outcomes.

Stewardship programs are however usually based on voluntary expressions of interest and this can result in a set of fragmented landscape components being under stewardship, while the buffer/corridor scenarios discussed above require some degree of coordination. Environmental tenders shift the market power from potential ecosystem services providers (landholders), back to the potential purchaser (governments, NGOs, corporations) because the latter groups' willingness to pay are not revealed. Once a high priority buffer/corridor area is known, then market power shifts back to the sellers, especially those who hold out to force the prices up. One possible means of managing this is to create a virtual 'commons', where the landholders are induced to act as a group, engaged in selling services (Ostrom et al. 1992). Ostrom *et al.* (1992) show that if internal (to a group) rules and communication processes are developed, then that group can act to manage aggregations of private land as something of a commons. With group agreements, the peer pressure and group feeling frees governments from some of the odium of apparent compulsion. Whatever the design, we consider tenure management to be a critical policy instrument, especially for conservation management.

### **4.3 Institutional adaptation**

As noted above, forest management cuts across a range of policy domains and state agencies and is subject to legislation which considers a range of things from occupational health and safety through to water quality and rare and endangered species. In keeping with a theme of this report and especially this section, we now briefly consider the institutional aspects of adaptive governance, and in particular overall coordination and the need for bridging organisations that can link up stakeholders and operate at regional and local levels (Folke et al. 2005).

There are four major reasons for having some overall (national) coordinating arrangement:

- The distribution of land management powers and programs across three levels of government;
- The complexity of the social-ecological systems being addressed, as described earlier;
- The need for engagement with international standards and agreements, such as Agenda 21, the Convention of Biological Diversity and the United Nations Forum on Forests (Australian Forestry Standard Ltd 2007); and
- The cross-border aspects of adaptation. This has two elements. First, similar forest types and in some cases actual forests are distributed across state and regional boundaries. Second, the scenarios presented for this project suggest that the locations of plantations may move, including across state borders. It is suggested here that buffers and corridors may need to be created or enhanced and this would require cross border coordination.

One framework through which to work is that for the Regional Forest Agreements (RFAs). These agreements are already based on overall coordination (by the Commonwealth) and they embed regional planning based on relatively sophisticated socio-economic and biophysical analyses used to inform decision-making and prioritisation. Under this system comprehensive regional assessments (CRAs) were conducted over the period of 1995-2000 to assess social, economic and environmental values of forest regions. These were later used to prepare 20 year regional forest agreements (RFAs) between the Australian and four State Governments – NSW, TAS, VIC and WA (Department of Agriculture Fisheries and Forestry 2008). These RFAs collectively cover about 20 million ha of forest lands. RFA areas can be managed for timber production and conservation. The sustainability of the RFA areas is monitored by the international Montreal Process Sustainable Forest Management Criteria and Indicators (C&I), as noted above.

At a higher level there is a Ministerial Council on Forestry, Fisheries and Aquaculture, which endorsed the indicators and could be the forum to oversee revised and possibly expanded RFAs. Some RFAs could remain as Commonwealth-state agreements though there might be a case for particular cross border arrangements, perhaps drawing on the experience of the Murray-Darling Basin Authority (MDBA), especially for major forest areas that cross Victoria/NSW and NSW/Qld (see Figures 2 and 3), however such decisions would require more detailed spatial analysis and impacts modelling to decide on need.

Finally, given the variation in local impacts, there may need to be institutional adaptation at the regional scale. Australia has a system of natural resources management organisations, state-based but in receipt of Commonwealth funding. The roles of these organisations could be extended to include forest management adaptation. In particular, these organisations would be best placed to address issues related to remnant vegetation in production landscapes and forests that have high resource protection values, such as those in riparian areas or recharge zones (for salinity control). These organizations have the contacts with landholders and the knowledge of site conditions. In addition, they could be champions of and advisors for farm forestry. This would be a reasonably cost-effective arrangement as specialists could be added to the organizations without the need for new administrative structures and costs. There would however, still be roles for NGOs at the regional scale

(Folke *et al.* 2005) as well as scientific organisations, such as the CSIRO in providing advice across administrative boundaries.

#### **4.4 Conclusions**

In this section, we described some existing policy frameworks and institutions and briefly discussed how they might be adapted for the governance of forests subject to significant climate change impacts. There would need to be more detailed research and consultation before specific institutional designs were developed. In general though, Australia has institutions capable of national coordination and implementation or national coordination with regional implementation. The level of coordination and action would be determined by the forest type being addressed. For example, the management of priority conservation areas would logically be at the federal level, under the EPBC Act and, for example, using the Environmental Stewardship Program or similar. Conversely, the mitigation of threats to valuable remnants in production landscapes could usefully be devolved to regional bodies.

Australia also has experience with a range of policy frameworks, from regulation through self-regulation and to market-based instruments. All of the approaches discussed here will have some roles in adaptive governance but a critical decision area is the mix of voluntary provision of ecosystem services and the more state-directed acquisitions. It could be argued that the general direction of forest and natural resources management policy is to make greater use of private property rights, whether for timber production or conservation forests. There would need to be a strong argument or an obvious increase in the extent and severity of the effects of climate change to drive a paradigm shift. Therefore, the provisional suggestion is that the first responses should involve extensions of current programs for purchasing environmental outcomes, with government acquisition and purchase being a fall-back where critical habitat is needed. This will be particularly important with regard to buffers/corridors and relocation sites.

Finally, while the degree of policy 'progression' or paradigmatic change will be partly determined by the severity of the biophysical impacts and consequent social effects, it will also depend on the extent to which citizens recognise and accept the problem and its manifestations, both in general and in relation to themselves. Hence, the penultimate chapter turns to considering this.

## 5 Community attitudes and responses

There are three reasons for examining community attitudes and likely responses to climate change. First, much of the value of Australian forests is intangible and to some extent dependent on people's perception (Chapter 3). To understand the perceptions is to know more about who values what (see for example Winter and Lockwood 2004). Second, understanding attitudes and beliefs provides an insight into potential autonomous adaptations, or the ways in which people will respond at the individual and small-group level to climate change. Finally and following from Chapter 4, policy effectiveness depends on community responses, especially in relation to accepting the need for, and type of proposed changes. This chapter contains a brief review of some studies of community attitudes to forests and then reports on a study of two forest-based communities.

A literature review of research in the area revealed that the majority of studies to date have been quantitative and focused on the statistical analysis of broader based socio-economic indicators from large data bases, which indicate demographic and other trends in these communities. There was a dearth of qualitative research exploring the impact of the changing forestry industry on local communities. This study examines community understanding and perceptions of climate change, climate change adaptation and the role and impact of the forestry industry in communities. The aim is to go beyond the statistical analyses of socio-economic data to provide a deep understanding of the 'on the ground' impacts that affect the residents and infrastructures of local communities when an industry, such as forestry, grows, shrinks or replaces existing industries or is in turn displaced by other land use activities. There is also some consideration of people's readiness for change, which is an important determinant of resilience.

Qualitative research does not identify trends or suggest generalisation of the results across whole populations. What it seeks to achieve is the collection of data which illuminates the phenomena under study. In this way, a deeper understanding is obtained from the full and meaningful responses made by the participants (Lincoln and Guba 1985). Sample size becomes less relevant to this particular approach and the priority becomes the creation of patterns and themes which adequately represent the participant descriptions.

### 5.1 Background

A number of relevant studies have been undertaken by Schirmer *et al.* (2008a; 2008b; 2008c; Schirmer *et al.* 2008d), Williams *et al.* (2008) and Milne *et al.* (2008) in which different qualitative research techniques were utilised to ascertain community perspectives on climate change and the impact of forestry. Although each of these studies gives valuable insight into community perceptions, the methodologies and scope of these differ. In September 2006, Schirmer *et al.* (2008) documented the responses of 57 residents obtained in group interviews conducted in Central Victoria and Victoria's 'Green Triangle'. Respondents discussed the nature of land use change and how it had affected their lives and the communities they lived in. The goal of the group interviews was to

“qualitatively describe the experience of these changes, focusing in particular on understanding the diversity of issues relating to land use change in the region, and how and why people experience change in different ways.” (Schirmer *et al.* 2008d)

In this report, Schirmer *et al.*, discussed the methodology applied by Slootweg *et al.* (2001) who argued that when examining the social impacts of changes such as new government policies, development or land use change “it is essential to understand that different people will experience change in different ways.” They suggested that because people are impacted by change in different ways it is necessary to examine both “the social changes that are caused by land use change, and the impacts of those social changes”.

Williams *et al.* (2008) conducted further research in the same region following up on the earlier work of Schirmer and others undertaking two surveys in 2007. The first survey was based on 899 responses to posted questionnaires to people selected at random but there was a lower than expected response rate and sampling biases. The second survey used face-to-face interviews from 414 residents aged 18–45 intercepted in main streets of towns across the study area.

“Respondents ... were reasonably similar to the population of interest (residents aged 18–45) in regard to age, gender and residence but may be unrepresentative in other ways. Despite these limitations, when viewed together, the surveys provide considerable information about residents’ views on land use change.” (Williams *et al.* 2008)

Shortcomings in available socio-economic data were identified by Schirmer *et al.* (2008b) who examined the use of widely used indicators which they found “provide a useful but limited understanding of the social and economic impacts of forestry in Australia.” Articulating a gap in the use of indicators in measuring social-economic trends they stated:

“Indicators are necessarily limited to data which can be regularly monitored and measured over time and compared across regions. They do not provide the in-depth data needed to better interpret and understand the diversity of ways forestry activities impact different individuals and groups.” (Schirmer *et al.* 2008b, page 65)

The authors went on to say that further work was required to gain a greater understanding of how perceptions of impact relate to measurable social and economic changes, and whether the impacts identified are solely a result of forest industry-based activities, or a greater array of factors.

“This can assist policy makers, the forest industry and communities in better understanding the impacts of forestry – both positive and negative – and how to maximise positive and minimise negative impacts. These studies may use a range of qualitative and quantitative methods to gain a more in-depth understanding of how different people experience and understand the impacts of changes to forestry in Australia.” (Schirmer *et al.* 2008b, page 73)

This study also considered the previous work of Milne *et al.* (2008) in which 148 farmers, community representatives and small business operators were interviewed or were involved in focus groups exploring perceptions of climate change vulnerability.

The Regional Forest Agreement (RFA) process also included efforts to consider community attitudes to forests and possible changes in forest management and policy. This was largely done through submissions and surveys but criticisms of that work included the dominance of major interest groups in relation submissions, low survey return rates and the exclusion of Indigenous peoples (McDonald 1999). McDonald (1999) also notes that the RFAs, as with other developments of NRM policy, may have been limited by lack of agency expertise in social science research and a tendency to regard results as 'soft' data.

Unlike the above studies, this research is based upon community members selected at random to participate in one-on-one interviews. It is intended to give direction to, as well as help plan, future research of social impacts of climate change at the national scale resulting in the development of adaptation policy and strategies. The purpose of this study was to use qualitative methods to examine community understanding and perception of climate change, climate change adaptation and the role and impact of the forestry industry

## 5.2 Research methodology

Qualitative research is a recognised and rigorous social research methodology that is used to gain in-depth knowledge and understanding of a particular phenomena, issue or question. This research strategy is often used to understand complex issues or to explore topics for the first time. The relevance of this methodology and its application to forestry was encapsulated by Schirmer *et al.* in their 2008 report:

“The complicated nature of human experiences of impacts of change means that studies which aim to objectively measure change through analysing statistics can only be partly effective in assessing the social impact of changes to forestry.”

These authors identified that if statistics and indicators were to be useful for identifying social change in sectors or groups or industries such as forestry, they needed to be accompanied by qualitative studies to interpret what these social changes might mean for individuals in these communities. In response to these findings this report goes beyond indicators and statistics and seeks to examine the experiences of a range of residents in forest industry communities to gauge their first hand experiences of this industry and the social impacts that may not be measured by statistical indicators.

“Because different people will be impacted by change in different ways, Slootweg *et al.* (2001) argue that it is necessary to examine both the social changes/characteristics that are caused by an industry such as forestry, and the impacts of those social changes/characteristics. It is therefore important to understand both the social changes and characteristics that may result from forestry (for example, to identify how demographic characteristics or the nature and availability of employment differ in regions with differing levels of dependence on forestry), and how people experience these changes.” (Schirmer *et al.* 2008c)

This report summarises the perceptions of residents from two communities. It outlines their perceptions and understanding of climate change and adaptation to climate change and their perceptions of the forestry industry.

Following consultations with NCCARF, two regions were identified: the Eden/Gippsland region (on the border of New South Wales and Victoria); and Tasmania. The communities around the town of Bombala in southern New South Wales and the town of Scottsdale in north-eastern Tasmania were then identified as study sites. Both regions have well established forest and timber industries encompassing a range of different industry sub-categories such as State forest reserves and plantation timber industries.

Respondents for this study were selected across a range of stakeholders within these communities. The only selection criteria applied was that respondents were over the age of 18 years and not directly involved with the forest or timber industry. A list of the types of participants was developed and researchers contacted a number of organisations in both districts to seek assistance in the recruitment of volunteers.

In-depth interviews were conducted with 23 respondents: 10 from the Bombala region; and 13 from the Scottsdale region. Respondents were from a range of occupation classes, including: librarian, retired and semi retirees, student, health worker, bank employee, office administration, social worker, minister of religion, electrician, self-employed, and council employee. Respondents included both males (11) and females (12), who ranged in ages ranging from 20 to 84 years old (median age 54.6 years). Each interview lasted approximately one hour and respondents were asked five open-ended questions, with the use of prompts where necessary, to fully explore their thoughts and opinions across:

Their understanding of climate change and how it may, or may not, impact on their region;

- Whether they had noticed any climate changes in their region and what they believed were the causes;
- What are their sources of information on climate change and do they find them reliable or trustworthy;
- Their attitudes to the forestry and timber industry; and
- Their attitudes to change and adaptation in response to climate change and what strategies they think need to be in place to accommodate climate change.

All interviews were audio-taped and transcribed *verbatim*. Data analysis followed an inductive process, using the constant comparative method as outlined by Glaser and Strauss (1967). This involved a process of coding, developing categories and constantly comparing and regrouping these categories to explore the understandings and perceptions of climate change and the forestry industry for this group.



### 5.3 Understandings of climate change

A key finding is that all participants across both communities indicated a strong understanding of climate change and believed climate change was occurring locally and globally. However, respondents differed in their perception as to whether climate change was anthropogenic or a process occurring unaided by human activity. Many respondents asked for a clarification of what type of climate change was meant and when questions were divided into anthropogenic and non-anthropogenic climate change, all respondents accepted that the latter form was occurring and indicated they were aware of historical and scientific research to support this form of climate change.

Respondents who accepted the concept of anthropogenic climate change had a number of perceptions of it. Some attributed human activities as being a major cause of climate change, while others stated they believed it was contributing but could not be considered the only cause of climate change. Respondents identified a lack of understanding of climate change in their communities saying it was rarely discussed or considered as being a priority over issues such as 'the drought' or changing rainfall patterns.

The division on the concept of climate change was reflected in comments from respondents who said people in their communities regularly spoke about and discussed changing weather patterns but rarely used the words climate change in conversations.

"We talk about the weather, so we talk about the changing, you know, especially with older farmers, about the drought and the rain and all those sort of things. But as soon as I think you mentioned the word 'climate change', it tends to switch people off."

Many identified that they could see climate change had occurred in their own lifetimes and this was identified as fewer cold mornings or less water in local waterways. Some respondents said seasons were not as predictable as they had been in the past. However, as stated above, many were undecided on whether these changes were anthropogenic climate change.

"My understanding of climate change is that, yes, the climate is changing. I mean, you can't deny that it's not when you look at - all the scientists, no matter what side it's on, will say it's happening. The argument, to me, seems to be what's causing it. That, I think, the jury is still out on. I mean, you have got eminent scientists on one side saying it's a natural phenomenon and it's happened all the time and why are we caring on about it? And then you've got people on the other side saying, "No, it's man-made. I tend to think it's a bit of a combination of both, actually. I think that the climate has always changed but I do think it's probably being exacerbated by us ripping oil and coal out of the earth and burning it into the atmosphere."

"That we are a blip on the map in evolution, aren't we? I mean, it's come about in the last decade or so. It's the latest new buzz word "climate change", it's all happening. I think it's just cyclic. It happened over the years and it's our turn to see it warm up or cool down or do whatever it's doing. I am concerned but I'm not worried."

All respondents acknowledged recent and ongoing changes in weather patterns were having varying impacts. In one region this was identified as a prolonged drought, fewer cold mornings and higher peak temperatures. In the other region, changing rainfall patterns was the most obvious change identified. Small future increases in temperature in both regions was seen as unlikely to impact on respondents who identified changing rainfall patterns, extremes in weather, increased risk from bushfires and higher sea levels as being of greater concern.

## **5.4 Perceptions of climate change information**

While all respondents understood the concept of climate change, many expressed that they were aware of divergent opinions on its causes and effects and many expressed concerns about the reliability of the information they were receiving. While the majority of respondents said they obtained information from the mainstream media, most said this information was unreliable and they perceived it as potentially biased. A smaller number of respondents sourced information from other mediums such as the internet or official reports. Although these were considered to be more reliable sources, a small number of respondents were still sceptical due to the ongoing divergence of opinion in the scientific community.

“But it's really hard to get a balanced view. There is a lot of people on both ends of the scale and there's some really credible people saying, there's going to be a seven degree warming, oceans will rise two metres and things like that and there's some really credible people on the other side saying, "It's a fraction of the change. It's all in the cycle." So who do you believe?”

“There is a lot of misinformation, I think, about how it all works. I think there's so much information out there. It's very hard to know who is telling the truth and who - you could talk to ten scientists and they will all probably tell you something different.”

Respondents said they wanted clear, concise and credible information to base judgments upon, with a number of respondents suggesting information on climate change needed to be localised. They identified local councils and local organisations as being community based and trusted sources of information.

“I think the government's got a fair bit to do with educating us, forcing the issue as well, like what needs to change.”

## **5.5 Community impacts of the forestry industry**

The majority of respondents acknowledged the importance of forests and timber industries in both regions. They acknowledged the importance of forestry as an employer and to the local economy.

“The industry is undervalued and it should be supported much more strongly by government and it should be - I don't think so much credence should be given to people who argue against it. If you are going to have a successful industry, you have got to have an industry which is large enough to compete.”

“Forests are important. They are important, wherever you are in the world. I can remember years and years ago I read - it was an article in some paper where they actually planted trees on the edge of Sahara desert and it doubled the rainfall. It actually started generating clouds and things like that. I mean, forests are critical to the planet.”

However, respondents identified a number of unforeseen community impacts. These are:

- The environmental impact of forestry on the community (fire, water, pests, biodiversity)
- The social-community impact (jobs, services, etc).

## **5.6 Environmental impact of forestry**

Environmental perceptions of respondents of the plantation industry included:

- a) it was bad for biodiversity because it creates a monoculture;
- b) problems associated with planting practices that were perceived as increasing fire risks for the local community;
- c) inadequate staffing of plantation properties to manage feral animals, disease and pests; and
- d) the impact of the plantation timber industry on water quality and water tables.

“The other issue I have with forestry, the way it is currently done, it is a monoculture which is not good for the environment. It's not good for the wildlife, it's not good - it makes it prone to catastrophic consequences. If you get a bug ... that only takes pines, then boom, the whole industry is down the gurgler. That's my main issue.”

“You put a forest in, walk away from it, and it's got an impact on the local community. I was with the fire brigade five years ago, or so, and we have had big forestry burns. Now, they walk in, put the forest in, walk away and it's the local community that are then responsible for keeping that from burning your town down. So from that type of impact, it would be nice to know that there is more support from forestry, more corporate responsibility was taking place.”

Respondents also questioned practices used by timber companies of trucking timber from one area to another because mills in certain areas were not set up to manage the timber grown in that district.

## **5.7 Social-community impact of forestry**

Respondents identified significant negative socio-economic impacts the forestry industry had on their communities. In one district respondents described that the number of rural properties acquired by the plantation industry had directly led to a local population decline of as much as 25 percent which resulted in significant social dislocation. This had flow-on effects to the rest of the local community resulting in reduction of staff and resources at schools and local businesses and other impacts such as insufficient people in the district to maintain a doctor and other medical and social services.

Respondents said that conflicting State and Commonwealth policies, laws and regulations allowed and encouraged the plantation timber industry to develop to the detriment of small rural communities.

“It is a small community, but it has – economically - it's gone backwards like a lot of other rural communities I suppose and we haven't really benefited. The forestry development that's happened, our community hasn't benefited. It really had the opposite effect.”

“You put a dairy farm in, you have got at least 24/7 job. You put trees in, you walk away and leave it for 20 years. So the whole family, there's whole bus routes, there's whole classrooms that have disappeared because there's no school children there. They have moved on. So that's changed the community; already we have noticed those.”

Respondents said during the initial phase of planting a small number of jobs were created. During the 15-20 year period needed to bring a plantation crop to commercial maturity, respondents said only a handful of employees were needed and many of these did not live in the district. Respondents said a number of undertakings were made about employment opportunities during the commence phase of intensive plantation activity in their region but these had not been fulfilled.

“When the plantations turned up, we thought that might be a replacement but as it's turned out, it's not. They have a rush for a couple of years as they get everything organised and then they leave them stand for another however long it takes and then they bring in outside contractors with big machines and sort of just - harvest. It's probably reasonably good for the regional economy, State economy, but it doesn't affect our local community that I can see so far.”

Most respondents were critical of Managed Investment Schemes (MIS) and regulatory frameworks which respondents said allowed the plantation timber industry to pay above market rates when buying prime agricultural land. Respondents perceived that MIS's were more about tax deductions for investors than about a viable timber industry.

“There's definitely a place for it but the planning for plantation expansion seriously needs looking at. Unfortunately, the structure at the moment doesn't encourage - well, there's no provision for planning. It's all driven by tax deduction investments which distorts, in our opinion - distorts the ideal locations being selected.”

“It has been a problem for us in this region because previously the - the superannuation fund people would come and purchase land, to get the MIS schemes in there and they didn't really care about how much it was costing to buy that land so our land values went up in our region, in our regional areas, which then put rates up and stuff like that and the farmers - they call themselves the real farmers - were saying, “Well, hold on, the value of our land hasn't gone up. It's only because this stupid MIS and all of the tax breaks it gets, now we are having to pay for it.” So we certainly, over the last five years, have had quite a bit of land taken up by MI schemes.”

In spite of the negative aspects of the forestry industry, respondents perceived it had a future in their district albeit subject to changes.

“In this community the balance goes to all economic development with people supporting forestry industry because they know lots of people. If they don't, they know others whose livelihood depends upon it. They know the community's livelihood depends upon it. And that's

where the problem between plantation versus agriculture, that's a tension because the community depends on both and you don't want to move the balance too far one way or the other or else things aren't viable."

## 5.8 Climate change adaptation

All respondents identified that they had adapted or were willing to further adapt so as to lessen their personal impact on the environment. Many felt that individuals needed to be accountable for human impacts on the planet and had noticed changes during their lifetimes that showed adaptation taking place. However, they said adaptation needed to be a whole of community approach with some highlighting:

"I think they're quite prepared to adapt, if we're looking at warmer periods, productivity-wise that will be a boost to this area because we are in a cold climate."

Respondents identified that changes in rainfall and weather patterns had already prompted adaptation in land use management and agricultural practices in the study regions. Some said these adaptations were due to lesser rainfall or changed rainfall patterns. Others said warmer temperatures and fewer frosts meant that a number of crops could now be grown that previously could not be grown in these regions.

"I think there's opportunities for this area as a result of that because our growing season is really short and so if temperatures do get a little warmer and we have maybe less incidence of frost, it's going to open up opportunities for different crops."

Respondents identified that some of the potential impacts requiring adaptation would be:

- a) uncertain weather and rainfall patterns which they were currently experiencing;
- b) changing patterns of pests and diseases;
- c) higher coastal water levels;
- d) the reluctance of industry to adapt until climate change impacted on its bottom line; and
- e) a lack of preparedness for change in these communities.

Respondents identified potential barriers to adaptation as being: excessive government bureaucracy and a 'who cares' attitude by some in their community.

## 5.9 Discussion

As identified above, to date only a small number of qualitative studies have been undertaken that examine perceptions of climate change, adaptation and attitudes towards forestry in communities associated with the forestry industry. This is the first study to examine the perceptions of a cross section of community members. The examination of a broad cross section of the community was highlighted by Slootweg et al. "The ways in which the social change processes are perceived, given meaning, or valued, depends on the social context in which various societal groups act. Some sectors

of society, or groups in society, are able to adapt quickly and make use of the opportunities of a new situation. Others are less able to adapt (for instance, various vulnerable groups) and will bear most of the negative consequences of change.” (2001)

These interviews give community voice to issues raised earlier in this report. First there is the ambivalent attitude to plantations, with acknowledgement of the economic benefits but concern about social impacts. The increase of plantation industries in recent years within these two rural communities was identified as having significant social impacts on these communities. The most significant issue identified is the dislocation of farming families from these communities who have not been replaced. Former farms used for plantation timber require few people to manage them during the 20 years to economic maturity and this is considered to have significant economic and employment consequences for the study regions. A further expansion of plantations under a CPRS or similar or increases in autonomous moves to particular higher rainfall areas are likely to trigger the same concerns. Some caution is needed because agricultural and pastoral areas with no plantations are also depopulating so land use change is not the only factor to consider.

The capacity of MIS to outbid other land users was also identified as an issue of major concern. This was identified as having negative consequences in terms of artificially increasing the price of land and having flow-on effects in the rest of the community in terms of valuations used for state and local government taxes and charges. It also meant that other potential users of the land (such as farmers) were at a significant financial disadvantage when purchasing land at prices which were considered to be artificially increased. Again, this supports the hypothesis advanced earlier in the report that increased competition for land may lead to increased prices. This warrants further investigation as land prices have generally increased over the last decade and there would need to be some investigation to confirm that demand for plantation land was necessarily the major or only factor in increases in particular areas.

The social responsibility of plantation operators was also questioned, as was their role as good corporate citizens. Respondents indicated that many promises of economic and employment opportunities offered by plantation operators at commencement of operation did not eventuate. These promises were subsequently seen as being used as a means of mitigating early opposition to such plantation operations. Once the plantations were established the operators were seen as walking away from responsibilities such as fire mitigation and leaving responsibility for this to locals in these communities who face an increased fire hazard as a result of plantation forestry. Other issues identified included: the impact of forests on water tables and water supplies; management of diseases, pests and feral animals; and the impact of monoculture plantation industries on biodiversity.

Although some plantation operators were seen as good corporate citizens and willing to provide support for local communities, respondents indicated corporate social responsibility towards rural communities was not common and did not replace the social inclusion of the families who had been displaced by plantation operations. Overall, the respondents in the two communities understood the potential for forestry to provide environmental opportunities for climate change adaptation and mitigation into the future. However, they were concerned as a result of their first-hand experience of

this industry and whether, in its current form and under current prudential regulation and supervision, it has the social capital and responsibility necessary to undertake this function.

Some of the responses also revealed some potentially critical issues in relation to attitudes to climate change. First, some responses indicated that the impacts of climate change were not necessarily imminent, meaning that community level preparedness to react may be somewhat different to the expectations in resources management policy communities. Second and somewhat conversely, there are those who see it as such a big phenomenon that a sort of resigned autonomous adaptation is really the only response. Combined with the general lack of faith in 'bureaucratic' interventions, this is a potential impediment to cooperatively planned adaptations. At the most extreme, this fatalism is revealed in the comments that this is another change in a long planetary history, perhaps ignoring the argument that it is a big change in modern human history. Third, the responses from this study show continuing uncertainty, if not dissension, about the causes and extent of climate change. While there is distrust of media sources and a desire for 'scientific' information, it is not clear whether more 'proof' would necessarily change minds given the ideological and political nature of the popular debates.

Fourth, there were comments that revealingly identified some potential benefits of climate change (better living conditions) and this reveals an important but little discussed issue. In order to get action, much of the policy and scientific discussions have focussed on the negatives, and major negative impacts, such as, in the case of forestry, a reduction in growth rates, and increased risk of fire, and pests and diseases. Yet, some people will enjoy the warmer weather, longer growing seasons and, as suggested in this report, benefit from an increased area suitable for forests. Fifth, it was clear that the experience of respondents was that people in the community were avoiding discussion of climate change. This might be because such discussion would generate conflict or it could be avoidance behaviour, in that to acknowledge the permanence of climate change, as opposed to seasonal and decadal fluctuations, might require confronting the need to change preferred social and work arrangements. Finally, some respondents seem to have little faith in the ability and inclination of other members of the community to adapt to climate change. An important aspect of community resilience is the ability to work together towards a common goal (Davidson et al. 1991).

## **5.10 Conclusions**

While this study was limited in scope and geography, it showed that people in these forest-dependent communities would be adapting to climate change impacts, while still adapting to the on-going structural changes from the policy and economic decisions discussed earlier in the report. There was no obvious confidence in governments, timber companies and communities in terms of ability to manage change. While changes in climate are acknowledged by residents of forestry communities, the cause of these changes is the subject of conjecture. Regardless, these individuals have already made many adaptation responses and have indicated a willingness to accept further adaptations, albeit this being something that occurs across the entire community. For these communities, it is not clear that there is the unity of purpose that would facilitate a coherent community response. In addition, these survey responses suggest that policy responses could contribute to perceptions of an

'elite' trying to force change on communities. In addition, the major mitigation response on the policy horizon (an ETS) would accelerate land use change in ways that many communities might resist. More plantations, either conservation or production, could be seen as accelerating the depopulation of rural areas, shifting ownership of land to people without the ties to traditional rural life.

We therefore make several recommendations in relation to community engagement. First, these surveys suggest the need for more social research, perhaps capturing a wider variety of communities. Second, the communities' concerns and uncertainties seem to us to support the progressive incremental approach recommended in the previous chapter. Third, there needs to be a strong emphasis on the co-benefits of adaptive measures so that the load does not rest solely on the need to respond to climate change. For example, if a CPRS or similar is introduced, then there may be ways to emphasise the habitat, resources protection, aesthetic and even eventual tourist benefits of new conservation plantations. Similarly, the regional economic benefits of timber or bio-fuel plantations could be emphasised. Further to that though, these preliminary results suggest the need for further thought on what sort of forest ownership should be encouraged. It could be that small-scale plantations established by 'local' people will be important in accustoming people to the changed landscapes.



## 6 Conclusions and Recommendations

This report was a scoping study of the socio-economic aspects of climate change in relation to a range of forest types. The aim was to provide a broad framework, including of forest types and policy responses, in the expectation that further research will be used to flesh out and develop the framework. We extrapolated from the main biophysical impacts to identify some of the potential socio-economic impacts and then went on to consider some policy and community responses.

### 6.1 Conclusions

An overarching theme that emerged from this research is that the socio-economic impacts of climate change on forests cannot and should not be considered in isolation. Nearly all the major impacts are likely to interact with and in some cases compound, other socio-economic phenomena. The first impact is that while Australia is a fire-prone country, climate change will increase the fire risk and with that comes increased damage costs, both monetary and psychological. There will also be increased control costs, both in monetary terms and in trade-offs such as the need to clear forest areas (for fire breaks) to protect whole forests. The fire risks are also influenced by other land use changes, such as the reforestation of former farming areas and the movement of people to forested lifestyle or transition regions. The increased fire risks will prompt further consideration of land use planning and vegetation management regulations in relation to rural residential areas and in plantation areas, especially if the CPRS leads to further expansion.

Second, there will be changes in growth rates, area and locations of plantations, which will lead to changes in regional economic output and even regional populations, with increases in some areas and decreases in others. Again, these changes will interact with the long-term depopulation of inland resource-based areas and the more recent efforts to switch from native forests to plantations and the relative profitability of different forms of land use. Further to this, policy responses that facilitate reforestation may contribute to the local tensions around landscape and regional economic change.

Third, climate change that contributes to the fragmentation of conservation forests will compound other effects, such as land use change around forests, land clearing and dieback. It might at first seem that climate change impacts that affect the existence, cultural and aesthetic values of forests, because of changes in composition, scale, landscape context and appearances are a discrete set of effects and this might be the case for some 'old growth' forests, but other areas, especially those subject to disturbances, have more obviously changed over time. It might be that slow change allows for people to develop notions of fixed landscapes and it is yet to be seen whether or not we can re-imagine those landscapes into the future.

Fourth, while the biophysical manifestations of climate change can reasonably be considered as a set of 'new' phenomena, at least they are new as policy problems, perhaps justifying institutional and policy instrument innovation, this is not obviously the case with the socio-economic impacts. These are relatively familiar problems, or perhaps manifestations of the core problem, and therefore it is

reasonable to first contemplate the use of familiar institutions and instruments, especially when there is as yet so little research on the extent and severity of these impacts and uncertainty about the efficacy of planned adaptations. This has the additional advantages of limiting the need for additional expenditure and of being less threatening to some communities than the appearance of an apparently major initiative.

Following that line of thinking, we identified some existing institutions that could be readily adapted to include consideration of climate change impacts, including the some form of inter-government coordination, regional NRM organisations and market-based stewardship programs. In regard to instruments, there has been some move towards the use of incentives and tenure management, rather than direct regulation and we see that at least in the early responses, these would be desirable policy instruments. This does not preclude the use of regulation, such as through land use planning and vegetation management rules and we presume that agencies managing public areas for conservation will remain critical to the management of larger conservation areas. There has been limited discussion of such agencies in this report, as their activities are considered to be within the scope of managing the direct biophysical impacts, discussed in WP2. Nonetheless, if one of the main high level strategies is to develop biolinks, which would have many co-benefits, then government agencies would be the key players in developing models of the preferred landscapes and, in some cases, filling in the biolink gaps, if necessary through direct acquisition and management of land.

Fifth, we consider that one of the potentially most influential policy responses would be incentives for forest-based sequestration. This would help maintain, if not increase the conservation and production forest estates which would in turn generate economic benefits, though the extent of the net benefit depends on what land use is displaced. While accelerated reforestation could have some negative social consequences, it is also an opportunity to encourage small-scale forestry within multi-function landscapes. This form of forestry could be considered as a long-term national investment in changing attitudes to plantations and in developing the skills of prospective growers.

Finally, we concluded, somewhat tentatively given the limited scope of the research that those involved in planned adaptations cannot take for granted the support of all communities, given that some people do not even accept that there are problems over and above the non-climate change factors outlined above. There was no obvious confidence in governments, timber companies and communities in terms of ability to manage change. Understanding and responding to community concerns will be an important aspect of adaptation.

## **6.2 Recommendations: Policy**

As extensively discussed, we recommend that early responses to the socio-economic impacts of climate change be addressed largely through the adaptation of existing institutions and policy instruments. In particular, we see NRM organisations and stewardship programs having potentially important early roles. This however, should be subject to monitoring socio-economic impacts. If these impacts are, or become more severe, then greater policy 'innovation' may be needed. Governments will have a direct role as incentives and voluntarism may have their limits if, for example, the aim is to

create forest extensions or corridors. As discussed, voluntary responses may leave gaps in the landscape as people hold out against land use change. Nonetheless, we recommend trying to achieve some change through market-based approaches but with additional efforts to create virtual commons, where peer pressure does some of the work. In an environment where there is resentment of existing government regulations, forced acquisitions will create a public relations problem. We also see a role for a coordinating body, such as ministerial councils, that can deal with cross-border coordination.

Second, despite the concerns about community responses to 'bureaucratic' initiatives, we see state agencies as crucial in undertaking or coordinating relevant research, providing advice on adaptation strategies, managing conservation areas and in designing and running stewardship programs that incorporate consideration of climate change.

Third, we consider that the creation of a market for forest-based sequestration, for example through an ETS, has the potential to offset a number of adverse socio-economic impacts, though we also noted that this could have its own secondary effects. Along with this, there needs to be careful consideration of the contract/resources security within any program, as forest managers, and prospective managers will be looking for long-term regulatory certainty. Some of the stewardship programs are now using long-term agreements and these might be needed to encourage responses that contribute to the development of the national estates.

Fourth, and overlapping with the three previous recommendations, we suggest that there be efforts to coordinate and emphasise any co-benefits resulting from policy responses. In this report we established that Australian forests, including production forests, contribute to multiple ecosystem services. There are a range of programs to purchase habitat, water quality and salinity control and these could be expanded and coordinated so that services can be bundled together. For example, if a CPRS or similar scheme was launched, governments and private donors could top up the sequestration payments to encourage the establishment of new forests as future reserves as other areas become less viable for particular species. As another example, an agency managing a stewardship program primarily aimed at conservation could undertake to additionally negotiate and validate sequestration outcomes. This would allow the agencies to bundle sequestration parcels together and reduce transaction costs.

Fifth, there are a number of reasons for considering renewing efforts to encourage small-scale forestry, including that;

- a) Such activities are more likely to be undertaken by people with social roots in the communities;
- b) The uncertainty over the financial viability of MISs, following some well-publicised financial collapses; and
- c) In lifestyle regions there will be former farm land that could be converted to plantations without reducing regional economic output and there will be people interested in small-scale forestry for the potential multiple benefits.

Again much depends on the additional incentives for sequestration being available. In addition, there could be problems with lifestyle landholders having limited production knowledge and unrealistic views of such an enterprise. Nonetheless, this warrants further consideration.

Sixth, there should be comprehensive impact assessments applied to future increases in the forest industry. Such an impact assessment should take into account the cumulative impact of any increase in forests in a region and its impact on demographic factors such as population, employment and services; the social impacts of such demographic changes; and whether such an increase in forest will have a cumulative impact on environmental factors such as bio-diversity and increased risks of fire.

Seventh, governments and industry bodies could support the adaptation of forest certification schemes to incorporate commitments that could ameliorate some of the effects of climate change on forests.

Finally, governments and industry bodies need to develop and agree means by which actions to address the impacts of climate change are prioritised. That is, should we give large conservation forests priority over the fire protection of lifestyle forests, for example? When we started this project, we hypothesised that decision-makers would be able to draw on the array of valuation methods discussed earlier and in the appendices, to make such decisions. At the end of this scoping project some reconsideration is warranted because of:

- The complexity in aggregating all values, particular where these are measured or estimated by different means;
- The likely high degree of variation in the value of different forests and forest patches, as demonstrated in chapter 3;
- The incremental nature of changes to the forests;
- The diffuseness of the socio-economic effects;
- The limited availability of base line valuations that could be used, although the RFA process provided a considerable amount of data that could be updated;
- The cost and resources required to do comprehensive assessments;
- Potential dissension in regard to the validity of some valuation methods, so that a lot of work could be undertaken and then be mired in methodological discussions.

There will be a trade-off between usability and specificity. One approach would be to use a 'benefits transfer' method (Bennett 2000), whereby the results of previous studies are taken from one region or situation to another similar area. Thus, decision-makers could select from the studies reviewed earlier and compile a set of values. The decision here is how far to stretch the similarities. In addition, as shown in the examples in Appendix 4 and in the earlier chapters, there is a wide range of values. Perhaps indicative values, for example forest types, could be developed and then used, at least until more research is undertaken.

As part of the RFA processes, Bennett (2000) proposed another approach to land use decision-making, namely threshold value analysis (TVA). TVA is used in situations where there is a trade-off, for example between production and conservation benefits. With TVA, the opportunity cost of ceasing timber production, for example, is estimated and then that value is presented to decision-makers who choose whether the conservation values are worth at least that much. A static TVA (Bennett 2000) is based on a snapshot of values, whereas a dynamic TVA includes changing values, for example it could be assumed that conservation value rises over time, especially if the quality of existing forests was in decline. This technique could assist adaptation decisions, where major investments, such as re-establishing habitats, buffers or corridors are considered. The threshold value of the conservation work is the cost of establishment plus the foregone cost of current land uses, which would usually be higher for cropping areas, than for extensive grazing for example. TVA has the advantage of working with the political process, whereby hopefully informed choices are presented to decision-makers

Finally, there is another decision-making framework that could be considered, especially in allocating resources, this being some form of multi-criteria assessment (MCA). RFAs are based to a certain extent on multi-criteria analysis, with ecological and economic values being considered against trade-offs. An MCA is a process based on values clarification, selection and weighting of attributes to be considered, the scoring of the attributes, the generation of options, a review of those options and a final decision. Imagining a forest adaptation scenario, decision-makers might be confronted by a choice of relocating species to a different but established habitat, establishing a new habitat for the future or purchasing areas adjacent to the existing and threatened site. Attributes considered could include cost, existence of other threatening processes, chances of success, community preferences and so on. These attributes are identified by experts and weighted for importance. Then they are scored, by either measurable values, such as for costs, or ranked by experts (chances of success) or representatives (community preferences). It is for this that MCAs are often criticised, for the comparison of 'apples and oranges'.

Hajkowicz (2006) strongly favours the use of MCAs but acknowledges that a single index, which is what an MCA can produce, does not explain general welfare (value) but he argues that specifically adapted indices are useful in making decisions. He further argues that the continuing interest in MCAs shows that relying solely on economic valuations is insufficient. MCAs are being used to make major allocations to natural resources management, from broadscale regional funding (Hajkowicz 2007) or in a less obvious way, as environmental benefits indices within conservation auction or tender schemes, such as the Victorian BushTender scheme. The Federal Government has run two MCA/tenders - the Tasmanian Forest Conservation Fund and the Environmental Stewardship Program. So, there are three levels at which MCA-type instruments might be applied in assisting adaptation decisions: allocating limited designated forest adaptation funds to forest types and regions where value losses might be highest; in deciding between adaptation options in specific situations; and in deciding on who to purchase forest protection and enhancement services from, more of which in the next section.

The other aspect of MCAs that is often promoted over just economic valuations, is their potential to be used in participative decision-making (Mabin et al. 2001; Stirling 2006). This is however, highly dependent on the process design. If experts select the attributes and the weights and participants are carefully selected, then real participation can be limited. The RFA process was an attempt to include non-economic value in considerations. There were a range of social analyses undertaken (Department of Primary Industries and Environment Social Assessment Unit 1998; Joint NSW/Commonwealth CRA/RFA Steering Committee 2000) but some argue that in the end, the focus on conservation versus production undermined consideration of other values (Hillier 2003; Lane 2003).

This is a complex but important matter and we suggest the need for expert advice on what might be appropriate.

### **6.3 Recommendations: Further research**

This report has identified a number of areas for which research is limited. We therefore provide some suggestions on future directions, including:

- The compilation of a baseline economic profile of Australia's forests, considering current uses, output and values to the extent that they can be estimated. The priority should be areas expected to be most affected by climate change, as discussed in this report.
- The use of baseline profiles to develop scenarios of possible economic and social changes, under climate change.
- Developing scenarios that can be used to show some of the potential effects of climate change on forests, preferably using visualisation techniques, following Sheppard (2005) and Ford *et al.* (2009). This will assist in determining people's responses to the visual changes in forests, whereas now these changes are diffuse and difficult to describe. This could particularly include the identification of likely tourist responses to these changes.
- Reviewing the current reserve system, considering the impacts of climate change, how the reserve system might be developed and the costs and social impacts of any such changes.
- Undertaking further economic and financial assessments of carbon sequestration scheme impacts, considering different prices, growth rates and alternative land uses.
- Undertaking risk assessments of changes in fire frequencies, particularly considering economic and social impacts and the implications for land use regulations and/or management strategies.
- Undertaking research into the attitudes of people living in fire-prone areas as to their intentions under climate change.
- Undertaking research into the attitudes of prospective forest managers under a regime of priced sequestration. This should particularly include potential small-scale growers.

- Undertaking further research into the design and optimal mix of regulation, incentives and virtual commons in managing dynamic landscapes.
- Reviewing the impact of current forestry and plantation industries on regional and rural communities to assess unforeseen negative social impacts and to examine opportunities to mitigate or correct imbalances which may have occurred. This will be necessary before further expectations in regard to adaptation are placed on communities.
- Governments investigating what level of new plantation forestry in a region would trigger requirements for impact assessment of future plantation forestry as a means of minimising social impact on rural communities.
- Examining legislation and regulations under which plantation industries operate to mitigate fire risk, ensure better pest management and ensure plantation operators do not transfer impacts of their operation onto the communities in which they operate.
- Government undertaking further research into understanding community perceptions of climate change as part of any education campaign supporting future adaptation strategies.
- Improving the prediction of net primary productivity (NPP)/biomass of possible plantation species in different parts of Australia for different years (say 2070, 2100 etc), in consideration of climate change impacts. This would help resource holders to estimate carbon rent value and make appropriate land use decision.
- Undertaking financial and economic assessments of the prospects for bio-fuels.
- Conducting a longitudinal study of socio-economic indicators to assess the reliability of using these to measure the impact of change impacts on local forestry communities.
- Examining the dependency of Indigenous people on non-wood-forest-products (NWFP). Research that identifies major NWFPs and analyses the impact of climate change on those species and explores the possible adaptive options is very important.

Health effects have not been considered in this report, they being part of another NCCARF project, but there are several studies that show that climate change could help to spread malaria, dengue fever and vector-borne disease in Australia. A recent study in Brazil found that there is a link between spread of malaria, dengue, and other vector-borne diseases and deforestation. They conclude that if forests are conserved, disease prevalence in local populations would be lower than what it would be if forests are cleared (Olander *et al.* 2009). Therefore, a study that verifies this issue in Australia, by overlaying the forest density map (closed forest, open forest and woodland forests) with a malaria, dengue, and other vector-borne diseases map, is crucial for understanding disease spread and management mechanisms.

# Appendix 1: Indicators for forest communities and industries

Schirmer *et al.* (Schirmer et al. 2008) developed indicators for monitoring the economics and some impacts of plantation forestry. Indicators were developed by identifying the types of information needed (by reviewing current literature, forest policies and media reports). The initial list of indicators identified were discussed at a workshop of forestry stakeholders, and then tested in two case study regions, and then refined again. This resulted in four broad sets of indicators, slightly adapted here.

Indicators which measure characteristics of the forest (timber) industry:

- Estimated value and volume of production;
- Direct employment in the forest/tourism industries;
- Efficiency of production, measured as labour productivity;
- Consumption of wood and paper products; and
- Proportion of land utilised by the forest industry. This would be especially important where people valued other forms of landscape, as noted in the previous section.

Impacts of the forest industry on its workforce:

- Income earned by forestry/tourism workers;
- Physical and mental health of forestry/tourism workers;
- Self-rated wellbeing of forestry/tourism workers;
- Age and gender of forestry/tourism workers;
- Forestry/tourism workers' attachment to place;
- Forestry/tourism workers' cultural and family attachment to forestry;
- Hours worked by forestry/tourism workers; and
- Education qualifications of forestry/tourism workers.

Impacts of the forest industry on the broader community:

- Dependence on the forest/tourist industries, measured as the proportion of the employed labour force working in the forest industry;
- Social characteristics of forestry-dependent communities. This could include lifestyle landscapes;
- Location of forest/tourism industry employment;
- Impact of plantation forestry (including conservation plantings) on rural population; and
- Values, uses and perceptions of forestry/tourist activities.

Impacts of the forest industry on Indigenous people:

- Quantity of Indigenous employment in the forest industry;
- Types of Indigenous employment in the forest industry; and



- Area of forest owned or accessed by Indigenous people.

These indicators can reveal the income flows, job opportunities and who holds forest assets and the structure of the local economy, which in turn can suggest the degree of economic vulnerability. It also reveals, through survey or focus groups, what local people think about the industries and forest uses. Hence, if there is some knowledge of the degree to which climate change would affect a particular area in terms of economic output, then the flow-on economic and social aspects can be assessed by way of climate change case study scenarios put to the stakeholders, as was done by the Sustainable Tourism CRC (2009). These scenarios could include production change assumptions and then flow-on effects could be estimated using the relevant multipliers.

## Appendix 2: Estimating carbon sequestration values

An area where monetary values can be estimated is for the regulatory process of carbon sequestration, provided the biomass can be estimated. A base case could be established through sampling and measuring trees or using imagery and spatial analysis. The 'loss' of biomass would be the difference between the base case and the projected area and growth rate of the relevant forest under climate change. Then a sequestration formula is applied to the biomass, such as those built into the FullCAM model within the National Carbon Accounting Toolbox (Richards and Evans 2005). Then, there are three ways to estimate a price. The first is to develop a long-run price trend, such as that used in the Australian Bureau of Agricultural and Resources Economics (2009) scenario discussed earlier, with a starting price and a set price increase. Alternatively, this same trend could be turned into an average price over a set period, following the method that was expected to be used in the CPRS (Australian Government 2008). Finally, the stock of stored carbon could be valued, which might be more applicable to old growth forests.

Carbon 'rental rates' are the value of holding 1 tonne of carbon in forests for 1 year (Sohngen et al. 2000; Sohngen 2008). Carbon rent allows forest carbon sequestration projects to be compared directly to the price of carbon abatement in the energy sector (Sohngen *et al.* 2000). Economic theory suggests that the price of carbon is equal to the marginal abatement cost for carbon, which is in turn equal to the present value of future marginal damage (Falk and Mendelsohn 1993). Given a set of current and future carbon prices, rental rates can be determined with present value techniques. If 1 tonne (t) of carbon (C) released from a tree into the atmosphere causes damage worth  $P^C t$  (i.e. the market price of C) and if we assume that the market price of C is constant, then the rental rate of storing carbon for one year ( $R^C t$  ( which can be calculated with the following formula (Sohngen 2008; Sohngen et al. 2000)).

$$\text{Carbon rent value } (R^C t) = (P^C t) \times (r) \dots \dots \dots (1)$$

where r is the interest rate as a fraction

By using this formula, we can estimate forest rent for different types of forests in various temporal and spatial scale, if we know forest biomass.

For example, if C prices are \$10 per tonne of CO<sub>2</sub> (\$36.7 per tonne of carbon) and the interest rate (discount rate) is 5% then the annual rent on 1 tonne of carbon stored for one year in forests is \$1.835. If a forest has 60 tonnes of carbon per ha then the annual rental value on the C is \$110/ha/yr. Then one can verify whether the rent of \$110/ha/yr is enough to change land from agriculture into forests.

## Appendix 3: Total Economic Value

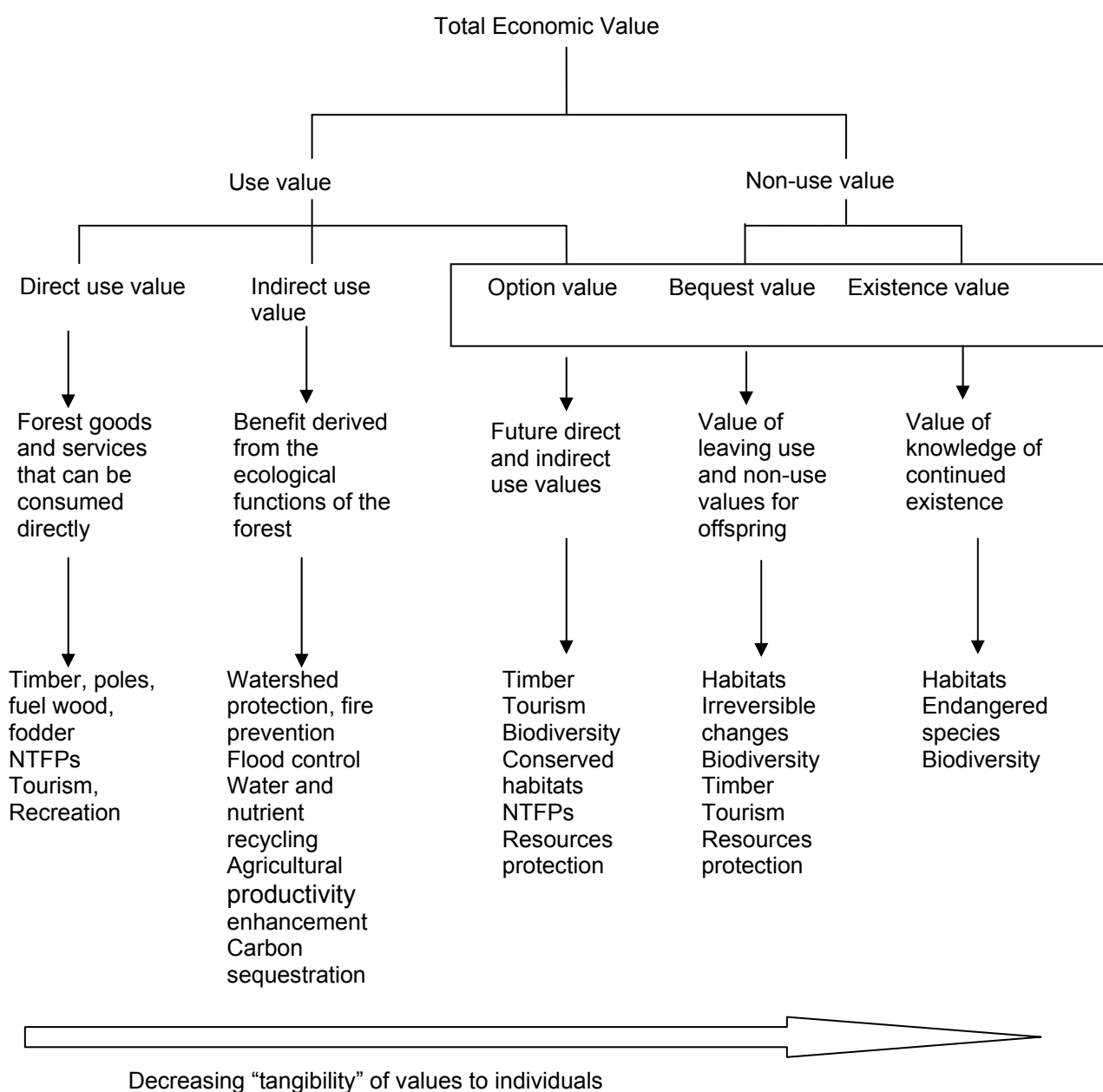
One means of identifying the range of forest benefits is to think in terms of total economic value (TEV). Valuation studies tend to concentrate on traded products (Kengen 1997) with estimates of indirect uses and non use values generally being at a more experimental phase (Pimental *et al.* 1997; Kramer *et al.* 2003). With the development of non-market valuation techniques and increasing acceptance of such valuation practices by policy-makers, the situation has changed considerably, especially during the last decade. The literature on assigning value to ecosystem services on the basis of TEV is extensive (Adger *et al.* 1995; Pimental *et al.* 1997; Tyrvaainen 1997; Mahapatra and Tewari 2005). The TEV framework orders the ecosystem services discussed earlier, into broad categories, as shown in Figure 9. The construction of this conceptual framework is slightly different to that used in the previous chapter and the reason is that the services are ordered according to the degree of tangibility to humans, which is then reflected in the methods of valuation.

On the left of the diagram are the use values which include direct, indirect and option values<sup>6</sup> (Freeman 2003). Direct use values are those values directly related to the use of forest goods or services such as timber, fuel wood, non-timber forest products (NTFPs) (medicine, food etc), recreation and tourism. These are often traded or market goods, though they can also be for direct consumption or enjoyed without direct payment, such as public parks. Indirect uses include carbon sequestration and resources protection through storing ground water, preventing soil erosion and reducing the impact of natural hazards (Anderson 1990; Adger *et al.* 1995; Mahapatra and Mitchell 1997; Dore and Guevara 2000; Tewari 2000; Hunt 2009). Option values are estimates of future use values.

As noted in the text, existence values reflect the benefits from simply knowing that a certain good or service exists (Bengston 1994). For example, those who are concerned with future damage to forests and landscapes from global warming might be willing to pay to reduce them, either directly or through taxes. Bequest values, the other non-use component, refer to benefits from ensuring that certain goods and services will be preserved for future generations (Adger *et al.* 1995), which goes to intergenerational equity. Both existence and bequest values can to some extent capture the spiritual values and the intrinsic value, where ideas such as those from deep ecology (Naess 1973) have had a more general influence.

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<sup>6</sup> Option values can be placed under both use and non-use values. They includes future direct and indirect use values.



**Figure 10:** Components of total economic value. *Source:* Adapted from Munasinghe and Lutz (1995).

The important point, especially for Australian forests with such a low proportion by area providing direct uses, is that ignoring the intangibles can lead to under-valuation (Adger et al. 1995; Bjornstad and Skonhott 2002) and inappropriate social decisions about forest conservation and protection (see for example Tisdell and Wilson 2004 on wildlife conservation). In the case of climate change impacts, changes in the composition and ecosystem health of forest systems, where there is no market or multiplier benefits, could be overlooked and in particular this might underestimate the opportunity costs of replacing forests with other forms of land use (see earlier discussion on competing land uses under climate change).

## Appendix 4: Selected Valuations of Conservation Forests

Study	Location	Scope	Method	Values
(Lockwood et al. 1993)	East Gippsland national estate forests	Willingness to reserve unprotected areas	Contingent Valuation (CV)	\$52/household (\$A4.1 million total)
(Bennett and Carter 1993)	Australian national estate	Conservation benefits	CV	\$A43.50/household/year
(Loomis et al. 1993)	Selected old growth forests	Protection	CV	\$A39-103/household
(van Bueren and Bennett 2000 cited in Venn 2005)	Australian native forests	All benefits except salinity control and sequestration		\$50 per ha per year
(estimated from Stoneham et al. 2003)	Gippsland	Native vegetation	BushTender prices	\$42/ha/yr
(Flatley and Bennett 1996),	Vanuatu forests	Preservation of forests	Choice Modelling with Australian tourists	\$A403,000/yr
(Cartwright 1985)	Tropical forests	Biodiversity	Opportunity cost (avoided deforestation)	\$US20/ha/yr
(Kramer and Mercer 1997)	Tropical forests (US households surveyed)	Protection of forests	CV	US\$21-31 per household for an additional 5 percent of forest cover
(Echeverria et al. 1995)	Costa Rica	Existence value	CV	\$US238/ha
(Loomis and Gonzalez-Cabon 1998)	Old growth forests: California; Oregon	Reduce catastrophic fires	CV	\$56/household for 2500 acres
(Raunikaar and Buongiorno 2006)	South central US forests	Non-timber values	CV	Willing to forego 60% of timber income

**Table 10:** Selected valuations of conservation forests.

In addition, Blamey *et al.* (2002) undertook a choice modelling study to provide estimates of the benefits of retaining remnant vegetation in the Desert Uplands region of Central Queensland. They used a series of trade-offs to illustrate relative value. According to the study, the estimated benefits that are reported for several tree clearing policy regimes are more stringent than those currently applied.

## References

- AACM International (1996). Farm forestry in the Murray Darling Basin: Farm forestry assessment report upper Condamine Catchment. Adelaide, Murray Darling Basin Commission.
- Aber, J., Neilson, R. P., et al. (2001). Forest Processes and Global Environmental Change: Predicting the Effects of Individual and Multiple Stressors. *BioScience* 51: 735-751.
- Action Salinity and Water Australia (2002). Investigating new approaches. Canberra, Action Salinity and Water Australia.
- Adger, W. N., Brown, K., et al. (1995). Total Economic Value of Forests in Mexico. *Ambio* 24: 286-296.
- Alavalapati, J., Shrestha, R., et al. (2004). Agroforestry development: An environmental economic perspective. *Agroforestry Systems* 61: 299-310.
- Alcamo, J., Kreileman, G.J.J., et al. (1997). Baseline Scenarios of Global Environmental Change. *Global Environmental Change* 6(4): 261-303
- Alig, R., Adams, D., et al. (2002). Projecting Impacts of Global Climate Change on the U.S. Forest and Agriculture Sectors and Carbon Budgets. *Forest Ecology and Management* 169: 3-14.
- Allison, I., Bindoff, N. L., et al. (2009) The Copenhagen Diagnosis, 2009: Updating the world on the Latest Climate Science. The University of New South Wales Climate Change Research Centre (CCRC), Sydney, Australia.
- Altman, J.C. and Jordan, K. (2008). Impact of Climate Change on Indigenous Australians: Submission to the Garnaut Climate Change Review, Centre for Aboriginal Economic Policy Research, Australian National University.
- Anderson, A. B. (1990). Alternatives to Deforestation: Steps Toward Sustainable Use of the Amazon Rainforest. New York, Columbia University Press.
- Anderson, A., May, P., et al. (1991). The Subsidy from Nature: Palm Forests, Peasantry, and Development on an Amazon Frontier. New York, Columbia University Press.
- Anderson, T. and Leal, D. (1999). Visions of the environment and rethinking the way we think. *Debating the Earth: The Environmental Politics Reader*. J. Dryzek and D. Schlosberg. New York, Oxford University Press: 207-230.
- Australian Government (2008). Carbon Pollution Reduction Scheme: White Paper Volume 1. Carbon Pollution Reduction Scheme: White Paper. Canberra, Commonwealth of Australia.
- Australian Bureau of Agricultural and Resources Economics (2007). Australian Commodities. Canberra, Commonwealth of Australia.

- Australian Bureau of Agricultural and Resources Economics (2009). Australian Forests and Wood Products Statistics. Australia.
- Australian Forestry Standard Ltd (2007). Forest management-Economic, social, environmental and cultural requirements for wood production. Canberra, Australian Forestry Standard Ltd.
- Barr, N. (2008). The social landscapes of rural Victoria. Landscape analysis and visualisation. C. Pettit, W. Cartwright, I. Bishop et al. Berlin, Springer.
- Barr, N., Karunaratne, K., et al. (2005). Australia's farmers: past, present and future. Canberra, Land & Water Australia.
- Bastin, G. and ACRIS Management Committee (2008). Rangelands 2008 - Taking the Pulse. National Land and Water Resources audit on behalf of the ACRIS Management Committee, Canberra.
- Battaglia, M., Bruce, J., et al. (2009). Climate Change and Australia's Plantation Estate: Analysis of Vulnerability and Preliminary Investigation of Adaptation Options, Report Prepared for Forest and Wood Products Australia, Forest and Wood Products Australia.
- Bayliss, B., Brennan, K., et al. (1997). Vulnerability Assessment of Predicted Climate Change and Sea Level Rise in the Alligator Rivers Region, Northern Territory Australia. Supervising Scientist Report. Canberra, Supervising Scientist Division.
- Bellamy, S. (2009). Discussion Paper: Trees, Agriculture and Emissions Trading. Perth, Department of Agriculture and Food, Government of Western Australia.
- Bengston, D. N. (1994). Changing Forest Values and Ecosystem Management. *Society and Natural Resources* 7: 515-533.
- Bennett, J. and Carter, M. (1993). Prospects for Contingent Valuation: Lessons from the South-East Forests. *Australian Journal of Agricultural Economics* 37(2): 79-93.
- Bennett, J. (2000). Threshold Value Analysis of Non-Use Values: Southern Region
- NSW Comprehensive Regional Assessments, Sydney, NSW Government and Commonwealth Government.
- Binning, C., Baker, B., et al. (2002). Making farm forestry pay - Markets for ecosystem services. Canberra, Rural Industries Research and Development Corporation.
- Bjornstad, E. and Skonhott, A. (2002). Wood Fuel or Carbon Sink? Aspects of Forestry in the Climate Question. *Environmental and Resource Economics* 23(4): 447-465.
- Blamey, R., Rolfe, J., et al. (2002). Valuing Remnant Vegetation in Central Queensland Using Choice Modelling. *Australian Journal of Agricultural and Resource Economics* 44(3): 439-456.
- Boisvenue, C., Even, S. T., et al. (2006). Impacts of Climate Change on Natural Forest Productivity - Evidence Since the Middle of the 20th Century. *Global Change Biology* 12(5): 862-882.

- Booth, T.H. and Jovanovic, T. (2005). Tree Species Selection and Climate Change in Australia. Commonwealth Scientific and Industrial Research Organisation Forestry and Forest Products Client Report No. 1569 for the Australian Greenhouse Office, Australian Greenhouse Office: 149.
- Borsboom, A., Wang, J., et al. (2002). Measurement and integration of fauna biodiversity values in Queensland agroforestry systems. Canberra, Rural Industries Research and Development Corporation.
- Boulter, S., Kitching, R. and Stadler, F., (2011). An assessment of the vulnerability of Australian Forests to the impacts of climate change. Gold Coast, Australia, National Climate Change Adaptation Research Facility.
- Bradshaw, C., Sohdi, N., et al. (2007). Global evidence that deforestation amplifies flood risk and severity in the developing world *Global Change Biology* 13(11): 2379 - 2395.
- Bradstock, R., Davies, I., et al. (2008). Effects of Climate Change on Bushfire Threats to Biodiversity, Ecosystem Processes and People in the Sydney Region. Final Report to the New South Wales Department of Environment and Climate Change, Centre for Environmental Risk Management of Bushfires, University of Wollongong & The Fenner School of Environment and Society, The Australian National University.
- Broadhurst, L. (2007). Managing Genetic Diversity in Remnant Vegetation. Canberra, Australian Government: Land & Water Australia. Commonwealth Scientific and Industrial Research Organisation.
- Buffier, B. and The Allen Consulting Group (2002). Environmental and commercial outcomes through agroforestry. Canberra, Rural Industries Research and Development Corporation.
- Bureau of Rural Science (2005). Socioeconomic Impacts of Plantation Forestry in the Great Southern Region (WA), Forests and Wood Products Research and Development Corporation, Bureau of Rural Science, Australian Government.
- Bureau of Rural Sciences (2008). 2008 Country Matters - Social Atlas of Rural and Regional Australia. Canberra, Bureau of Rural Sciences.
- Burns, K., Vedi, J., et al. (2009). Opportunities for forestry under the Carbon Pollution Reduction Scheme (CPRS): an examination of some key factors. Canberra, Australian Bureau of Agricultural and Resources Economics.
- Burrows, W. H. (1990) Prospects for increased production in the north-east Australian beef industry through pasture development and management. *Agricultural Science*, 3, 19-24.
- Burton, D., McCarl, B., et al. (1998). Economic Dimensions of Climate Change Impacts on Southern Forests. The Productivity and Sustainability of Southern Forest Ecosystems in a Changing Environment. New York, Springer.



- Capill, L. (2000). *Farm Forestry Success in New Zealand. Sustainable Small-scale Forestry: Socio-economic Analysis and Policy*. S. Harrison, J. Herbohn and K. Herbohn. Cheltenham, Edward Elgar: 123-137.
- Carberry, P., Meinke, H., et al. (2002). Modelling crop growth and yield under the environmental changes induced by windbreaks: Simulation of potential benefits at selected sites in Australia. *Australian Journal of Experimental Agriculture*(42): 887-900.
- Carter, T.R., Jones, R.N., et al., (2007). *New Assessment Methods and the Characterisation of Future Conditions. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E., Eds., Cambridge University Press, Cambridge, UK, 133-171.
- Cartwright, J. (1985). The Politics of Preserving Natural Areas in Third World States. *The Environmentalist* 5(3): 179-186.
- Cashore, B. and Howlett M. (2007). Punctuating which equilibrium? Understanding Thermostatic Policy Dynamics in the Pacific Northwest Forestry. *American Journal of Political Science* 51(3): 532-551.
- Cayan, D. R., Luers, A.L., et al. (2008). Overview of the California Climate Change Scenarios Project. *Climatic Change* 87(1): S1-S6.
- Centre for International Economics (1997). A plan to achieve the plantations 2020 Vision. Retrieved September 23, 2002, from <http://www.plantations2020.com.au/>.
- Chopra, K. (1993). The Value of Non-Timber Forest Products: An Estimation for Tropical Deciduous Forests in India. *Economics Botany* 47(3).
- Climate Action Network Australia (2006). *Social Impacts of Climate Change: Indigenous Communities*, Climate Action Network Australia.
- Cockfield, G. (2005). *Evaluating a markets-based incentive scheme for farm forestry*. Brisbane, University of Queensland.
- Cockfield, G. and Botterill, L. (2006). Rural Adjustment Schemes: Juggling politics, welfare and markets. *Australian Journal of Public Administration* 65(2): 70-82.
- Commonwealth of Australia (1992). *National forest policy statement: A new focus for Australia's forests*. Canberra, Commonwealth of Australia.
- Cooperative Research Centre: Sustainable Tourism (2009). *The Impacts of Climate Change on Australian Tourism Destinations: Developing Adaptation and Response Strategies - A Scoping Study*. Cairns, Cooperative Research Centre: Sustainable Tourism.

- Cramer, W., Bondeau, A., et al. (2004). Tropical Forests and the Global Carbon Cycle: Impacts of Atmospheric Carbon Dioxide, Climate Change and Rate of Deforestation. *Philosophical Transactions* 359(1443): 331-343.
- Cresswell, I. and Thomas, G. (1997). *Terrestrial and Marine Protected Areas in Australia*. Canberra, Environment Australia, Biodiversity Group.
- CSIRO (2007). Overview of project methods: A report to the Australian Government from the CSIRO Murray-Darling Sustainable Yields project.
- CSIRO and Bureau of Meteorology (2007). *Climate Change in Australia - Technical Report*. CSIRO, p. 140.
- Dale, V. H., Joyce, L. A., et al. (2001). Climate Change and Forest Disturbances. *BioScience* 51: 723-734.
- Daniels, J. (2004). *Assessing socio-economic resiliency in Washington Counties*. General Technical Report Portland, USDA Forest Service.
- Davidson, W., Cotter, P., et al. (1991). Social predispositions for the development of sense of community. *Psychological Reports* 68: 817-818.
- Department of Agriculture Fisheries and Forestry (2008). *The Changing Face of Australia's Forests: A Summary of Major Changes in Australia's Forests Since 1992*, Department of Agriculture, Fisheries and Forestry, Australian Government.
- Department of Climate Change (2009a). *Discussion Paper: Design Issues Relating to Reforestation. Carbon Pollution Reduction Scheme Stakeholder Consultation* Canberra, Australian Government: Department of Climate Change.
- Department of Climate Change (2009b). *Overview of National Carbon Accounting Toolbox and Reforestation Reporting Requirements. Carbon Pollution Reduction Scheme Stakeholder Consultation*. Canberra, Australian Government: Department of Climate Change.
- Department of Climate Change (2010). *Reducing Australia's Emissions*, Australian Government: Department of Climate Change.
- Department of Environment and Heritage (2006). *Impacts of Climate on Carbon Fluxes in Australian Forests. A component of the Greenhouse Action in Regional Australia R&D Plan*. Canberra: 17.
- Department of Primary Industries and Environment Social Assessment Unit (1998). *Social Values of Forests Eden CRA Region. A report undertaken for the NSW CRA/RFA Steering Committee*. Sydney, NSW/Commonwealth CRA/RFA Steering Committee.
- Department of the Environment, Water Heritage and the Arts (2009). *Protected area information*, Department of the Environment, Water, Heritage and the Arts.

- Department of the Environment, Water Heritage and the Arts (2009). National Vegetation Information System, Major Vegetation Groups, <http://www.environment.gov.au/erin/nvis/index.html>, accessed December 13, 2009.
- Donohue, R.J., McVicar, T.R. and Roderick M.L. (2010). Assessing the ability of potential evaporation formulations to capture the dynamics in evaporative demand within a changing climate. *Journal of Hydrology*, doi: 10.1016/j.jhydrol.2010.03.020.
- Dore, M. H. and Guevara, R., Eds. (2000). *Sustainable Forest Management and Global Climate Change - Selected Case Studies from the Americas*. Cheltenham, Edward Elgar.
- Dunlop, M. and Brown, P. R. (2008). Implications of climate change for Australia's National Reserve System: A preliminary assessment, CSIRO Sustainable Ecosystems Report. A report to the Department of Climate Change and the Department of the Environment, Water, Heritage and the Arts, Commonwealth Scientific and Industrial Research Organisation.
- Eastaugh, C. (2008). *Adaptations of Forests to Climate Change: A Multidisciplinary Review*. IUFRO Occasional Papers. Vienna, IUFRO Secretariat.
- Echeverria, J., Hanrahan, M., et al. (1995). Valuation of Non-priced Amenities Provided by the Biological Resources within the Monteverde Cloud Forest Preserve, Costa Rica. *Ecological Economics* 13: 43-52.
- Eiser, D. and Roberts, D. (2002). The Employment and Output Effects of Changing Patterns of Afforestation in Scotland. *Journal of Agricultural Economics* 53(1): 65-81.
- Emtage, N., Herbohn, J. et al. (2007). Landholder Profiling and Typologies for Natural Resource–Management Policy and Program Support: Potential and Constraints. *Environmental Management* 40(3): 481-492.
- Environment Australia (2000). Revision of the interim biogeographic regionalisation of Australia (IBRA) and the development of version 5.1. - summary report. Environment Australia, Canberra.
- Falk, I. and Mendelsohn, R. (1993). The Economics of Controlling Stock Pollutants: An Efficient Strategy for Greenhouse Gases. *Journal of Environmental Economics and Management* 25: 76-88.
- Fischlin, A., Midgley, G. F., et al. (2007). Ecosystems, Their Properties, Goods, and Services. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C.E. Cambridge, Cambridge University Press: 211-272.
- Flannigan, M. D., Bergeron, Y., et al. (1998). Future Wildfire in Circumboreal Forests in Relation to Global Warming. *Journal of Vegetation Science* 9: 469-476.

- Flannigan, M. D., Stocks, B. J., et al. (2000). Climate Change and Forest Fires. *The Science of the Total Environment* 262(3): 21-229.
- Flatley, G. W. and Bennett, J. W. (1996). Using Contingent Valuation to Determine Australian Tourist's Values for Forest Conservation in Vanuatu. *Economic Analysis and Policy* 26(2): 111-128.
- Folke, C. F., Hahn, T., et al. (2005). Adaptive Governance of Social-Ecological Systems. *Annual Review of Environmental Resources* 30: 441-473.
- Food and Agriculture Organisation (2005). Drowning in fiction or thriving on facts? Bangkok, Center for International Forestry Research and Food and Agriculture Organisation.
- Ford, R. M., Williams, K. J., et al. (2009). A Value Basis for the Social Acceptability of Clearfelling in Tasmania, Australia. *Landscape and Urban Planning* 90(3-4): 196-206.
- Freeman, A. M. (2003). *The Measurement of Environment and Resource Values: Theory and Methods*. Washington, DC, Resources for the Future.
- Gavran, M. and Parsons, M. (2010) Australia's Plantations 2010 Inventory Update. National Forest Inventory, Bureau of Rural Sciences, Canberra.
- Gifford, R. M. and Howden, M. (2001). Vegetation Thickening in an Ecological Perspective: Significance to National Greenhouse Gas Inventories. *Environmental Science & Policy* 4: 59-72.
- Gillespie Economics (1997). *Economic Value of Recreation and Tourism in Forests of the Eden RFA*. Sydney, NSW National Parks and Wildlife Service.
- Glaser, B. G. and Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York, Aldine.
- Godoy, R., Lubowski, R., et al. (1993). A Method for the Economic Valuation of Non-Timber Tropical Forest Products. *Economic Botany* 47(3): 220-233.
- Gunasekera, D., Tulloh, C., et al. (2008). *Climate Change: Opportunities and Challenges in Australian Agriculture*. Canberra, Australian Bureau of Agricultural and Resource Economics.
- Hajkowicz, S. (2006). Multi-attributed environmental index construction. *Ecological Economics* 57: 122-139.
- Hajkowicz, S. (2007). Allocating scarce financial resources across regions for environmental management in Queensland, Australia. *Ecological Economics* 61: 208-216.
- Harrison, S., Eono, J., et al. (1996). Attitudes to tree planting and assistance schemes by Queensland landholders. *Managing and Growing Trees Training Conference*, Department of Natural Resources.

- Haslem, A. and Bennett, A. (2008). Countryside elements and the conservation of birds in agricultural environments. *Agriculture, ecosystems and Environment* 125: 191-2003.
- Hassall and Associates (1999). *Greenhouse, carbon trading and land management*. Canberra, Land and Water Resources Research and Development Corporation.
- Heaney, A., Beare, S., et al. (2000). Targeting reforestation for salinity management. *Australian Commodities* 7(3): 511-518.
- Herbohn, J., Emtage, N., et al. (2005). Attitudes of landholders to farm forestry in tropical eastern Australia. *Australian Forestry* 68(1): 50-58.
- Hilbert, D. W., Ostendorf, B., et al. (2001). Sensitivity of Tropical Forests to Climate Change in the Humid Tropics of North Queensland. *Austral Ecology* 26: 590-603.
- Hillier, J. (2003). Fighting over the forests: Environmental Conflict and Decision-making Capacity in Forest Planning Processes. *Australian Geographical Studies* 41(3): 251-269.
- Hobbs, R., Floyd, R., et al. (2003). *Hardwood Plantations: Quantifying Conservation and Environmental Services Benefits*. Canberra, Rural Industries Research and Development Corporation.
- Hobbs, R.J. and McIntyre, S. (2005). Categorizing Australian landscapes as an aid to assessing the generality of landscape management guidelines. *Global Ecology and Biogeography*. 14:1-15.
- Howard, A. F., Rice, R. E., et al. (1996). Simulated Financial Returns and Selected Environmental Impacts from Four Alternative Silvicultural Prescriptions Applied in the Neotropics: A Case Study of the Chimanes Forest, Bolivia. *Forest Ecology and Management* 89: 43-57.
- Hughes, L. (2003). Climate Change and Australia: Trends, Projections and Impacts. *Austral Ecology* 28: 423-443.
- Hugo, G. (2008). *Future Urban Population and Settlement Transitions. Transitions: Pathways Towards Sustainable Urban Development in Australia*. P. Newton. Canberra, CSIRO.
- Hui, X., Yi, Q., et al. (2007). Assessment of Indirect Use Values of Forest Biodiversity in Yaoluoping National Nature Reserve, Anhui Province. *Chinese Geographical Science* 13(3): 277-283.
- Hunt, C. A. G. (2009). *Carbon Sinks and Climate Change - Forests in the Fight Against Global Warming*. Cheltenham, Edward Elgar.
- IPCC (2007a). Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Eds. S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Cambridge, United Kingdom and New York, NY, USA, p. 996.
- IPCC (2007b) Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Eds. M.L. Parry, O.F. Canziani, J.P. Palutikof,

- P.J. van der Linden and C.E. Hanson. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Irland, L., Adams, D., et al. (2001). Assessing Socioeconomic Impacts of Climate Change on U.S. Forest, Wood-Product Markets, and Forest Recreation. *BioScience* 51(9): 753-764.
- Island Press (2007). *Millenium Ecosystem Assessment: A toolkit for Understanding and Action*. Washington, Island Press.
- Iverson, L. R. and Prasad, A. M. (2001). Potential Changes in Tree Species Richness and Forest Community Types Following Climate Change. *Ecosystems* 4(3): 186-199.
- Joint ANZECC / MCFFA National Forest Policy Statement Implementation Sub-committee (1997). *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia*. Canberra, Australian and New Zealand Environment and Conservation Council and Ministerial Council on Forestry, Fisheries and Aquaculture.
- Joint NSW/Commonwealth CRA/RFA Steering Committee (2000). *Social Assessment Report Southern Region NSW. A project undertaken as part of the NSW Comprehensive Regional Assessments*. Sydney, Commonwealth of Australia.
- Kallio, A. M. I. (2010). Accounting for Uncertainty in a Forest Sector Model Using Monte Carlo Simulation. *Forest Policy and Economics* 12(1): 9-16.
- Kengen, S. (1997). *Forest Valuation for Decision-Making: Lessons of Experience and Proposals for Improvement*. Rome, Food and Agriculture Organisation of the United Nations.
- Knowler, D. and Canby, K. (1998). *Forest Management in Nepal: Economics and Ecology*. Draft Working Paper No. 2. Washington, DC, World Bank.
- Kramer, R. A. and Mercer, D. E. (1997). Valuing a Global Environmental Good: U.S. Residents' Willingness to Pay to Protect Tropical Rain Forests. *Land Economics* 73(2): 196-210.
- Lane, M. (2003). Decentralization or privatization of environmental governance? Forest conflict and bioregional assessment in Australia. *Journal of Rural Studies* 19: 283-294.
- Lawson, K., Burns, K., et al. (2008). *Analysing the economic potential of forestry for carbon sequestration under alternative carbon price paths*. Canberra, Australian Bureau of Agricultural and Resources Economics.
- Lehtonen, E., Kuuluvainen, J., et al. (2003). Non-Market Benefits of Forest Conservation in Southern Finland. *Environmental Science & Policy* 6(3): 195-204.
- Leppanen, J., Linden, M., et al. (2005). The Private Cost and Timber Market Implications of Increasing Strict Forest Conservation in Finland. *Forest Policy and Economics* 7(1): 71-83.
- Lincoln, Y. S. and Guba, E. G. (1985). *Naturalistic Inquiry*. Beverly Hills, CA, Sage Publications, Inc.

- Lindenmayer, D. and R. Dobbs (2004). Fauna Conservation in Australian plantation forests - a review. *Biological Conservation* 119: 151-168.
- Lockwood, M., Loomis, J., et al. (1993). A Contingent Valuation Survey and Benefit-Cost Analysis of Forest Preservation in East Gippsland. *Journal of Environmental Management* 38: 233-243.
- Loomis, J. B. and Gonzalez-Cabon, A. (1998). A Willingness to Pay Function for Protecting Acres of Spotted Owl Habitat from Fire. *Ecological Economics* 25: 315-322.
- Loomis, J., Lockwood, M., et al. (1993). Some Empirical Evidence on Embedding Effects in Contingent Valuation of Forest Protection. *Journal of Environmental Economics and Management* 24(1): 45-55.
- Loyn, R., McNab, E., et al. (2007). Eucalypt plantations as habitat for birds on previously cleared farmland in south-eastern Australia. *Biological Conservation* 137: 533-548.
- Lucas, C., Hennessy, K., et al. (2007). Bushfire Weather in Southeast Australia: Recent Trends and Projected Climate Change Impacts. Consultancy report prepared for The Climate Institute of Australia, by the Bushfire Cooperative Research Centre and the Commonwealth Scientific and Industrial Research Organisation, Commonwealth Scientific and Industrial Research Organisation. Bushfire Cooperative Research Centre for Forestry.
- Mabin, V., Menzies, M., et al. (2001). Public sector priority setting using decision support tools. *Australian Journal of Public Administration* 60(2): 44-59.
- Mahapatra, A. K. and Mitchell, C. P. (1997). Sustainable Development of Non-Timber Forest Products: Implication for Forest Management in India. *Forest Ecology and Management* 94(1-3): 15-29.
- Mahapatra, A. K. and Tewari, D. D. (2005). Importance of Non-Timber Forest Products in the Economic Valuation of Dry Deciduous Forests of India. *Forest Policy and Economics* 7: 455-467.
- Maille, P. and Mendelsohn, R. (1993). Valuing Ecotourism in Madagascar. *Journal of Environmental Management* 38: 213-218.
- Mallawaarachchi, T., Blamey, R., et al. (2001). Community Values for Environmental Protection in a Cane Farming Catchment in Northern Australia: A Choice Modelling Study. *Journal of Environmental Management* 62(3): 301-316.
- Mallick, R. M. (2000). Sustainable Management of Non-Timber Forest Products in Orissa: Some Issues and Options. *Indian Journal of Agricultural Economics* 55(3): 385-396.
- Maron, M. and Fitzsimons, J., (2007). Agricultural intensification and loss of matrix habitat over 23 years in the West Wimmera, south-eastern Australia. *Biological Conservation* 135(4): 587-593.

- McDonald, J. (1999). Regional Forest (Dis)Agreements: The RFA Process and Sustainable Forest Management. *Bond Law Review* 11(2).
- McGuffog, I. and Western, J. (1993). Social impact assessment of the cessation of logging on Fraser Island: an evaluation of the workers special adjustment package. Brisbane, University of Queensland.
- McNulty, S. G. and Abe, J. D. (2001). United States National Climate Change Assessment on Forest Ecosystems: An Introduction. *BioScience* 51: 720-722.
- McVicar, T.R., Van Niel, T.G., et al., (2008). Wind speed climatology and trends for Australia 1975-2006: capturing the stilling phenomenon and comparisons with near-surface reanalysis output. *Geophysical Research Letters* 35: L20403.
- Medlyn, B. E., Zeppel, M., et al., (2011). Biophysical impacts of climate change on Australia's forests. Contribution of Work Package 2 to the Forest Vulnerability Assessment, Gold Coast, Australia, National Climate Change Adaptation Research Facility.
- Milne, M., Stenekes, N., et al. (2008). Climate Risk and Industry Adaptation. Report Prepared for the Rural and Policy Innovation Division of the Department of Agriculture, Fisheries and Forestry. Canberra, Department of Agriculture, Fisheries and Forestry.
- Montreal Process Implementation Group for Australia (2008). Australia's State of the Forests Report 2008. Canberra, Bureau of Rural Sciences.
- Munasinghe, M. and Lutz., E. (1995). Environmental Economics and Valuation in Development Decision-making. In: *Environmental Economics and Natural Resource Management in Developing Countries*. Munasinghe, M. (Eds.) pp. 17–45. Washington DC.: World Bank.
- Munday, M. and Roberts, A. (2001). The role of the forestry industry transactions in the rural economy. *Journal of Rural Studies* 17: 333-346.
- Naess, A. (1973). The Shallow and the Deep, Long Range Ecology Movement: A Summary. *Inquiry* 16: 95-100.
- National Economics and Australian Local Government Association (2008). State of the Regions 2007-08. Canberra, Australian Local Government Association.
- National Farm Forestry Roundtable (2000). National Strategy for Low Rainfall Farm Forestry in Australia, Report to Commonwealth Minister for Primary Industries and Energy. Canberra, Commonwealth Government.
- National Forest Inventory (1997). National Plantation Inventory of Australia/National Forest Inventory. Canberra, Bureau of Resource Sciences.
- New South Wales Comprehensive Regional Assessments/Regional Forest Agreements Steering Committee (1997). Economic Value of Recreation and Tourism in the Forests of the Eden



- RFA. Prepared for New South Wales National Parks and Wildlife Service by Gillespie Economics, New South Wales National Parks and Wildlife Service and Gillespie Economics.
- NSW Department of Industry and Investment (2010, February 2010). Summary of gross margins for NSW beef enterprises. Farm Enterprise Budget Series. Retrieved April 4, 2010.
- O'Connell, D., Braid, A., et al. (2009). Sustainable Production of Bioenergy: A review of global bioenergy sustainability frameworks and assessment systems. Canberra, Rural Industries Research and Development Corporation.
- Olander, L., Boyd, W., et al., (2009) International Forest Carbon and the Climate Change Challenge: Issues and Options, Nicholas Institute for Environmental Policy Solutions, Duke University, Report no. NI R 09-04, June.
- Ostrom, E., Walker, J., et al. (1992). Covenants With or Without Sword: Self-Governance is Possible. *The American Political Science Review* 86(2): 404-417.
- Pagiola, S. (2002). Paying for Water Services in Central America. Selling Forest Environmental Services: Market-based Mechanisms for Conservation and Development. S. Pagiola, J. Bishop and N. Landell Mills. London, Earthscan: 37-59.
- Pagiola, S., Agostini, P., et al. (2004). Paying for Biodiversity Conservation Services in Agricultural Landscapes. Washington, The World Bank Environment Department.
- Parkins, J. and MacKendrick, N. (2007). Assessing community vulnerability: A study of the mountain pine beetle outbreak in British Columbia, Canada. *Global Environmental Change* 17: 460-471.
- Parson, E.A., Corell, R.W., et al. (2003). Understanding Climate Impacts, Vulnerabilities, and Adaptation in the United States: Building a Capacity for Assessment. *Climatic Change* 57(1-2): 9-42.
- Pearce, D.W. and Pearce, C. G. (2001). The Value of Forest Ecosystems. Report to the Secretariat of the United Nations Convention on Biological Diversity. Montreal.
- Peng, B. and Parton, K. A. (2008). Effect of Climate Change on Australian Rural and Remote Regions: What Do We Know and What Do We Need to Know? *Australian Journal of Rural Health* 16: 2-4.
- Perez-Garcia, J., Joyce, L., et al. (1997). Economic Impacts of Climatic Change on the Global Forest Sector: An Integrated Ecological/Economic Assessment. *Critical Reviews in Environmental Science and Technology* 27(2): 123-138.
- Peters, C. M., Gentry, A. H., et al. (1989). Valuation of an Amazonian Rainforest. *Nature* 339: 655-656.
- Pickering, C., Good, R., et al. (2004). Potential Effects of Global Warming on the Biota of the Australian Alps: A Report for the Australian Greenhouse Office. Canberra, Australian Greenhouse Office.

- Pimental, D., Mcnair, M., et al. (1997). The Value of Forests to World Food Security. *Human Ecology* 25(1): 91-121.
- Powell, R., Chalmers, L., et al. (1999). Regional Impact Assessment for the Upper North East CRA Region Centre for Agricultural and Regional Economics. A Project Undertaken as Part of the NSW Comprehensive Regional Assessments. Project Numbers NU 12/ES & NA 39/ES Gillespie Economics.
- Pritchard, P. and Donaldson, J. (2000). Farm Forestry Policy in Australia - a Working Paper. Developing Policies to Encourage Small-Scale Forestry, Kuranda, IUFRO Research Group 3.08.
- Raunikaar, R. and Buongiorno, J. (2006). Willingness to Pay for Forest Amenities: The Case of Non-Industrial Owners in South Central United States. *Ecological Economics* 56(1): 132-143.
- Richards, G. and Evans, D. (2005). FullCam. Canberra, Department of Climate Change.
- Roderick, M.L. and Farquhar, G.D. (2004). Changes in Australian pan evaporation from 1970 to 2002 *International Journal of Climatology*. 24:1077-1090.
- Rush Social Research (1997). Local impacts of forest industry expenditure in the Eden CRA region A report undertaken for the NSW CRA/RFA Steering Committee. Sydney, NSW CRA/RFA Steering Committee.
- Scherr, S., White, A., et al. (2004). For Services Rendered: The current status and future potential of markets for ecosystem services provided by tropical forests. Yokohama, International Tropical Timber Organisation.
- Schirmer, J. (2009a). Socioeconomic Impacts of the Plantation Industry on Rural Communities in Tasmania Technical Report 199, Cooperative Research Centre for Forestry.
- Schirmer, J. (2009b). Socioeconomic Impacts of the Plantation Industry on Rural Communities in Western Australia: Technical Report 198, Cooperative Research Centre for Forestry.
- Schirmer, J., Loxton, E., et al. (2008a). Monitoring the Social and Economic Impacts of Forestry: A Case Study of North East Tasmania. Report prepared for Department of Agriculture, Fisheries and Forestry by the Fenner School of Environment and Society. Canberra, Department of Agriculture, Fisheries and Forestry. Fenner School of Environment and Society.
- Schirmer, J., Loxton, E., et al. (2008b). Monitoring the Social and Economic Impacts of Forestry: Recommended Indicators for Monitoring Social and Economic Impacts of Forestry Over Time in Australia. Report prepared for Department of Agriculture, Fisheries and Forestry by the Fenner School of Environment and Society. Canberra, Department of Agriculture, Fisheries and Forestry. Fenner School of Environment and Society.
- Schirmer, J., Loxton, E., et al. (2008c). Monitoring the Social and Economic Impacts of Forestry: A Case Study of the Green Triangle. Report prepared for Department of Agriculture, Fisheries

and Forestry by the Fenner School of Environment and Society. Canberra, Department of Agriculture, Fisheries and Forestry. Fenner School of Environment and Society.

Schirmer, J., Williams, K., et al. (2008d). Living with Land Use Change: Different Views and Perspectives. Report Prepared for the Socio-Economic Impacts of Land Use Change in the Green Triangle and Central Victoria Study, Fenner School of Environment and Society, Australian National University, Cooperative Research Centre for Forestry, Victorian Department of Primary Industries and School of Resource Management, The University of Melbourne.

Schjolden, A. (2004). Towards Assessing Socioeconomic Impacts of Climate Change in Norway: Sensitivity in the Primary Sectors: Fisheries, Agriculture and Forestry, Center for International Climate and Environmental Research.

Sedjo, R. and Sohngen, B. (2009). The Implications of Increased Use of Wood for Biofuel Production, Resources for the Future: Issue Brief # 09-04.

Sheppard, S. (2005). Landscape visualisation and climate change: the potential for influencing perceptions and behaviour. *Environmental Science & Policy* 8: 637-654.

Sitch, S., Huntingford, C., et al., (2008). Evaluation of the terrestrial carbon cycle, future plant geography and climate-carbon cycle feedbacks using five dynamic global vegetation models (DGVMs). *Global Change Biology* 14: 2015-2039.

Sinclair Knight Merz (1999). Mid-Term Review of the Natural Heritage Trust: A Report on the Farm Forestry Program. Canberra, Commonwealth Government.

Slootweg, R., Vanclay, F., et al. (2001). Function Evaluation as a Framework for the Integration of Social and Environmental Impact Assessment. *Impact Assessment and Project Appraisal*.

Smit, B., Burton, I., et al. (2000). An anatomy of adaptation to climate change and variability. *Climatic Change* 45: 223-251.

Sohngen, B. (2008). Climate Change, Agriculture, Forests, and Biofuels. International Agricultural Trade Research Consortium Annual General Meeting. Scottsdale, Arizona.

Sohngen, B. and Mendelsohn, R. (1998). Valuing the Market Impact of Large Scale Ecological Change: The Effect of Climate Change on US Timber. *American Economic Review* 88(4): 689-710.

Sohngen, B. and Mendelsohn, R. (2001). Timber: Ecological-Economic Analysis. Global Warming and the American Economy: A Regional Assessment of Climate Change Impacts. Mendelsohn, R. Northampton, MA, Edward Elgar.

Sohngen, B., Mendelsohn, R. O., et al. (2000). Estimating the Cost of Carbon Sequestration in Global Forests, National Centre for Environmental Research, United States Environmental Protection Agency.

- Sohnngen, B., Mendelsohn, R., et al. (2001). A Global Model of Climate Change Impacts on Timber Markets. *Journal of Agricultural and Resource Economics* 26(2): 326-343.
- Sohnngen, B. and Sedjo, R. (2004). Impacts of Climate Change on Forest Product Markets: Implications for North American Producers, US Environmental Protection Agency: Climate Analysis Branch.
- State Forests of NSW and Commonwealth Bank (1999). Investment framework for planted forests in the New South Wales portion of the Murray-Darling Basin, NSW State Forests.
- Steffen, W., Burbidge, A. A., et al., (2009) Australia's biodiversity and climate change: a strategic assessment of the vulnerability of Australia's biodiversity to climate change. CSIRO Publishing, Collingwood, Victoria.
- Stirling, A. (2006). Analysis, participation and power: justification and closure in participatory multi-criteria analysis. *Land Use Policy* 23: 95-107.
- Stirzaker, B., Lefroy, T., et al. (2000). A Revolution in Land Use: Emerging Land Use Systems for Managing Dryland Salinity. Dickson, CSIRO Land and Water.
- Stoneham, G., Chaudry, V., et al. (2003). Auctions for Conservation Contracts: An Empirical Examination of Victoria's BushTender Trial. *Australian Journal of Agricultural and Resources Economics* 47(4): 477-500.
- Sustainable Tourism Cooperative Research Centre (2009). The Impacts of Climate Change on Australian Tourism Destinations: Developing Adaptation and Response Strategies. Cairns, Sustainable Tourism Cooperative Research Centre.
- Tavoni, M., Sohnngen, B., et al. (2007). Forestry and the Carbon Market Response to Stabilize Climate. *Energy Policy* 35(11): 5346-5353.
- Tewari, D. D. (2000). Managing Non-Timber Forest Products as an Economic Resource. *The Journal of Interdisciplinary Economics* 11: 269-287.
- The Allen Consulting Group (2006). Victoria's forest industries: An economic impact assessment. Melbourne, Victoria Association of Forest Industries.
- Thomson, D. (2008). Plantation and Managed Investment Scheme Facts, National Plantations 2020.
- Thomson, K. J. and Psaltopoulos D., (2005). Economy-wide effects of forestry development scenarios in rural Scotland. *Forest Policy and Economics* 7: 515-525.
- Tisdell, C. and Wilson, C. (2004). Economics of Wildlife Conservation. *Wildlife Tourism - Impacts, Management and Planning*. Higginbottom, K. Altona, Sustainable Tourism CRC, Common Ground Publications.
- Tobias, D. and Mendelsohn, R. (1991). Valuing Ecotourism in a Tropical Rainforest Reserve. *Ambio* 20: 91-93.

- Tonts, M., Campbell, C., et al. (2001). Socioeconomic impacts of farm forestry. Canberra, Rural Industries Research and Development Corporation.
- Tyrvaainen, L. (1997). The Amenity Value of the Urban Forest: An Application of the Hedonic Pricing Method. *Landscape and Urban Planning* 37(3-4): 211-222.
- U.S. Global Change Research Program (2009). *Global Climate Change Impacts in the United States* Cambridge, Cambridge University Press.
- van Bueren, M. (2001). Emerging markets for environmental services: Implications and opportunities for resource management in Australia. Canberra, Rural Industries Research and Development Corporation/Land and Water Australia/Forest, Wood and Paper Research and Development Corporation.
- van Kooten, G. (2008). Climatic Change and Canada's Boreal Forest: Socio-Economic Issues and Implications for Land Use. *Canadian Journal of Agricultural Economics* 43(1): 133-148.
- Venn, T. (2005). Financial and economic performance of long-rotation hardwood plantation investments in Queensland, Australia. *Forest Policy and Economics* 7: 437-454.
- Ward, F. and D. Beal (2000). *Valuing nature with travel cost models : a manual*. Cheltenham, Edward Elgar.
- Warrick, R. A. (2009) From CLIMACTS to SimCLIM: The development of an integrated model for assessing impacts and adaptation to climate change. *Integrated Regional Assessment: Challenges and Case Studies* (eds C. G. Knight & J. Jaeger). Cambridge University Press, Cambridge, UK.
- Williams, K. (2008). *Community Attitudes to Plantations: Survey of the View of Residents of Tasmania*. Science for Sustainable Forest Landscapes. Hobart, Cooperative Research Centre for Forestry: 17.
- Williams, K., Dunn, C., et al. (2008). *Understanding Residents' Views on Land Use Change*. Report Prepared for the Socio-Economic Impacts of Land Use Change in the Green Triangle and Central Victoria Project, School of Resource Management and Geography, The University of Melbourne and Cooperative Research Centre for Forestry.
- Wilson, R. and Turton, S. (2011). *Climate change adaptation options, tools and vulnerability*. Contribution of Work Package 4 to the Forest Vulnerability Assessment, Gold Coast, Australia, National Climate Change Adaptation Research Facility.
- Winter, C. (2007). The Intrinsic, Instrumental and Spiritual Values of Natural Area Visitors and the General Public: A Comparative Study. *Journal of Sustainable Tourism* 15(6): 599-614.
- Winter, C. and Lockwood, M. (2004). The Natural Area Value Scale: A New Instrument for Measuring Natural Area Values. *Australasian Journal of Environmental Management* 11(1): 11-20.

- Wood, K., Roiko, A., et al. (2011). Establishing the need and consultation with key stakeholders in forest policy and management under climate change. Contribution of Work Package 1 to the Forest Vulnerability Assessment, Gold Coast, Australia, National Climate Change Adaptation Research Facility.
- Wu, H., Fu, Q., et al. (2008). Production of Mallee Biomass in Western Australia: Energy Balance Analysis. *Energy & Fuels* 22(190-198).
- Xu, Z. and Bengston, D. N. (1997). Trends in National Forest Values among Forestry Professionals, Environmentalists, and the News Media, 1982-1993. *Society and Natural Resources* 10: 43-59.