

# Garnaut Climate Change Review

## The potential impacts of climate change on the forest and wood products manufacturing sector in Australia

Prepared by  
Genesis Buchanan, Catherine Tulloh and Melanie Ford, ABARE

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## 1 Summary

The forest and wood product manufacturing sector is an important part of Australia's economy. Forested areas account for about 19 per cent of Australia's landmass (MIG 2008) and the manufacture of wood products contributed about 0.7 per cent of gross domestic product (GDP) in 2005–06 (ABARE 2008).

Climate change could potentially have a significant impact on the sector through changes in temperature, rainfall and extreme weather events. The net impact of climate change on the sector is unclear at present: it will depend on interactions between temperature, precipitation, carbon fertilisation and soil nutrient levels and will differ from region to region across Australia. For example,

- changes in water availability are projected to be a primary determinant of changes in forest productivity
- the effect of changes in temperature on forest productivity will depend on the interplay between extended growing seasons and increased water demand
- trees subjected to water logging and/or drought are more susceptible to pest and disease outbreaks
- increased atmospheric carbon dioxide (CO<sub>2</sub>) concentration levels are projected to increase forest growth rates, however, this is expected to be limited by reduced water availability
- more frequent extreme events such as storms, drought and fire will increase risk with the potential for large scale losses.

Different countries are projected to experience different impacts of climate change resulting in changes in comparative advantages in the production of wood products and shifting trade patterns. The broad consensus in the literature is that global forest productivity and output of wood products will increase as a result of climate change.

The various potential impacts of climate change on the forest and wood products sector will require adaptation measures to minimise costs to the sector and ecosystems.

Mitigation policies are most likely to impact the forest and wood products sector by creating new market opportunities and increased demand for wood products or services including carbon sequestration. However, costs of production and processing will increase as a price is placed on carbon.

Further research is required to identify specific risks, their potential impacts at a regional scale and possible adaptation strategies. Scientists and economists will need to work together to understand these impacts and the implications for the forest and wood products sector in Australia.

The government has a role to play in consulting with the sector to understand key challenges and opportunities and provide a policy environment that is conducive to an effective response to climate change and the emerging policy environment.

## **2 Introduction**

The Australian forestry sector, including the manufacture of wood products, will be affected not only by the direct impacts of climate change but also by a changed institutional environment where a price is placed on greenhouse gas emissions. These changes present both challenges and opportunities for the sector.

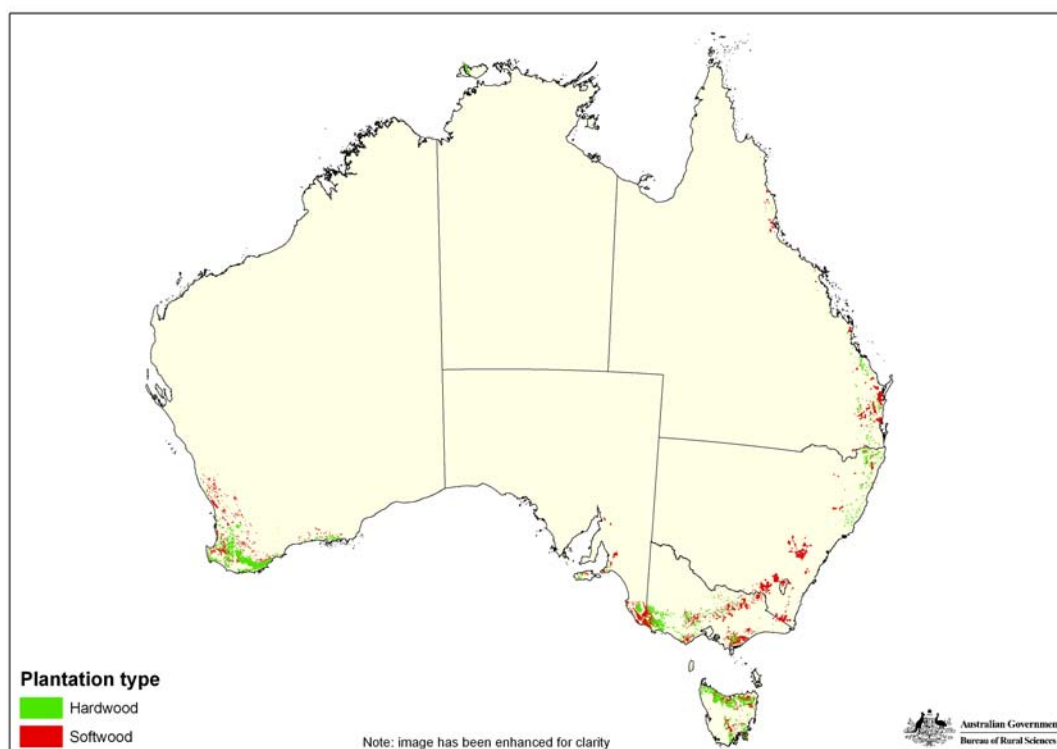
In this article both the direct and indirect impacts of climate change on the forest and wood products sector, as well as the challenges and opportunities that arise from these impacts, are discussed. Attention is given to the possible adaptive strategies that may be adopted by the sector as well as to the significant role the forest and wood products sector could play in the mitigation of greenhouse gasses.

### 3 The Australian forest and wood product sector

Latest available estimates indicate that Australia has around 149 million hectares of forested land, covering approximately 19 per cent of the country's landmass (MIG 2008). Of this total forested area, 1.9 million hectares, or about 1 per cent, is plantation (National Forest Inventory 2008). The remaining area is native forests. Less than one per cent of the total native forest area is harvested on average each year and around 16 per cent is protected in nature conservation reserves (MIG 2008). Between 1999–00 and 2006–07 the volume of timber harvested from Australian native forests (natural forests excluding plantations of native species) has declined while the volume harvested from plantations (coniferous exotic and native plantations and native broadleaved plantations) has increased by 40 per cent. About 67 per cent of gross log production value was derived from plantation forests in 2006–07 (ABARE 2008).

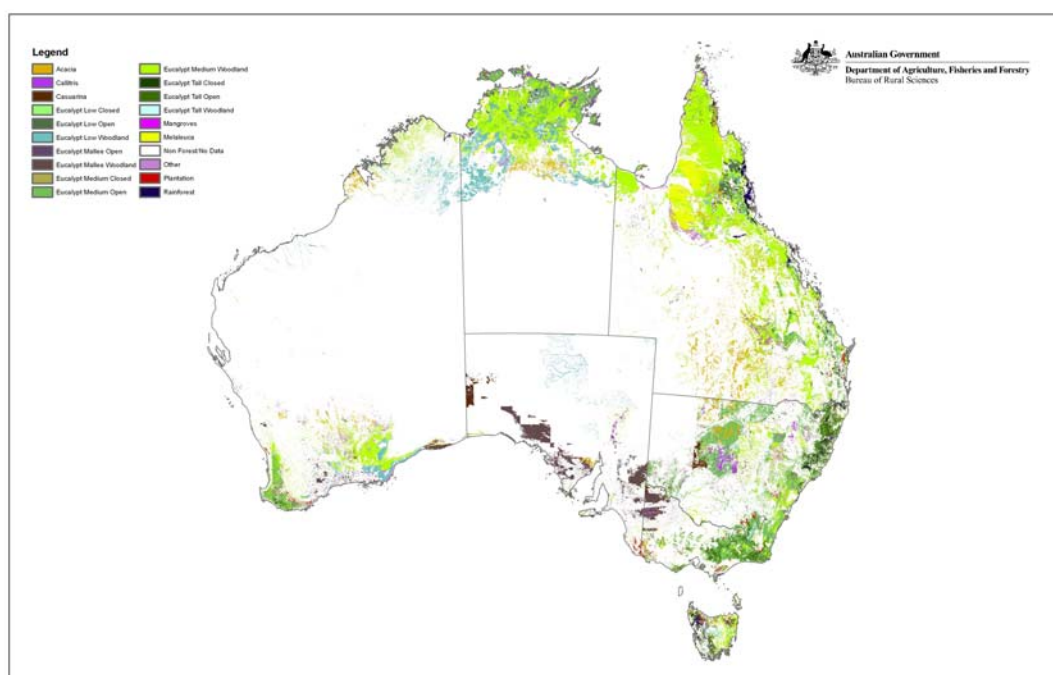
The distribution of Australia's forests is broadly dependent on climatic and soil conditions. The vast majority of forests are confined to regions where rainfall exceeds 500 millimetres (mm) a year. This occurs in Tasmania and on the Australian mainland in northern, eastern and south-western coastal zones, with notable exceptions of natural native forests in the Mallee of northern Victoria and eastern goldfields of Western Australia, central New South Wales and South Australia (see figures 1 and 2; MIG 2008). Victoria, Western Australia and New South Wales are the states with the largest areas under plantation forests, each accounting for around 20 per cent of the nation's plantations (Gavran and Parsons 2008). Native forests are dominated by Eucalypt and Acacia species (MIG 2008). The make up of plantation forests has changed in recent years. Previously dominated by exotic softwood species, now the sector is characterised as a mix containing around 46 per cent hardwoods (MIG 2008, Gavran and Parsons 2008).

Figure 1 Plantation forest distribution



Source: Parsons et al. 2006

Figure 2 Forest types and distribution in Australia



Source: MIG 2008

The production of wood products is an important manufacturing industry in Australia with a turnover of \$19 billion in the financial year 2005–06 (ABARE 2008). Direct employment in the sector has been relatively stable over the past decade, estimated at 83 400 in 2006–07. Of these the majority work in manufacturing industries such as paper and veneer production, whilst the remainder are employed in forestry and logging (ABARE 2008). The sector is particularly important as an employer in rural areas with some small communities highly dependent on forest industries as the primary source of employment (MIG 2008).

Australia is a net importer of wood products, importing \$4.2 billion and with an annual deficit of \$1.9 billion in 2006–07. The majority of imports are paper products. The principal sources of Australia's forest product imports include China, Indonesia and New Zealand. The forest product sector in Australia is also a major export earner with annual exports reaching \$2.4 billion in 2006–07, or about 1 per cent of total Australian export value. The majority of these earnings are attributed to woodchips (40 per cent), paper and paperboard (28 per cent), wood based panels (5 per cent), and sawnwood (6 per cent). Key export markets include China, Japan and New Zealand (ABARE 2008).

Forests also contribute value to other sectors of the economy. Australia's natural forests are of significant value for tourism and recreational uses. Forest ecosystems are sources of native bush food, game meat, wildflowers, eucalyptus and native sandalwood oils and provide areas for honey production. Some forests may also be grazed. Furthermore, forests provide a number of ecological services such as water retention and purification, erosion control, provision of shade and atmospheric moisture, nutrient recycling and provision of a store for biodiversity and genetic diversity. Other attributes such as existence or aesthetic values are also provided by forests but are difficult to quantify.

## 4 Direct impacts of climate change

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BOM) (2007) predict that not only will climate change alter temperature and precipitation patterns in Australia, but also wind speed, incidence of fire, frosts, cyclones, severe thunderstorms and drought. These changes in climatic conditions are expected to impact on the forest and wood products sector. However, the likely impacts on the sector are still uncertain. The impacts of climate change are also expected to differ significantly among regions, sites and across seasons.

### 4.1 Temperature

Small increases in temperature may have significant impacts on Australia's forests. Higher temperatures are expected to expand the growing season of forests in the cooler areas of southern Australia, leading to gains in productivity (IPCC 2007). Increased transpiration rates, however, may counteract this increase in productivity. Higher evaporation rates are also expected in some regions (CSIRO and BOM 2007) which in turn may restrict water supply to forests. Total changes in productivity due to temperature increases will depend upon the interplay between gains from extended growing seasons and losses from decreased water availability, transpiration and evaporation.

Further impacts on forests could arise from the projected increased occurrence of high temperature days and nights. Australia is expected to have a substantial increase in days classed as extremely hot (over 35 degrees Celsius) across all regions. This could lead to heat stress for some species. However, some of the negative impact of this may be offset by a decrease in occurrence and severity of frost (CSIRO and BOM 2007).

Many Australian plant species currently occupy a narrowly defined climatic range and may therefore be susceptible to extinction or displacement under consistently warmer temperatures (Hughes 2003). In native forests, warming of just 1 degree Celsius (above 1990 levels) is projected to lead to the loss of up to 25 per cent of the core habitat of Eucalypt species Australia wide, increasing to a 53 per cent loss with warming of 3 degrees Celsius (Hughes et al. 1996). Likewise, tropical rainforests have been shown to be highly sensitive to even small changes in temperature (Hilbert et al. 2001). If even a modest proportion of species are unable to adapt to changing conditions there could be significant changes in tree distribution and native forests yields. The types of species of plantation trees may also be altered, since currently planted species are situated in areas just inside their climate suitability range. This is applicable to the dominant plantation species, *Pinus radiata*, where large areas of current plantations are located in regions that would be unsuitable if temperatures rise by 4 degrees Celsius, relative to 1990 temperatures (Howden et al. 2003). Rising mean temperatures are expected to shift species' geographic ranges upwards in altitude and/or toward the poles, although the ability for tree species to relocate will be constrained by other factors such as precipitation and soil conditions (Hughes 2002). Relocation of plantations may be further constrained by competing land uses and associated high land values.

### 4.2 Rainfall and water availability

The level of precipitation is very important for forest distribution with most forests located in areas of annual rainfall above 500 mm a year. According to CSIRO and BOM (2007) annual average precipitation is expected to fall by up to 20 per cent by 2050, relative to 1990, in southern areas of Australia where the majority of forest plantations are concentrated. Any dramatic or sustained decreases in rainfall or water availability will undoubtedly have negative impacts on forests' net primary productivity (Pittock 2003). On average, yields are projected to increase under specified wetter scenarios and decrease under dryer scenarios, however, the change in yields will vary significantly between species (Preston and Jones 2006). Water limitations are also a major concern for the plantation sector and *Eucalyptus globulus* plantations have shown increased mortality rates in years of low precipitation (Howden et al. 2003). The range and make up of some native forests which are strongly influenced by the availability of water are also expected to change as a result of changing precipitation patterns (Fensham et al. 2005; Freiberg and Turton 2007).

### 4.3 Pests and diseases

Current knowledge on increased risk of damage to forests caused by pest or pathogen outbreaks arising from climate change is limited (Chakraborty 2005). However, increased climatic variability with extremely wet and extremely dry periods may compromise the generally good health of Australia's forests (Preston and Jones 2006). Trees stressed by water-logging or drought are more susceptible to attacks by pests or diseases (Sutherst and Floyd 1999). The fungal pathogen *Phytophthora cinnamomi* is of particular concern to forests in the south of Australia as it is very damaging and thrives in these conditions (Preston and Jones 2006).

Increased spread of weeds in forests may also occur, competing with trees for soil and water resources. Weedy species tend to respond vigorously to increased levels of CO<sub>2</sub> (Howden et al. 2003) and changes in temperature and rainfall patterns may cause outbreaks of weed species that are currently contained (Kriticos and Filmer 2007). There is concern that pests and diseases currently restricted to the warm tropical regions in northern Australia may move south into more temperate zones (Sutherst 2000). Warmer temperatures, however, may discourage pests that generally inhabit cooler areas (Howden et al. 1999). Individual site and species specific studies are required to assess the effects of increased CO<sub>2</sub> and temperature on these pests before more accurate projections can be made about their impact on forests. Warmer temperatures may discourage pests that generally inhabit cooler conditions (Howden et al. 1999).

### 4.4 CO<sub>2</sub> fertilisation

The concentration of CO<sub>2</sub> in the atmosphere has risen markedly since pre-industrial times. The majority of studies indicate that plants and plant ecosystems in Australia and around the world show positive growth responses to heightened levels of CO<sub>2</sub>, although the magnitude of these responses varies due to environmental and physiological conditions of species (Steffen and Canadell 2005). In particular, mature, dormant or young plants not yet in a rapid growth phase show limited response to enhanced CO<sub>2</sub> concentration. CO<sub>2</sub> fertilisation is thus more likely to be significant in plantation forests which have short rotations and so are comprised of fast growing trees or saplings (Steffen and Canadell 2005). In addition the fertilisation affect may be constrained by the relatively poor nutrient status of Australia's soils and by water availability (Steffen and Canadell 2005). These constraints mean overall impacts of elevated CO<sub>2</sub> as estimated in controlled experiments may overstate actual responses in the field (IPCC 2007).

Changes in CO<sub>2</sub> concentrations are also likely to cause changes in the distribution of forests since trees favour higher levels of atmospheric CO<sub>2</sub> compared to other plants. Trees benefit most from increased CO<sub>2</sub> levels compared to many grasses and shrubs. As a result the predicted overall net impact of increased CO<sub>2</sub> concentrations is the spread of woody biomass at the expense of more open grasslands (Bowman et al. 2001; Berry and Roderick 2006), representing a possible increase in areas where forestry is viable.

### 4.5 Extreme climate events

In Australia, tropical cyclones are predicted to increase in intensity with a possible decrease in frequency (CSIRO and BOM 2007). This is likely to impact significantly on shallow rooted, tall rainforest trees by causing defoliation, breakage and uprooting (Stork et al. 2007). A projected increase in the intensity of precipitation and violent storms may cause forest damage (particularly in young plantations) and increased soil erosion in some regions (Pittock 2003).

Drought can have negative impacts on plantation forests by reducing productivity, increasing mortality of saplings and seedlings and increasing vulnerability to pests and pathogens (Pittock 2003). Forests could also face increasing competition from other users of water resources as the frequency of droughts is projected to increase. Establishment of new plantations may be difficult since additional watering may be required during juvenile phases of tree growth and obtaining water rights may become more difficult (Forest and Wood Products Research and Development Corporation 2004). Furthermore, forestry may face pressure from other land users during drought since trees reduce the net runoff into catchment areas above that of pasture or crop uses (Parsons et al. 2007).

Climate change is expected to increase the frequency, intensity and size of bushfires (Ellis et al. 2004). Increased frequency of fires could alter the structure and composition of native forests and cause more regular losses in plantations (National Forest Inventory 2003). The increased risk of losses due to fire may threaten the security and viability of plantation forests and the forest product manufacturing sector (Hennessy et al. 2005). Soil erosion may be further exacerbated by increases in fire frequency since fire destroys the protection that accumulated forest floor litter and vegetation provide (National Forest Inventory 2003).

#### **4.6 Overall expected outcome**

The overall direct impacts of climate change on the forest and wood products sector depend upon the interplay between beneficial factors such as longer growing seasons in southern Australia and fertilisation from enhanced CO<sub>2</sub> concentrations and constraining factors such as falls in precipitation, warming above a species threshold, increased extreme weather events including fire and outbreaks of pests and pathogens.

Modelling studies that examined the interactions between temperature, CO<sub>2</sub> concentration and rainfall for Australian forests show an increase in generic forest growth in the south but a decrease in the north where high magnitude temperature increases are projected to cause decreases in growth rates (Kirshbaum 1999). Water availability is important because gains are only possible where water is not limited or where rainfall is not projected to decline appreciably. The dominant softwood plantation species in Australia (*Pinus radiata*) is likely to experience declines in growth rates in most areas except Tasmania and high altitude sites in southern Australia. However, a more recent study (Simioni et al. 2007) shows that these generalised findings are highly variable from site to site (due to variation in soil quality and precipitation patterns) and reflect high levels of uncertainty in predicting future outcomes for the forest and wood products sector. Furthermore, the models used in these studies do not incorporate the risk of increased fire incidence, storms, drought and pest or disease outbreaks. These events may offset some of the predicted gains for the forest and wood products sector.

## **5 Indirect impacts of climate change**

Climate change will impact on the competitiveness of, and demand for, Australian wood products. This is because different nations are expected to experience differing impacts of climate change, altering the productivity, supply and price of timber products on international markets. While the quantitative predictions in the literature vary widely, there is a broad consensus that global forest product output will increase as a result of climate change (Lee and Lyon 2004; Perez-Garcia et al. 2002; Sohngen et al. 2001).

Growth in forest productivity is projected to be largest in cooler regions such as New Zealand and the boreal forests of northern America and Eurasia due to the extended growing seasons predicted in these areas (Perez-Garcia et al. 2002).

## 6 Adaptation

The various potential impacts of climate change on the forest and wood products sector may require adaptation measures to minimise costs to the sector and ecosystems. Adjusting production systems in response to actual or expected changes can either limit the harmful impacts of a changing climate or exploit opportunities that arise as a result of the change in climate (Kleine and Roberts 2007). Natural forest systems are expected to undergo a degree of natural adaptation or acclimatisation. However, this will be limited under more rapid or severe climate change scenarios (Kleine and Roberts 2007).

Some adaptation, such as altering rotation lengths and shifting to more suitable species, will take place autonomously as plantation forest owners react to changing returns on their products. Other adaptation measures of a strategic nature may be supported through government initiatives.

Planned measures may include research and development to enhance forest productivity, species selection and varietal development, expanding reserve areas to maintain biodiversity or developing landscapes to minimise fire and pest damage.

In table A, some of the adaptation options available to the forest and wood products sector are outlined. Some of these actions are preparatory actions that can be adopted in anticipation of climate change but before significant change is apparent. For example, identification of more suitable genotypes for the expected climate should be done before climate change impacts intensify, so that as the climate changes the alternative genotypes can be introduced to rotations. Forest plantations generally operate on long time horizons so it is important that investments in a range of adaptive responses are available to choose from at the time of replanting each rotation to minimise expected losses due to climate change.

**Table A Adaptation options in the forest and wood products sector**

	<b>Plantation forests</b>	<b>Natural forests</b>	<b>Wood processing</b>
Immediate/ preparatory actions	<ul style="list-style-type: none"> <li>• identify more suitable genotypes for the expected climate</li> <li>• enhance forest growth and yield models to include climate variables</li> <li>• develop fire smart landscapes</li> <li>• develop alternative harvesting systems</li> <li>• consider climate change projections in planning maintenance, infrastructure replacement and rotation lengths</li> <li>• plan landscapes to minimise the spread of insects and diseases</li> </ul>	<ul style="list-style-type: none"> <li>• conserve biodiversity by expanding reserve areas and improve management of reserve areas</li> <li>• maintain connectivity in a varied landscape</li> <li>• develop fire smart landscapes</li> </ul>	<ul style="list-style-type: none"> <li>• develop wood processing technologies that can use altered wood quality and size</li> <li>• consider climate change projections in planning maintenance and infrastructure replacement</li> </ul>
Medium term actions	<ul style="list-style-type: none"> <li>• plant alternate genotypes that are adapted to expected changes in climate (e.g. drought)</li> <li>• sanitation thinning</li> <li>• increase the amount of salvage logging</li> <li>• shorten rotation lengths to allow for adaptive flexibility</li> <li>• water management such as reservoir development and flood protection</li> <li>• implement altered harvesting processes</li> <li>• increase the frequency of roads and infrastructure maintenance</li> <li>• buy forest insurance</li> <li>• diversify or move out of the sector</li> </ul>	<ul style="list-style-type: none"> <li>• water management such as reservoir development and flood protection</li> <li>• increase the frequency of roads and infrastructure maintenance</li> <li>• use monitoring systems to determine what changes are occurring</li> <li>• undertake active management to assist dispersal of species that become stranded as bioclimatic zones move, translocate species and use breeding programs</li> </ul>	<ul style="list-style-type: none"> <li>• increase the frequency of roads and infrastructure maintenance</li> <li>• diversify or move out of the sector</li> </ul>

Sources: Spittlehouse and Stewart 2003; Krankina et al. 1997; PMSEIC 2007; Kleine and Roberts 2007; IPCC 2007.

## 7 Mitigation

Australian forests are a net sequester of carbon, with forest land sequestering 54.5 million tonnes (Mt) of carbon dioxide equivalent (CO<sub>2</sub>-eq) in 2005 (NGGI 2007). The forest and wood products sector does, however, produce some greenhouse gas emissions through the use of fuels. Emissions from the sector could be lowered further through more efficient or reduced fuel use and energy efficiency improvements in harvesting and processing (Gunasekera et al. 2007).

Mitigation policies are most likely to impact the forest and wood products sector by creating new market opportunities and increased demand for wood products or sequestration services. Forests can aid in the reduction of net greenhouse gas emissions through sequestration of carbon, supplying biomass as an energy source or replacing more emission intensive products used in other sectors such as building (CRC for Greenhouse Accounting 2006).

### 7.1 Opportunities for carbon offsets

Emissions trading schemes implemented either domestically or internationally are expected to create opportunities for forestry as a source of carbon offsets. Emission trading schemes already in operation, including the Greenhouse Gas Reduction Scheme (GGAS) in NSW and Emission Trading under the Kyoto Protocol internationally, allow emissions to be offset with forestry sequestration credits. GGAS credits from forests are currently being sold for between A\$15 per tonne (t) of CO<sub>2</sub>-eq and A\$23/t CO<sub>2</sub>-eq (Carbon Offsets Guide Australia 2007) and Kyoto units are sold for around A\$13.50/t CO<sub>2</sub>-eq (New Zealand Treasury 2008). Forest offsets in Australia are also sold for use in the voluntary market. The introduction of a national emissions trading scheme in Australia may provide incentives to increase the area of forest plantations in Australia or alter rotation lengths. The incentives for providing forest offsets are determined by a range of factors including the opportunity cost of land; the prices received for logs; biomass and carbon credits; discount rates as well as forest management practices and policy instruments (Gunasekera et al. 2007).

The capacity for forests to provide carbon offsets may be negatively affected by projected climatic changes. Lower average rainfall in some regions in particular may slow the rate of sequestration and hence reduce the net present value of investing in forest sequestration services (Steffen and Canadell 2005). Furthermore, given projected reduced water availability across the southern areas of Australia, plantations are likely to be required to purchase water licenses (Forest and Wood Products Research and Development Corporation 2004) further reducing the profitability of supplying carbon offsets. An emissions trading scheme will also increase the price of emissions intensive inputs such as fuel.

### 7.2 Biomass and biofuels from wood products

Carbon pricing is also likely to improve the cost competitiveness of biomass generated electricity relative to traditional fossil fuel generated electricity. Increased demand for wood waste from mainstream forestry activities and also wood grown for use as fuel (fuelwood) from plantations is expected to increase the returns to, and value of, land under forest plantation.

Fuelwood can also be used for methanol or ethanol production for use as a transport fuel. In the absence of government support, ethanol and methanol from renewable (biomass) sources are generally not currently cost competitive with crude oil based products. However, if the price of oil based products increases in response to geopolitical concerns, supply constraints and/or the introduction of carbon prices, renewable fuels may become a viable alternative, further increasing demand for fuelwood provided they are cost competitive.

Under existing carbon accounting frameworks used in the Kyoto Protocol, wood products are considered to be carbon neutral as the amount of carbon assumed to be emitted at the time of harvest is equal to the amount of carbon sequestered during the growing life of the tree (NSW DPI 2003). However, carbon stores in harvested wood products are not emitted to the atmosphere until the wood is burnt or decays, which could be several decades after harvest.

Some common substitutes for wood have high net emissions of carbon. Therefore, under a carbon price, timber products may become more cost competitive with products such as coal for energy or steel and concrete for the building sector (Burns et al. 1999). The Cooperative Research Centre for Greenhouse Accounting (2006) has demonstrated that using wood products in construction of a single-storey house could save up to 25t CO<sub>2</sub>-eq per house.

## 8 Conclusion

The overall impacts of climate change on the forest and wood products sector are uncertain. The projected increases in productivity from a slight warming and CO<sub>2</sub> fertilisation may be offset by declines in water availability and increased incidence of extreme events. If the Australian forestry and wood products sector wishes to remain competitive it must be ready to adapt to the changing climate and policy environment. The forest and wood products sector must also consider the opportunities that arise through participating in mitigation processes.

Further research and development is needed. The potential impacts of climate change may be broadly understood but the specifics are not. More research on specific risks and their potential impacts is needed. There is also a strong need for more regional analysis so that sector participants in different regions can better understand, and adapt to, the possible changes in climatic conditions that they are likely to face. The role of scientific analysis is vitally important in all these processes, but enhanced understanding will come from joint analysis and research conducted in a multi disciplinary framework including scientists and economists. The desired result is a comprehensive understanding of the domestic and international conditions associated with potential climate change impacts on the forest and wood products sector in Australia. Further work is also needed to identify potential adaptation strategies with regional focus again being important. There must be strong forestry and wood products sector and government consultation so that key concerns and issues associated with climate change impacts are understood. Government's key role will be to provide a policy and regulatory environment that minimises the cost of responding to climate change in an emerging climate change response policy environment.

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