Chapter 10

Implications of water scarcity for economic and social values

10.1 Overview

A sustainable future for the Riverina will depend on the development of less water-dependent industries. The decline in the irrigated agricultural industry has already had a large impact on the bioregion, and the future of the regional economy and its communities will ultimately depend on the transformation of primary industries in response to a future with less water.

This chapter looks at the likely social and economic impacts on the Riverina bioregion of less water through river regulation and a changing and variable climate, by:

- considering the general socio-economic impacts of water scarcity on the region
- assessing likely sustainable yields in the forestry industry
- considering possible alternatives for the forestry industry under a water-scarce future
- analysing the adaptive capacity of forestry-dependent towns and communities
- proposing approaches for building the adaptive capacity of the region's communities.

It supports Steps 3 and 4 of the analytical framework by:

- assessing long-term sustainable yields of timber able to be supported under predicted future flooding regimes
- assessing the implications for the future of the forestry industry of changes in quality and quantity of timber yields
- assessing the ability of local communities to adapt to changes in the forestry industry and, more broadly, to the predicted impacts of climate change.

The key findings of this chapter are:

- While the Riverina bioregion as a whole is likely to have the capacity to adapt to the impacts of changes in climate through the development of new technology and new industries, some existing industries – including the red gum forestry industry – are particularly vulnerable to futures with scarce water.
- Long-term sustainable yields of quota and ex-quota sawlogs are expected to be reduced by up to 70 per cent due to the combined effects of river regulation, enhanced forest management prescriptions, the current drought and climate change. The quality and size of sawlogs is also likely to decline. However, evidence clearly suggests that higher yields are possible if more favourable flooding regimes can be achieved. It would also be possible to continue higher levels of sawlog harvesting in the near term, for a defined period of time, as part of a managed industry transition strategy.
- Short-term increases in volumes of low quality timber and firewood may be realised if ecological thinning, consistent with the principles identified in **Chapter 11**, is applied in some areas of the river red gum forests. This may benefit businesses which are able to utilise this resource.
- The future river red gum sawmilling and processing industry is likely to be smaller than at present. On the basis of current sawmill operations, long term sustainable yields of sawlogs from public land under assumed likely flooding regimes are expected to be sufficient to support only one, or perhaps, two fixed location sawmills. In the short to medium term, it would be possible sustain higher volumes of sawlogs than are available over the long term as part of a managed industry transition strategy. New technologies may also help recover greater value from smaller and poorer quality logs.
- The long term yield estimates presented in this chapter are conservative, but realistic on the basis of the available evidence. Further modelling, using Forests NSW's FRAMES and related software at a Water Management Unit level and adjusted for the changed forest structure and growth rates of contemporary river red gum forests, will provide more precise estimates of future yields, product classes, and wood supply options.
- There is potential for the establishment of new forestry-based industries given a sufficiently high carbon price, technology development and industry innovation. New energy generation technologies and appropriately sited forest plantations for carbon sequestration are two possible examples.
- While forest-based industries are a small part of the NSW Riverina regional economy[1], the potential decline in size of the current red gum forestry industry would have a significant impact on some smaller towns.
- The twin towns of Barham-Koondrook and the town of Mathoura have less capacity to adapt to changes in climate than other towns and have the highest reliance on the red gum forestry industry. Conversely, Deniliquin appears to exhibit the greatest resilience to potential climate change impacts, with a lower vulnerability to change, a greater degree of industry diversity and low reliance on the red gum forestry industry.
- The capacity of industries in the region and their dependent communities to adapt to changes in climate could be supported through a variety of approaches. These include information provision, skills and capacity development, and investment in infrastructure and programs to support regional development.

10.2 Potential socio-economic impacts of water scarcity

The combined impacts of river regulation, climate variability and predicted climate change are expected to reduce water availability in the Riverina bioregion. This could result in increased competition for available water and further reductions in water to river red gum forests. Responding to potential water scarcity may be within the adaptive capacity of the broad Riverina bioregion. However, there are likely to be significant socio-economic impacts at a local level.

10.2.1 Broad impacts on the Riverina bioregion

Within the Riverina bioregion, employment is dominated by the following sectors: agriculture, fisheries and forestry and

[1] The size and structure of the NSW Riverina regional economy is discussed in more detail in **Chapter 5**.

related processing operations; education and training; and retail (discussed in **Chapter 5**). Tourism is also an important contributor to the NSW Riverina regional economy.

The socio-economic impacts on the region from less water may potentially include the following:

- changes in land use
- changes in industry productivity
- impacts on export earnings and the viability of rural communities
- dislocation of industries, infrastructure and regional economies as current economic activities cease to be viable
- increased competition for water, leading to reduced economic and/or environmental sustainability
- insufficient water to sustain existing highly water-dependent industries (e.g. dairy operations)
- reduction in agricultural crop production and associated increases in annual crop variability (quality and quantity)
- reduction in sustainable forestry yield due to lower growth rates from reduced flooding
- a reduction in viability of dairy, pig and poultry (meat and egg) production due to an increase in feed prices
- increased loss of infrastructure from extreme natural events
- changes in water quality as a result of rising river salinity and associated decline in river health affecting agriculture due to the reduced productivity of water used for irrigation – impacting on industrial and residential users (Hacker et al., 2006; Beare and Hearney, 2002).

The industries that are the most significant water users in the region are agriculture and associated manufacturing activities. Given the climate's influence on agricultural productivity, the agriculture industry is projected to be one of the most adversely affected from a change in water availability (DECC, 2009b).

Table 10.1 below provides a summary of the possible implications of climate change impacts on water availability relevant for industry sectors in the Riverina bioregion.

The agricultural commodities that used the most water in the Riverina bioregion include rice production, dairy farming and irrigated pasture for other livestock and rice cultivation. A recent report by CARE (2009) scoped the impacts that may arise from climate change over the next 50 years. The report concludes that there are likely to be significant impacts on the Riverina over the next 50 years due to reductions in available water, the high level of agricultural production, and the dependence upon irrigation. This will affect agriculture, particularly the rice and irrigated dairy industries and, compounded by water licence buybacks, these impacts are likely to have flow-on effects across the region.

In summarising the impact of climate change (incorporating climate variability and Government adjustment through water buybacks) on the Riverina economy, CARE (2009) reports that there are a number of factors that will minimise the impacts, including:

- there is some input substitution that offsets the reduced water use
- there are transfers of water under the trading arrangements that result in some water being transferred to higher value users
- revenue obtained from the buybacks will be spent on the adjustments made by the recipients.

Table 10.1: Possible climate change impacts on water availability and implications for the Riverina bioregion

Climate Variable	Implications
Temperature	• Decline in grape quality in the viticulture industry
Rainfall patterns and evaporation rates	• Reduction in water availability • Impacts on production of agricultural industries relying on irrigation/water • Impacts on production of rain-fed and irrigated fodder and grain production
Hydrological change/ water resources	• Increased variability of rainfall and, particularly, river flow due to climate change will reduce the reliability of water supply for irrigation industries • Impacts on agricultural industries relying on irrigation – decreases in the value of irrigated agricultural production • Anticipated that by 2030 the value of agriculture in the Basin could fall by 12 per cent and this loss could increase to 49 per cent by 2050 and 92 per cent by 2100 • Impacts on settlements that depend on the Murray-Darling system for water supplies
Landscapes and ecosystems	• Additional pressures on natural systems in the Murray-Darling Basin which are already under pressure from reduced inflows from a drying climate and over-allocated water for irrigation • Increased woody weed invasions, erosion, loss of biodiversity and impacts on aquatic species, with flow-on effects to communities and industry sectors depending on healthy ecosystems, including forestry and tourism sectors • Impacts to river red gum forests due to decreased flooding events and flow-on effects to forestry and tourism sectors

Sources: Commonwealth Department of Climate Change, 2009; DECC, 2009; Webb, 2006; Hacker et al., 2007; Jones and Hennessy 2000; Hafo et al., 2009)

CARE (2009) finds that there is significant capacity for adaptation across the Riverina. It reports that the reduction in water availability is likely to be within the adaptive range of many producers who are already developing new technologies for drier and more variable climate conditions.

10.2.2 Localised impacts within the Riverina bioregion

While the impacts of a reduction in water availability may be within the adaptive capacity of the broader region (CARE, 2009), there are likely to be significant impacts at a local level. CARE (2009) states that climate change will have most impact on those businesses that have the highest dependence on primary industries. It adds that in the major centres, the existence of entrepreneurial people, capital and technology are increasingly driving business growth and these have little to do with climate change.

The most vulnerable businesses will be those that are the highest users of water, or those that:

- are already stressed – either economically or biophysically, as a result of, for example, land degradation, salinisation and loss of biodiversity
- are at the edge of their climate tolerance
- have made large and long-lived investments such as dedicated irrigation systems, slow-growing cultivars or processing facilities (Allen Consulting, 2005)
- generate less value per unit ($/GL) of water – as water becomes more scare and potentially more expensive, these commodities may be the first to exit the market.

CARE (2009) reports that many smaller centres located in the dryland farming areas are likely to continue to struggle, and businesses in those towns will have difficulty remaining viable. It concludes that these towns and their businesses will need to find new economic activities that fit with trends in the economy and make use of new technologies that enable businesses to reach beyond their local market area.

10.2.3 Impacts on forestry towns within the Riverina bioregion

Some industries including the red gum forestry industry are particularly vulnerable to futures with scarce water. While forestry is a small part of the NSW Riverina regional economy, a decline in the red gum forestry industry would have a considerable impact on some readily identified smaller towns. These towns include Barham-Koondrook (in Victoria), Mathoura, Deniliquin, Balranald, Darlington Point and Merbein (in Victoria). These towns are already dealing with the impacts of ongoing drought on their agricultural businesses.

Qualitative evidence from submissions to, and discussions held by, the NRC in the bioregion suggest that businesses directly or indirectly dependent on river red gum forest industries are vulnerable.

CARE (2009) summarised short term impacts on local businesses and communities, which included (among other impacts):

- reduced production
- flow-on effects from reduced production to other related industries
- flow-on effects to households through reduced employment and wages, and reduced business earnings
- reduced expenditure by households
- an intensification of the competition for water among the various users.

CARE (2009) goes on to say that the effect of reduced supply of a variable (such as timber) will usually be a net reduction in production, Gross Regional Product and possibly some deterioration in social conditions related to lower household income, reduced job opportunities and increased costs associated with the new production and consumption systems.

Submissions to the NRC from forestry related businesses and local shires in the Riverina raise these concerns and place them in the context of the local communities that will be impacted. They express concern that changes to the red gum forestry industry will impact in a negative way on local communities.

Balranald Shire says that the "forestry industry provides a diversity of income streams for local communities. Removal of a significant industry will mean that the capacity of the community to survive downturns in other key economic activities will be substantially diminished. In addition, the social fabric of the communities will diminish as the forestry industry is the keystone of fundraising for most clubs."

Other submissions discussed the impact of a likely loss of jobs and the lack of other employment options in many small centres, especially following a downturn in agriculture due to the recent drought. They discussed the flow-on impacts to the smaller towns including loss of businesses, income and people from towns and loss of services and clubs and associated community cohesion. Many submissions described the risks to these communities in detail and with concern for the survival of several smaller towns.

CARE (2009) says that the severity of those effects will be related to the importance of the affected industries in the economy and the opportunities that exist for developing alternative business activity that can offset the reductions. Submissions to the NRC have highlighted the importance of forestry related businesses to their towns and argued that other business activities are not available to them.

It is important to note that the cumulative flow-on impacts of river regulation, national water reform, climate variability and climate change on communities are uncertain.

There are opportunities for regional communities through the water reform process and these should be fully explored. Through The Living Murray program, environmental water will be delivered to the icon sites and there will be opportunities for governments, water users and communities to manipulate those flows to get the best outcomes for the river red gum forests. This may include, for example, 'piggy-backing' environmental flows onto natural unregulated flows through the system to achieve a longer flooding event. There are good examples of this being undertaken on a small scale in the past with good ecological outcomes.

Opportunistic and pre-planned flooding events may have the potential to support not only ecological values but also socio-economic outcomes, and may be one pathway toward a new sustainable future for communities in the Riverina bioregion.

A discussion of what climate variability and climate change means for forest industries, particularly timber production, follows. The sensitivity of Riverina towns to these impacts, the opportunities available to them and the structural adjustment that may be required in response, is provided at the end of this chapter.

10.3 Implications for timber supply

In considering the implications of reduced water availability on the timber yields that can be sustained by the river red gum forests, the NRC has focused on a long-term (100-year) timeframe. Over this timeframe, a reduction of up to 70 per cent in yields is estimated due to the combined effects of river regulation, enhanced forest management prescriptions, climate variability and climate change. Higher volumes of timber could be harvested in the near term, for a defined period of time, as part of a managed industry transition strategy. This may assist the red gum forestry industry to adjust to the sustainable yields available over the longer term. Further modelling using FRAMES, taking account of likely changes in forest structure and growth rates at a water management unit level, will provide more precise estimates of future yields, product classes and wood supply options.

10.3.1 Factors impacting timber production

The long-term sustainable yield of sawlogs is already being impacted by the combination of increased river regulation, forest management prescriptions to protect habitat trees and threatened species, and the current drought. Reductions in the extent and frequency of flooding under future climate change scenarios are expected to further reduce long-term yields.

The sustainable level of timber production from the river red gum forests of the Riverina bioregion depends on both the area available for harvest, growth rate and regeneration of trees on those areas. As a water dependent species, growth rates of river red gums depend primarily on water availability. Silvicultural practices can also have an impact on long-term growth rates, for example, by reducing competition for available water and promoting tree regeneration.

Current base allocations of high quality (quota) sawlogs reflect yield estimates of merchantable[2] sawlogs nominated in Management Area plans in the mid 1980s for the Murray and Mildura Management Areas (Forests NSW, 2008). Base allocations for the Murrumbidgee and Narrandera Management Areas were revised downward between 2005 and 2009. The long-term yields estimated in these plans are based on estimates of growth rates over the medium term, in line with ability of forests to sustainably produce primary product of quota sawlogs (GHD, 2009). Supply of low quality (ex-quota) timber products and residue is in conjunction with the production of high quality sawlogs and silvicultural operations, in accordance with current and future market demands (Forests NSW, 2008).[3]

Forests NSW is currently conducting a review of long-term yield of all classes of product from the river red gum forests using a strategic planning tool called FRAMES (Forest Resource And Management Evaluation System). An Auditor-General's Performance Audit in 2009 concluded that FRAMES is robust in its operational aspects and that procedures for collecting data to calibrate the model are sound (Auditor General, 2009)[4]. This was confirmed by a peer review of FRAMES conducted by the NRC.

However, the NRC's analysis of FRAMES outputs for the river red gum Management Areas, informed by consultation with Forests NSW, suggests a number of key issues for estimates of future timber yields. Firstly, although underlying sustainable yield estimates are based on long-term non-declining yields over a 200-year period, current base allocations have been set on a 70-year planning horizon within that context. This has the effect of allowing a higher level of harvesting earlier in the period, which would be balanced by reduced levels of harvesting later in the period. However, the 70-year planning horizon is less than the river red gum timber production rotation age of 90-120 years; a planning horizon within that range would be more appropriate for the assessment of long-term sustained yield that the NRC has been asked to conduct. Doing so would reduce levels of harvesting compared to current allocations.

Secondly, previous calculations of long-term sustainable yields were based on growth and mortality rates achieved under historic flooding regimes. A recent review of growth and mortality rates since 2003 by Forests NSW indicates these figures need to be revised for water-stressed forests. When compared to the period 1970–2002, post-2003 growth rates have halved and mortality rates have doubled, and this is assumed to be due to the ongoing drought (Forests NSW, pers. comm., 2009). These drought impacted growth and mortality rates are indicative of those likely in river red gum forests that no longer receive regular watering because of river regulation, and have to survive in the drier future predicted for the bioregion under predicted climate change scenarios.

Thirdly, increasing constraints on harvesting to protect other forest values (for example, potential expansion of the reserve system) are likely to reduce the sustainable yield of sawlogs from river red gum forests.

Taken together, these factors suggest that current sustainable yields from NSW river red gum forests need to be revised downwards, to reflect the combined influence of historical factors, policy decisions to maintain historical levels of timber allocation in all but the Murrumbidgee Management Area, and future climate change.

The following section considers the impact of these factors, in the context of expected climate change, on likely long-term sustainable yields.

[2] Merchantable sawlogs referred to in the Murray Management Area Plan include quota and ex-quota sawlogs (Forestry Commission of NSW, 1985).

[3] Actual harvest of ex-quota sawlogs have recently been above base allocations due to the poorer quality stands that have been harvested over the past 2-3 years. These annual overcuts are being debited against a small historic undercut in ex-quota sawlogs over the past decade or so, ensuring that the harvest of ex-quota sawlogs is within the long term sustainable yield. This is not the case for quota grade sawlogs, for which actual volumes cut have been close to base allocations, once consideration is made for the revision of base allocations for Murrumbidgee and Narrandera Management Areas.

[4] The Auditor-General's Performance Audit also concluded that Forests NSW has adequate estimates of how much timber is available from native forests, but that more could be done to improve reliability (Auditor General, 2009). Forests NSW advised the Auditor General that yield estimates have not been routinely compared to actual harvest results because there are significant variations between individual harvest areas within a region, thereby making it difficult to compare the actual with predicted volumes (Auditor General, 2009). Forests NSW has accepted the Auditor General's recommendation to compare harvest results to yield estimates over five-year periods as a means of testing the accuracy of estimates and to report the results annually commencing June 2010 (Forests NSW, pers. comm., 2009).

10.3.2 Review of long-term sustainable yield estimates

As part of this assessment, the NRC reviewed the impact of future climate change scenarios on the long term (100-year plus) sustainable supply of timber expected to be available from various forests. As the FRAMES model used by Forests NSW is not currently able to model timber yields at the level of Water Management Units for which climate change impacts on water availability were modelled, an alternative approach was used. The FRAMES model used by Forests NSW predicts stand characteristics and timber yields at a 'forest estate' level, namely each Management Area within the Riverina bioregion. FRAMES does not provide estimates at the level of individual forests or, in the terms of the NRC's assessment, water management units.

As an alternative to FRAMES, long-term (approximately 100 year) sustainable yields were estimated by applying growth rates in m^3 per hectare per year to areas expected to continue to produce timber. The NRC developed a simple spreadsheet model to undertake these analyses, and used independent expert review to corroborate the approach and results.

Methodology

The methodology that the NRC used focused on quota and ex-quota sawlogs, and comprised:

1. estimating the area[5] of Site Quality 1 and Site Quality 2 in each water management unit predicted to receive regular watering under the likely future environmental watering commitments discussed in **Chapter 8**
2. assuming that historical growth (1970–2002), mortality and other stand parameters would continue to apply in these parts of the forest receiving regular watering
3. assuming that net growth in those Site Quality 1 and Site Quality 2 areas of the forest that did not receive regular watering (step 1) would be 25 per cent of the growth rate of regularly watered area
4. assuming that there was no net growth of quota quality sawlogs in Site Quality 3 areas
5. varying assumptions of the extent of water management units watered (step 1) on the basis of expert opinion from forest managers.

The rationale for the assumptions is outlined below. The resultant estimates are indicative, but the methodology is amenable to modelling alternative assumptions.

This methodology was applied to estimate long-term sustainable yields for the Millewa forests[6] and Koondrook-Perricoota/Campbells Island forests. The NRC conducted detailed long-term sustainable yield analysis only for these Central Murray State Forests, for two reasons. First, as shown in **Table 10.2** below, some 86 per cent of long-term sustained

Table 10.2: Proportion of Murray Management Area (MA) timber yields by water management unit[7]

Water management unit	Timber yield (percentage of long term sustainable yield for Murray MA)
Millewa forests	56
Koondrook-Perricoota and Campbells Island forests	30
Werai forests	8
Upper Murray River riparian zone	3
Edward/Wakool and Edward River riparian zone	3

Table 10.3: Area (ha) by Site Quality (SQ) in Millewa forests and Koondrook-Perricoota forests (NRC analysis of data supplied by Forests NSW)

	SQ 1 (ha)	SQ 2 (ha)	SQ 3 (ha)	Total (ha)
Millewa forests	8,960	17,227	4,000	30,187
Koondrook-Perricoota and Campbells Island forests	3,286	19,098	6,252	28,636
Total[8]	12,246	36,325	10,252	58,823

[5] Areas of State Forest were classified by Site Quality by Forests NSW in the 1970s. These classifications are still in use for the purposes of managing forest areas.

[6] The Millewa forests for which long term sustainable yields were estimated include Millewa, Moira and Gulpa Island.

[7] Figures generated by FRAMES on the relative contributions to long term sustained yield in the Central Murray forests. Care should be taken in translating these to volumes. Contributions do not include the relative quality of the sawlogs produced. In general terms, the higher quality sawlogs required for veneer and furniture tend to be sourced from the Millewa forests.

[8] These figures are lower than the total 69,000 hectares of net harvestable area reported by Forests NSW as being managed for timber production in the Murray Management Area as they do not include smaller areas of productive forests such as Werai.

yield in the Murray Management Area originates from these forests; secondly, predicted flood regime mapping was available only for these forests.

Assumptions

The total areas of river red gum forests assumed in the NRC's modelling are shown in **Table 10.3** below. Areas of Site Quality 1 and 2 were included as they produce almost all current quota timber. Areas of Site Quality 3 were not included in the estimates as they produce little quota or ex-quota timber, which reflects their position in the landscape and historic lack of access to water.

The percentage of Site Quality 1 and Site Quality 2 areas predicted to receive regular watering under future climate change scenarios were estimated using the climate scenarios outlined in **Chapter 7** of this report and the hydrological modelling outlined in **Chapter 8**. While all modelling has inherent uncertainty as to its accuracy, the future climate scenarios used in this report are intended to adequately represent the range of possible impacts under climate change (as discussed in **Section 7.5**). Based on these predicted climate scenarios, the flooding regimes discussed in **Chapter 8** indicate a substantial reduction in the magnitude, frequency and duration of floods can be expected for the majority of forest stands, particularly the larger forest groups of Millewa and Koondrook-Perricoota. Without the delivery of additional environmental water to these forests, growth rates could be expected to continue the decline observed since 2003.

Two scenarios of future flow regimes were considered and compared to estimates of long-term yield based on applying historic growth rates across all areas of Site Quality 1 and

Perricoota State Forest

Table 10.4: Modelled extent of flooding in Millewa forests by Site Quality (SQ)
(NRC analysis using a River Analysis Package and Water Technology modelling)

Flow regime (60+ days duration)	Modelled inundation extent for combined Millewa forests*		
	SQ1	SQ2	SQ3
18,300 ML/d	32%	12%	2%
25,300 ML/d	48%	33%	19%
35,000 ML/d	58%	46%	30%

* This was applied to Site Quality definitions based on older mapping by Forests NSW, rather than more recent mapping used in **Chapter 8**.

Table 10.5: Modelled extent with flood enhancement works in Koondrook-Perricoota forests by Site Quality (SQ)
(NRC analysis using data from DHI Water and Environment, 2008)

Flow regime	Modelled inundation extent for combined Koondrook-Perricoota forests*		
	SQ1	SQ2	SQ3
Minimum operating strategy of 2,000 ML/d diversion for 100 days	46%	42%	33%
Preferred operating strategy of up to 6,000 ML/d diversion for 105 days**	57%	63%	45%

* Modelling for the scenario without flood enhancement works is for the combined Gunbower, Koondrook and Perricoota forests.

** Preferred operating regime is for 6,000 ML/d for 50 days then 3,400 ML/d for 55 days. Inundation extents are shown for 6,000 ML/day diversion.

[9] The areas derived for this assessment are consistent with those used by Forests NSW FRAMES model and are within 1 per cent or 2 per cent of figures provided by NSW FPA (pers. comm., 19 November 2009).

Site Quality 2:

- A 'Minimum watering' scenario which assumed 18,300 ML/day for the Millewa forests and the minimum operating strategy of 2,000 ML/d for the Koondrook-Perricoota forests
- An 'Upper bound' scenario which assumed 35,000 ML/day for the Millewa forests and the preferred operating strategy of up to 6,000 ML/d for the Koondrook-Perricoota forests.

Tables 10.4 and **10.5** show the modelled inundation extents for the Millewa forests and the Koondrook-Perricoota forests under these scenarios. Numbers differ slightly from those in **Chapter 8** as the Site Quality was defined based on data from Forests NSW mapping conducted in the 1970s, rather than more recent mapping used to determine Benson vegetation classes.[9]

Growth rates used in calculating yield estimates (as shown in **Table 10.6**) were based on the following assumptions:

- Historic growth rates (1970–2002) derived from Forests NSW Permanent Growth Plots were used for flooded areas of Site Quality 1 and Site Quality 2. Growth rates for Quota sawlogs for areas of Site Quality 1 and Site Quality 2 expected to be regularly flooded were based on the basal area growth model used in FRAMES.[10] Growth rates for Ex-quota sawlogs were assumed to be 70 per cent of the rate for Quota sawlogs. This is consistent with the ratio of base allocation of Ex-quota to Quota sawlogs.
- For areas of Site Quality 1 and Site Quality 2 not predicted to be flooded, a growth rate of 25 per cent of the historic growth rate (1970–2002) was assumed for the 100-year planning period. Areas not predicted to directly receive flooding may still achieve some growth due to the effect of flood water extending beyond the mapped extent of the flood, or through access to groundwater. The estimated growth rate for these areas was derived from data from Forests NSW Permanent Growth Plots in the period 2003–08, which show a 50 per cent drought-induced reduction in growth rates and doubling of drought-induced mortality rates to 1.5 per cent per year. The interaction of drought and mortality over a 100-year planning period is difficult to predict without further FRAMES modelling. For the indicative purposes of this exercise, a growth rate of 25 per cent of the historic growth rate was assumed, corresponding to the equivalent of 50 per cent of historic growth rates applied to 50 per cent of the trees over the 100-year period.
- Areas of Site Quality 3 were assumed to have negligible growth rates for quota timber, whether watered or not. This is consistent with results from strategic inventory sampling by Forests NSW, which indicates these areas do not currently produce significant amounts of quota quality timber.

These historic growth rates (1970–2002) are considered to be the most appropriate to use in this assessment as they are based on monitoring conducted by Forests NSW for the Central Murray State Forests. They therefore reflect the influence of the stand structure and historical silvicultural management of these specific forests on their growth rates. A range of other growth rates have been estimated by previous studies under different assumptions regarding watering and silvicultural regimes, as shown in **Table 10.7**. Growth rates at the upper end of the range are indicative of the yields that could be achieved under more favourable flooding regimes. It is also possible that selective thinning to favour the growth of dominant trees could increase the yields of higher quality timber. These two issues are discussed in more detail below, together with the results of the NRC's estimates of the long-term sustainable yield of red gum timber.

The likelihood of historic growth rates (1970–2002) being achieved on flooded areas was assessed by considering:

- The likelihood of modelled flow rates being achieved given operating and regulatory constraints
- Whether the modelled frequency of flooding under climate change scenarios is likely to be regular enough to maintain historical growth rates (1970–2002) for forests receiving water.

As shown in **Table 10.8**, for the Millewa forests, available volumes of environmental water, existing infrastructure and the extent of preparation for implementing the Barmah-Millewa Icon Site Management Plan provide reasonable confidence that 18,300 ML/d can be delivered in the future. However, given the current easement constraints of 25,000 ML/d between Hume Dam and Lake Mulwala, there is limited potential to artificially deliver larger floods to the forest unless easements are increased. The delivery of floods larger than 25,000 ML/d to Millewa forests depends on contributing natural flood flows from the unregulated Ovens River being passed downstream of Lake Mulwala/Yarrawonga Weir. It is possible that larger floods could be achieved if current easement constraints were removed, or if environmental water releases from the Hume Dam were timed to supplement flows from the Ovens River. These changes may be supported by future funding or management plans. Therefore the 'Upper bound' scenario is considered to be within the bounds of possible outcomes, but less likely than the 'Minimum watering' scenario.

For the Koondrook-Perricoota forests, proposed flood enhancement works are needed to allow floods of the necessary frequency, volume and duration to maintain the health of the forests. There is a reasonable level of confidence the flood enhancement works will be implemented; however, it will be several years before regular operation of the works is expected to improve the health of the forests. As shown in **Table 10.9**, there is reasonable likelihood the extent of flooding modelled for the 'Minimum watering' scenario of 2,000 ML/day diversion will be achieved, as this represents the minimum water requirement to deliver the environmental outcomes required to support the investment. However, the extent of flooding modelled for the 'Upper bound' scenario is

[10] Growth rates were derived over a 50-year period for current standing stock, assuming no silviculture and therefore no silviculture induced regeneration of new trees. Without the introduction of regenerating trees, the average growth rates could be expected to be slower over a 100-year period as the average tree age increases. However, if active but conservative silviculture is applied, rates close to the 50 year growth rate could be achieved over a 100-year period by reducing competition and reducing the average tree age. By comparison, the growth rate for quota quality sawlogs estimated in the 1985 Murray Area Management Plan (Forestry Commission of NSW 1985) was "between about 0.40 and 0.53 m3 gross/ ha/year", based on permanent growth plot data over the period 1971–1982.

[11] Growth rates for current standing trees were derived from Forests NSW FRAMES model over a 50 year period.

Table 10.6: Growth rates of Quota-grade timber assumed in NRC modelling of long-term sustainable yields by Site Quality (SQ)

Growth rates (m3/ha/year)	SQ 1 (ha)	SQ 2 (ha)	SQ 3 (ha)
Areas flooded	0.60	0.26*	0
Areas not flooded	0.15	0.06	0

*Average across SQ2 sites. A growth rate of 0.40m^3/hectare/year was used for more productive sites and 0.20m^3/hectare/year for less productive sites.

Table 10.7: Range of reported growth rates or production rates for river red gums

Growth rate or production rate (m3/ha/yr)	Timber quality	Site Quality (SQ)	Watering regime	Other factors impacting growth	Source
3.5	Merchantable logs	High quality	Pre-regulation (1940s and 50s), regular flooding	Selective thinning	Jacobs, 1955
Up to 4.8	NA	SQ1	Pre-regulation, natural flood regimes	Even aged stands	Baur, 1983
Up to 3.2	NA	SQ2	Pre-regulation, natural flood regimes	Even aged stands	Baur, 1983
1.43–0.67	Merchantable logs	All	Annual (winter) flooding, upper end of range for forest in flood water, lower end of range for areas up to 75m from flood	Data for Gulpa Island	Bacon et al., 1992
0.78	Saw logs	Average for SQ1- 3	Flooding 7–8 years in 10	Barmah forest, with 'current' forest management	Maunsell, 2003
0.60	High quality saw logs	SQ1	Pre-drought (1970–2002)	Data for Central Murray State forests	Forests NSW[11]
0.22	Saw logs	Average for SQ1- 3	Flooding 4 or 5 years in 10	Barmah forest, with 'current' forest management	Maunsell, 2003
0.18–0.16	Merchantable logs	All	No flood for 2 years, upper end of range for forest in flood water, lower end of range for areas up to 75m from flood area	Data for Gulpa Island	Bacon et al., 1992
Negligible	Saw logs	SQ1, 2, 3	2 years out of 10	Barmah forest, with 'current' forest management	Maunsell, 2003

Table 10.8: Likelihood of modelled flow rates being achieved for the Millewa forests

Scenario	Flow rates	Factors required to achieve flow rates	Likelihood
Minimum watering	18,300 ML/day	100 GL/yr environmental water entitlements plus 50 GL/yr lower security allocations provided for Millewa.	Reasonable
Upper bound watering	35,000 ML/day	As above for Millewa, but with either expansion of legal operating constraints for regulated flows between Hume Dam and Lake Mulwala, or natural flooding from the Ovens River.	Low

Table 10.9: Likelihood of modelled flow rates being achieved for the Koondrook-Perricoota forests

Scenario	Flow rates	Factors required to achieve flow rates	Likelihood
Minimum watering	2,000 ML/day	Koondrook-Perricoota Flood Enhancement works built at capital cost of $56m and minimum 2,000 ML/day operating strategy implemented.	Reasonable
Upper bound watering	Up to 6,000 ML/day	As above, but preferred (maximum) 6,000 ML/day operating strategy implemented at Koondrook-Perricoota.	Low

considered less likely. While the proposed scheme is capable of inundating up to 52 per cent of the forest (with the 6,000 ML/d event), this extent of flooding cannot be maintained. The maximum maintainable extent across the whole forest is 41 per cent, with this reducing quickly during the flood recession.

It is likely that flooding frequencies of every 2–3 years for Millewa and up to every four years for Koondrook-Perricoota are close to those experienced post-river regulation but prior to the current drought. **Table 10.10** below shows a range of reference frequencies of flooding both pre-river regulation and post-river regulation. For the Millewa forests, as discussed in **Section 8.7** of this report, CSIRO MDBSY modelled floods exceeding 18,300 ML/day[12] as likely to occur on average each 2.6 years with current levels of water resource extractions and historic (1895–2006) climate conditions. For the Koondrook-Perricoota and Campbells Island forests, as discussed in **Section 8.8** of this report, CSIRO MDBSY modelled floods exceeding 30,000 ML/day as likely to occur once every 3.8 years on average under historic (1895–2006) climate conditions but with current levels of water resource extraction. As river inflows during 1970–2002 (prior to the current drought) were similar to the long-term historic levels (see **Section 7.2**), it is reasonable to assume that flooding frequencies would have been similar to these modelled rates. Flooding frequencies of every five years of less frequently are unlikely to be sufficient to maintain historic growth rates (Maunsell, 2003).

The modelled frequency of different flows for Millewa forests is shown in **Table 10.11** below under two climate change scenarios (as outlined in **Chapter 8**):

- Scenario B – recent climate (1997 to 2006, 'step-change') with current water resource development extractions
- Scenario Cmid – best estimate (median) future climate to 2030 with current water resource development extractions.

Table 10.10: Reference flooding frequency (Dexter and Poynter, 2005 and NRC analysis)

Flooding regime	Average period between floods	Source
Barmah forest		
Pre-river regulation (1891–1934)	1.4–1.6 years*	Dexter and Poynter (2005)
Pre-drought (1955–2001)		
• 25%–50% of forest	2–2.5 years**	Dexter and Poynter (2005)
• up to 75% of forest	>5 years***	Dexter and Poynter (2005)
Millewa forests Historic climate (1895–2006) with current water resource development extractions (18,300 ML/day)	2.6	NRC analysis using CSIRO and Water Technology modelling
Koondrook-Perricoota forests Historic climate (1895–2006) with current development (30,000 ML/day for 30 days)	3.8	NRC analysis using CSIRO and TLM modelling

* Estimated from flooding frequency of 7–8 years in 10 observed pre-river regulation.

** Estimated from flooding frequency of 4–5 years in 10 as a result of actual Murray River flows below Yarrawonga/Tocumwal since 1955.

*** Estimated from flooding frequency of less than or equal to 2 years in 10, which was present/predicted as a consequence of MDBMC and NSW and Victoria state land and water management policy decisions.

Table 10.11: Modelled frequency of flooding in Millewa forests
(NRC analysis using a River Analysis Package and Water Technology modelling)

	Average period between floods in years (assuming current levels of development)	
Flow regime (60+ days duration)	**Cmid**	**B**
18,300 ML/d ('Minimum watering')	3.5	8.2
25,300 ML/d	5.4	14.2
35,000 ML/d ('Upper bound watering')	Not available	Not available

[12] As discussed in **Section 8.4.1** of this report, a summer–spring flood of more than 18,300 ML/day is likely to be needed to achieve 55 per cent inundation of the Barmah-Millewa forests.

Based on these frequencies, the 'minimum watering' scenario for the Millewa forest group is reasonably likely to maintain pre-drought growth rates under the best estimate (median) future climate to 2030 for the 32 per cent of Site Quality 1 and 12 per cent of Site Quality 2 that is inundated. However, under Scenario B (recent 'step-change' climate), flooding is unlikely to be frequent enough to maintain historical growth rates (observed between 1970 and 2002). Flooding frequencies under the 'upper bound' watering scenario are also unlikely to maintain historical growth rates.

The frequency of flooding in the Koondrook-Perricoota forests will depend on the actual operating strategies put in place following the proposed engineering works; flood frequencies of one in three years (or around 3.3 years between events) were modelled in investment proposals. The acceptable minimum target for reduced flood frequency is considered to be half of the natural frequency, or around one year in three (TLM, 2008). If these rates are achieved, pre-drought growth rates may be maintained in Koondrook-Perricoota.

Results

Based on this methodology, a range of estimated long-term sustainable yields were modelled under different scenarios, as shown in **Table 10.12** and **Table 10.13**. Given the simplified nature of the methodology used, these estimates should be regarded only as indicative, and it would be desirable to substantiate the indicative estimates by using FRAMES for a more comprehensive analysis than was possible within the timeframe of this assessment.

The likelihood of each scenario being realised has also been assessed based on judgements about the delivery of water volumes required for the assumptions behind each scenario. The 'Minimum watering' scenario is considered to have reasonable likelihood, as there is some confidence the factors required to achieve the assumed flooding regimes are feasible. The 'Upper bound' watering scenario is considered less likely, as the required flooding is at the upper end of what is considered feasible given current water policy settings. The

Table 10.12: Summary of yield estimates for the combined Millewa, Koondrook-Perricoota and Campbells Island forests

Scenario	Estimated yield of Quota and Ex-quota sawlogs (m³/year)			Assumptions	Likelihood of modelled flow rates being achieved	Likelihood of sufficient flooding frequency to achieve pre-drought growth rates
	Areas flooded*	Areas not flooded**	Total			
Minimum watering	7,700	5,000	12,700	• Millewa forests inundated per modelled 18,300 ML/day flow regime (32% Site Quality 1 and 12% Site Quality 2 areas inundated). • Koondrook-Perricoota forests inundated per modelled 2,000 ML/day diversion rate (46% Site Quality 1 and 42% Site Quality 2 areas inundated). • Same percentage inundation assumptions for Campbells Island forest as for Koondrook-Perricoota forests.	Reasonable	Reasonable
Upper bound watering	14,400	3,300	17,700	• Millewa forests inundated per modelled 35,500 ML/day flow regime (58% Site Quality 1 and 46% Site Quality 2 areas inundated). • Koondrook-Perricoota forests inundated per modelled 6,000 ML/day diversion rate (57% Site Quality 1 and 63% Site Quality 2 areas inundated). • Same percentage inundation assumptions for Campbells Island forest as for Koondrook-Perricoota forests.	Low	Low
Continuation of historic growth	NA	NA	27,600***	• All of Site Quality 1 and Site Quality 2 areas in Millewa forests, Koondrook-Perricoota and Campbells Island forests achieve historic growth rates.	Unlikely	Unlikely

* Assumes inundation occurs at sufficient frequency and duration to sustain growth rates of river red gums based on 1970–2002 PGP data.

** Assumes growth rates of 25% of those in flooded areas.

*** This estimate was derived by applying the growth rates shown in **Table 10.6** to the 48,571 hectares of Site Quality 1 and Site Quality 2 in the Millewa forests, Koondrook-Perricoota forests and Campbells Island forest shown in **Table 10.3**. Estimates for other areas of forest in the Murray Management Area were not included as it is the NRC's assessment that they are unlikely to provide substantial long-term yields. By comparison, the long-term sustained yield of merchantable sawlogs (quota and ex-quota) in the 1985 Murray Management Area Plan (Forestry Commission of NSW, 1985), was estimated between 22,400 and 29,700 m³/year from 56,000 hectares of Site Quality 1 and Site Quality 2 in the Millewa, Koondrook, Werai, Mulwala and Wakool forests.

'Continuation of historic growth' scenario is considered unlikely in the long term as it would imply a return to the higher growth rates experienced between the 1970s and 2002. These were achieved under pre-drought conditions which are contrary to the climate change predictions for south-eastern Australia.

For these reasons, the 'Minimum watering' scenario shown in **Table 10.12** and **Table 10.13** is more likely than the 'Upper bound watering' scenario. Consequently, assuming the frequency of inundation is sufficient to maintain historic growth rates in those areas receiving water, long-term sustainable yields of quota and ex-quota sawlogs are more likely to be in the order of 13,000 m^3/year than 18,000 m^3/year. For the reasons discussed in **Chapter 8**, sufficient water is unlikely to be available under future climate change scenarios to support higher yields.

The estimated long-term sustainable yield from the Millewa, Koondrook-Perricoota and Campbells Island forests, of around 13,000 m^3/year, represents only 30 per cent of the 2008–09 base allocations of quota and ex-quota timber from these forests of around 41,000 m^3 (including small volumes from the Werai forests)[13]. While information on future water availability was not available for other areas of State Forest, reductions of a similar order of magnitude are likely given the substantial reduction in the magnitude, frequency and duration of floods under future climate change scenarios discussed in **Chapter 8**.

However, some submissions have suggested that growth rates substantially greater than those realised historically could be achieved through more frequent and prolonged watering. For example, Dexter and TCA (Maunsell, 2003) estimated a range of yields, assuming various watering and silvicultural regimes, for the Barmah forest in Victoria. Yield estimates for those flooding regimes nominated by Dexter and TCA (Maunsell, 2003) which the NRC considers most likely (flooding frequency 2–2.5 years/decade) generated yields comparable to those from Forests NSW data used in the NRC's modelling. Higher yields nominated by Dexter and TCA required much more frequent flooding, of 7-8 years every decade. At these very frequent flooding rates, and under a silvicultural regime approximating that which the NRC recommends in **Chapter 11**, Dexter and TCA's estimates might generate yields of 2 m^3/ha/yr across all site quality classes[14]. Dexter and TCA (Maunsell, 2003) noted that achieving this outcome would require substantial engineering works and water, and so implementation may be limited in practice. At slightly lesser flooding frequencies, of 6–7 years every decade, the comparable estimate is 1.55 m^3/ha/yr[15].

If these estimates of higher growth rates were applied to the 40 per cent of Koondrook-Perricoota flooded under the 2,000 ML/day scenario, long-term sustained yield would rise from around 5,700m^3/year (estimated on the basis above)to between 15,500 and 20,000 m^3/year. These figures demonstrate the potential for adequate watering to enhance river red gum yields, as well as the health of the forest more generally. This result applies similarly to other areas of river red gum forest.

There is evidence from previous studies (Baur, 1984; Dexter 1970; Horner et al., 2009), and empirical evidence in a number

Table 10.13: Range of possible yield estimates from Millewa, Koondrook-Perricoota and Campbells Island forests, by timber quality (m3/year)

	Areas flooded		Areas not flooded (assumed to produce ex-quota sawlogs)	Total
	Quota	Ex-quota		
Minimum watering scenario				
Millewa forests	2,000	1,400	3,600	7,000
Koondrook-Perricoota and Campbells Island forests	2,500	1,700	1,400	5,700
Total	**4,500**	**3,200**	**5,000**	**12,700**
Upper bound watering scenario				
Millewa forests	5,000	3,500	2,300	10,700
Koondrook-Perricoota and Campbells Island forests	3,500	2,500	1,000	7,000
Total	**8,500**	**6,000**	**3,300**	**17,700**
Continuation of historic growth				
Millewa forests	10,500	7,300		17,800
Koondrook-Perricoota and Campbells Island forests	5,700	4,100		9,800
Total	**16,200**	**11,400**		**27,600**

13 Based on the minimum watering scenario which is considered more likely.

14 Dexter and TCA's Scenario 2, without Low Bank Works, gives yield estimates of 1.35 m^3/ha/year for sawlogs only to 2.35 m^3/ha/year for sawlogs plus other products (Maunsell, 2003).

15 Per NSW FPA pers. comm., 25 November 2009.

Inspection of sawlogs at Gulpa Mill

of submissions, that yields of higher quality timber could be improved by thinning (**Chapter 11**). To the extent that the thinning practiced previously in the Central Murray State Forests has impacted on the stand growth assessed by the Forests NSW Permanent Growth Plot network, some of these impacts will have been captured in that data. Further research will be necessary to determine the extent to which this is the case, and to clarify the impacts of thinning on both watered and unwatered stands on growth and yield of different log quality classes.

Other submissions have suggested that sustainable long-term yields may be achieved from areas of the forests that are not regularly inundated with flood water, but which have access to groundwater sources. There is evidence that river red gums opportunistically use groundwater as a water source in some forests of the Riverina bioregion. Shallow floodplain groundwater systems are recharged by flooding, which is likely to be more significant than recharge from rainfall and regional groundwater flow in some areas. However, as discussed in **Section 8.13** of this report, groundwater levels in both deep and shallow aquifers in the Riverina bioregion are falling due to groundwater extraction and recent climatic conditions. Therefore it is likely that groundwater has and will become less accessible as a source of water for vegetation.

Conclusion

On the basis of the scenarios modelled above, the NRC's assessment is that long-term sustainable yields (of quota and ex-quota logs combined) are in the order of 13,000 m^3/year may be available from the Central Murray State Forests if the planned Millewa Icon Site Watering Plan and Koondrook-Perricoota flood enhancement works are implemented. In the NRC's view, the river red gum stands along the majority of the Murrumbidgee River, along the Lachlan River, and along the Edward, Wakool and Murray rivers downstream of Koondrook-Perricoota forests, are unlikely to provide substantial long-term sustainable yields. A significant reduction in flood extent, duration and frequency under climate change scenarios is expected for the majority of these forests, as discussed in **Chapter 8**. Many of the forests along the Lachlan and lower reaches of the other river systems are already in poor health and productivity because of lack of flooding and drought. The river red gum stands along the Upper Murray River, and possibly the Upper Murrumbidgee, are likely to be more resilient to climate change as they have better prospects of receiving what water is available. However, the Upper Murray River forests cover only very small areas and are unlikely to provide significant volumes of timber, and those in the Upper Murrumbidgee have been heavily logged in the past decade.

10.3.3 Transition to sustainable yields

These estimates are for long-term sawlog yields that could be maintained over a 100-year timeframe, should conditions required for growth be maintained. However, as at present, forest managers or government can also opt to maintain a higher level of harvest than the long-term sustained yield for some defined period of time. This is a defensible management option as long as:

- the basis for that decision is transparent

[16] Once these principles are codified in an Integrated Forestry Operations Agreement, the NRC considers they will maintain the ecological character of the forests, and protect matters of National Environmental Significance, while continuing to support production values.

- the silvicultural principles[16] enunciated in **Chapter 11** are respected
- the consequences in terms of the ultimate reduction in yield are similarly clear
- a strategy is put in place to manage the ultimate decline in timber volumes available to the red gum forestry industry.

Modelling using FRAMES, adjusted for areas at a water management unit level and to model for changes in vegetation structure and growth rates, would be required to provide adequate information to understand the implications of harvesting at higher rates over the near to medium term. As an example of the way in which yield might be 'brought forward', Forests NSW quota allocations for the Central Murray State Forests based on a 70-year planning cycle, of around 23,000 m^3/year, are around 40 per cent higher than those for the same forests based on a 100-year planning cycle. The current allocations reflect a conscious decision by Forests NSW to optimise production from these forests, given their uneven age structure which is dominated by standing stock generated in the 1880s.

There is less certainty about the future yield of ex-quota sawlogs, and about short- to medium-term volumes of lower quality logs that may be available as a result of declining stand health in many forests. However, field observations by the NRC, and a number of submissions, suggest these volumes may be substantial. Provided the principles outlined in **Chapter 11** are respected, there is no reason why these volumes should not be available to industry from forests managed for production. There may also be commercially viable volumes available from other tenures in which ecological thinning is permissible in line with the principles outlined in **Chapter 11**. Further modelling using FRAMES is necessary to clarify the volumes likely to be available. Accessing some proportion of this currently standing resource would provide a further means of assisting the red gum forestry industry to adjust to the sustainable yields available in the longer term.

10.4 Implications for industry future

The unprecedented changes in the river red gum forests of the Riverina bioregion in response to river regulation, climate variability and predicted climate change will have profound implications for the future of the forest-based industries which currently rely on them. A return to the conditions under which the current forests, and associated red gum forestry industry structure developed, will not be possible. Change is inevitable as some elements of the industry adapt and others choose to exit. Completely new industries may develop in response to the opportunities afforded by the changing situation, and in doing so transform the nature of the forest-based industry. Either way, the future forest-based industry in the region will look very different from how it does today.

10.4.1 Implications for the current industry structure

Indicative estimates of long-term sustainable yields of sawlogs that might be expected to be available from the Millewa and Koondrook-Perricoota Forests under climate change scenarios represent substantial reductions, of up to 70 per cent, compared to current base allocations. Equally substantial reductions can be expected for other forest groups in the Riverina bioregion. Base allocations of quota and ex-quota sawlogs will need to be reduced to reflect long term sustainable yields, prior to any consideration of changes in land tenure. In the short to medium term, at least, timber production from the river red gum forests

Furniture made from river red gum

will shift significantly toward lower quality timber as reductions in growth rates and increases in mortality observed during the current drought reduce the availability of high quality quota sawlogs. However, significant volumes of lower quality timber are still likely to be available from both public and private land. In addition, substantial volumes of lower grade timber may be available on a short- to medium-term basis if ecological thinning, consistent with the principles outlined in **Chapter 11**, is carried out in particular forests.

The current forestry industry structure will need to change in response to reduced quality and quantity of timber yields. There may also be an increased variability in supply, reflecting a different mix of land tenures and management objectives in the future. The overall impact on the industry will depend on the diversity of responses of individual business. This in turn will depend on the flexibility of their business strategy and on the extent to which technological change and product markets develop to optimise the use of the future river red gum resources. While it is not possible to predict the exact outcome of these changes, some broad general trends can be considered likely.

The future river red gum sawmilling and processing industry is likely to be smaller than at present. It will have a much more limited resource base to draw on, particularly of high quality logs in the short-medium term as a consequence of the legacy of river regulation and drought. In contrast, the legacies of river regulation and drought are likely to provide a substantial resource of lower quality timber, suitable mostly for residual products. The reduced availability of high quality timber may favour businesses with low capital intensity, given the lower product margins associated with lower grade timber products, or businesses which are able to recover greater value from lower grade products.

However, in the short to medium term, it would be possible to sustain higher volumes of sawlogs than are available over the long term as part of a managed industry transition strategy discussed in **10.3.3**. New technologies may also help recover greater value from smaller and poorer quality logs, and partially offset the decline in the traditional higher quality log resource.

If base allocations are reduced to reflect long-term sustainable timber yields, only one or perhaps two of the current six quota mills are likely to be supported. The eight ex-quota mills currently in operation are also likely to be impacted by reduced ex-quota allocations. However, some of these businesses may benefit from an increase in low quality timber and firewood over the medium term. Residue operators are the most likely to benefit from changes in allocations, and the number or size of existing businesses may increase if large volumes of low quality timber are available from ecologically-focused management of forests and bushfire hazard reduction.

10.4.2 Opportunities for adaptation

The ability of businesses to adapt to changes in timber supply will depend on a range of factors including the flexibility of their current business structure, access to capital, and the strength of their distribution channels and ties to end markets. Forestry industry businesses surveyed during this assessment have implemented a range of strategies to maximise their returns. The current status of plant and equipment, business focus, current supply volumes, and reliance on timber of certain quality varies between businesses in the industry.

Quota mills

Three of the six quota mills have pursued a strategy of investing in value adding equipment to produce kiln dried timber, furniture and veneer products. These mills have a reliance on high quality quota timber. Given future reductions in the availability of Australian native hardwood timber, there is potential for a boutique value-adding industry. However, the low volumes of high quality timber and uncertainty of supply pose significant constraints on investment in equipment, marketing and distribution that are likely to limit the size of industry. Three other mills have opted to adjust to lower quality of timber, with a focus on sleeper and firewood products. These mills are relatively better placed to adapt to higher near term volumes of lower grade timber.

Within the constraints of the quality of the resource, limited resource security and the scale of processing enterprises and ability to finance capital investment, the red gum processing industry has been quite innovative over the last decade. The technology to add value to high quality timber resource is spread across the primary processing industry as most quota mills dry timber, and veneering, laminating and finger jointing is undertaken by various producers as well as the production of traditional products such as strip flooring. Further, new technologies for recovering higher value products from smaller and poorer quality logs[17] may assist all mills to adapt to a resource with these characteristics.

The distinctive appearance of red gum timber, combined with the increasing scarcity of Australian red hardwoods and increasing restrictions on the import of competing tropical timbers, may support a boutique market for high-end, value-added timber products. Red gum timber is a recognised red hardwood used for appearance grade products in Australia and internationally. Supply of Australian alternative red hardwoods (notably jarrah) has been restricted by previous Regional Forest Agreements. Imports of dark red hardwoods from natural forests abroad are diminishing because of over-exploitation (Jaakko Poyry, 2005), and are likely to diminish further as a result of Australian Government policy to curtail the import of illegally harvested timber (DAFF, 2009). Import of red gum hardwood products from plantations abroad, such as those in South East Asia, may increase as solid wood products are increasingly recovered from these plantations. However, these plantations are typically grown by farmers on short (3-10 year) rotations, and generate small-size timber suitable for a limited range of value-added products[18].

One opportunity for adaptation is consolidation between quota mills to optimise current and potential further investment in technology. Technologies such as veneering allow greater volumes of end product from increasingly scarce high quality timber (BIS Shrapnel, 2001). There may also be some opportunity for newer sawing systems to improve the recovery of quality timber from smaller logs or enable a greater focus on production of feature timber from lower quality logs. However, there are limits in the extent to which further investment in value

[17] For example, Buraphawood (www.buraphawood.com) utilises short-rotation plantation-grown red gum timber from Laos to produce architectural and furniture products.

[18] See, for example, www.buraphawood.com

adding equipment can improve the volume recovery of timber suitable for higher value products.

Access to alternative sources of timber from private land may ease adaptation in the short term. However, the low quality and variability of supply means substitution for timber from public land is likely only to make a marginal difference to mills which have invested in value-adding equipment. The two mills which have pursued a strategy of focusing on sleeper and firewood products have already moved to source timber from private land.

Ex-quota mills

The eight ex-quota mills which rely on timber from public land already have inherent flexibility in operations, which is reflected in their responsiveness to the variable markets for lower grade sleepers and firewood. The mobile nature of their operations and lower capital investment in equipment support this flexibility. These operations may benefit from increases in lower quality timber and firewood from ecological thinning of forests.

The mobile ex-quota sawmills are almost exclusively operated by small family companies or partnerships. This element of the forestry industry is characterised by improvisation. Some of the more entrepreneurial operators have diversified and expanded their operations by harvesting and processing forest residues for woodchips, firewood and craftwood (URS, 2001).

Markets for firewood products offer an opportunity for mobile ex-quota mills to adapt to changes in timber supply. The firewood market for native hardwood timber is estimated to be in the order of 5–7 million tonnes (Driscoll et al., 2000). Assuming this demand remains, the market should be able to absorb increases on top of the current supply of approximately 100,000 tonnes per annum of red gum timber from public land. Despite its highly seasonal nature, there is potential for the red gum firewood market to expand to less traditional supply areas of Adelaide and Sydney (BIS Shrapnel, 2001).

Residue operators

Residue operators reliant on public land run flexible businesses with low capital investment. Generally the equipment used by residue operators is mobile as firewood is cut in the forest and capital costs are minimised as equipment is second hand (BIS Shrapnel, 2001). These operators are likely to benefit from the increased volumes of low grade timber available from ecological thinning and bushfire hazard reduction.

10.4.3 Opportunities for transformation

There is potential to drive the establishment of new timber industries given a sufficiently high carbon price, technology development and industry innovation. New energy generation technologies may make it viable to utilise the increased volumes of low quality timber from dead and dying trees, ecological thinning and bushfire hazard reduction. Plantation timber grown for carbon sequestration may also become financially viable with a sufficiently high carbon price. These are opportunities for transformation rather than adaptation of the current industry, given the uncertainty over carbon pricing, water availability and the timeframe involved in investment and development of new technologies and new plantations.

Prospects for energy and chemical feedstock production

Several submissions have suggested an opportunity for further investment in innovative technologies for utilising lower grade wood and residues for energy or biofuels. Adding value to residues currently used for firewood, mulch sawdust and even bark is possible, but would require higher returns than from existing markets to warrant the capital expenditure. However, with a carbon price signal in place, pyrolysis to produce charcoal for use in metallurgical processes, biochar and bio-oil or chemical precursors, as well as production of ethanol from wood, are possible technologies for consideration.

The most suitable technology is likely to be pyrolysis to produce energy from biochar, biogas and electricity; or from biochar and bio-oil. Advances in pyrolysis technology indicate the potential for it to be deployed at smaller or modular less capital intensive scales and utilise feedstock of wider technical specification than in the past. Such technologies should be eligible for renewable energy certificates and would benefit from increased competitiveness against conventional fossil fuels under the planned Carbon Pollution Reduction Scheme.

Production of ethanol from wood is also possible, but the technology to convert eucalypts to ethanol commercially has not yet been demonstrated. Significant capital investment would be required and, as with pyrolysis, the business case would be sensitive to the cost, quality and security of supply of feedstock.

Prospects for forest plantations in the Riverina bioregion

A number of submissions have raised the prospect of planted forest resources, particularly through various forms of farm planting, emerging as an alternative source of wood supply to the native river red gum forests. A body of work over the past decade, including a number of trials, has assessed the prospects for low-rainfall farm forestry of eucalypt species in the NSW Riverina (CSIRO et al., 2001; Stephens et al., 2002; Borschmann and Poynter, 2003; Scott, 2006). The results of these trials confirmed that 'conventional' commercial plantation or farm forestry was not viable in the majority of the Riverina bioregion without access to irrigation (Scott J, former Executive Officer, Murray Riverina Farm Forestry, pers. comm., 2009).

As discussed in **Chapter 7**, the NRC's assessment is that the Riverina is facing a more water-scarce, rather than water-rich, future, and so it seems unlikely that irrigated plantations of red gums could be established on any scale. This conclusion is consistent with that reported by Powell (2009), in his summary of research outcomes from the Joint Venture Agroforestry Program, and with those reported more generally by CSIRO et al (2001). It contrasts with that reported for north-east Victoria by Borschmann and Poynter (2003) principally because of the substantial difference in rainfall, and thus growth rates, between the two regions.

A more promising direction for commercial tree planting may be that directed primarily at carbon sequestration. Such plantations may also provide other environmental services and are likely to involve the establishment of novel tree crops such as oil mallees. Both the Garnaut Climate Change Review (2008) and the Wentworth Group of Concerned Scientists (2009) advocate large-scale reforestation as one of the means to mitigate climate change, and point out that extensive areas of Australia's low rainfall zones may be suitable for such reforestation. The extent to which carbon sequestration-based commercial opportunities

Deniliquin Town Centre

will be realised depends on the future arrangements for any Australian carbon pollution reduction scheme, and possibly on related international arrangements.

In summary, the low rainfall across most of the Riverina bioregion precludes commercial returns from conventional plantation or farm forestry crops unless they can be irrigated. Tree planting which generates returns from novel products, and from carbon sequestration and perhaps other environmental services, are more likely to have potential in the Riverina. Both the growth rates and products from such plantings mean they are unlikely to substitute for red gum timber production in anything other than the very long term.

10.5 Implications for local communities and towns

Towns within the Riverina bioregion are facing a decline in their economic base due to the impacts of ongoing drought on the agricultural industries which form the base of their economies. For those towns in the region with ties to the river red gum forests, river regulation is also impacting the health and productivity of these forests. The predicted impacts of climate change are likely to continue these trends.

The ability of local communities to adapt to such changes is in part dependent on the diversity of industries that support those communities and the varied opportunities available to accommodate industry change. Social research over the past 30 years has shown that while some communities are able to respond to change effectively, others are less able to make a progressive shift.

The NRC has assessed the adaptive capacity of towns in the Riverina and found that several towns have close ties to the forest industry through the employment and local expenditure it provides. Of these, the twin towns of Barham-Koondrook and the town of Mathoura have less capacity to adapt to changes in climate than other towns and have the highest reliance on the red gum forestry industry. Conversely, Deniliquin appears to exhibit the greatest resilience to potential climate change impacts, with a lower vulnerability to change, a greater degree of industry diversity and low reliance on the red gum forestry industry.

10.5.1 Approach to analysing adaptive capacity of Riverina towns

The adaptive capacity of seven towns within the Riverina bioregion which have close links to the red gum forestry industry reliant on public land was assessed using a range of available statistical indicators. These indicators were compared between towns and to an average for outer regional NSW.

The conceptual framework for the analysis was based on the assumption that a community's capacity to adapt to change is dependent on the status of its economic, physical, human and social capitals. Central to the framework is the inter-relationship between capitals. Where one capital is depleted, other community capitals are also likely to become compromised. For example, the depletion of human capital through deterioration of education levels or community health is likely to impact on social and economic capitals.

Brown (undated) highlights that a community's adaptive capacity may be slowed by a number of factors including:

- age profile
- education profile
- employment profile
- income levels
- diversity of current income sources.

Each aspect of economic, physical, human and social capital was assessed using a range of demographic indicators sourced from readily available published information (such as ABS data)

Consultation with forestry industry representitives

and supplemented by primary surveys with forestry industry operators and discussions with local councils undertaken by the NRC. The indicators selected are broadly in line with other similar studies of social vulnerability in communities which rely heavily on a single industry (CARE, 2009).

For the purpose of the current work, the NRC has defined the NSW portion of the Riverina bioregion as including the Statistical Local Areas of Balranald, Berrigan, Conargo, Deniliquin, Griffith, Murray, Murrumbidgee, Wakool and Wentworth. The location of the Riverina bioregion is described in more detail in **Chapter 2**.

The towns of Barham-Koondrook (which functions as one community), Deniliquin, Mathoura, Darlington Point, Balranald and Merbein were assessed as being likely to have the most reliance on the forests. These were towns with 1 per cent employment or greater in the red gum forestry industry. Echuca-Moama was not included as a town of interest as it does not have direct employment in the forestry industry. This selection of towns was cross-checked with NSW Forest Products Association, the peak representative body for the forestry industry.

10.5.2 Indicators of adaptive capacity

Economic capital and associated variables

The status of a town's economic resources has significant implications in relation to its ability to cope with change. Moreover, a town with strained economic resources at an individual or household level is likely to be more vulnerable to change or a disruption in industry activities, especially if the town is heavily dependent upon that specific industry for economic sustainability. Low levels of individual or household economic capital will also adversely affect individual abilities to recover from the impacts of significant change in the structure of their local economies, as well as their capabilities to adapt to new economic activities.

The diversity and range of industry or commercial economic activities is a key indicator of a community's capacity to accommodate further industry diversification and hence, economic growth. For example, a community with a predominant dependency on the forestry sector, and with limited diversification across other industry sectors, is likely to be particularly sensitive to changes within the forestry industry.

Economic variables used in this assessment include, but are not limited to:

- home ownership (whereby a high proportion of residents renting from Government or community organisations would suggest a lack of capital investment at an individual or household level)
- income levels (whereby a high proportion of income earners earning less than $500 per week is considered to indicate low levels of economic resources and disadvantage at an individual or household level)
- employment status (including total employment in the forestry industry)
- economic diversity (using the Herfindahl Index[19], where a high index score represents greater industry concentration and limited industrial diversification).

Physical capital and associated variables

The physical resources of a town or community include its built infrastructure and services including hospitals, schools, health care, aged care and child care. These services and resources are important factors in determining a community's adaptive capacity. A highly remote community, which lacks access to basic facilities and other social services, may lack the capacity to enhance its local human skills base, and might also be disadvantaged in capitalising on opportunities for further industry development and economic capital growth.

While it seems logical that larger towns provide more services, other factors are also important considerations. For example, personal mobility and car ownership enable people to travel further and more often and large supermarkets in nearby regional centres reduce the need for general stores in small towns.

Access to information is also important as it enables members of the community to address their information needs, and connect with other members of the community and the broader society.

Physical variables used in this assessment include, but are not limited to:

- distance from regional service centres
- access to internet
- accessibility to public services (for example, a library).

[19] The Herfindahl Index squares the market-share of commercial and industry activities, and then sums those squares. (Bradley and Gans, 1998)

Human capital and associated variables

Human capital can provide an indication of the health and welfare of human beings, their knowledge and skills, as well as their overall capacities to contribute to ongoing community sustainability. A community that has a higher proportion of lower skilled persons and is heavily dependent on a particular industry tends to be more vulnerable to potential risks and threats to its livelihood. Some studies have shown that less skilled communities are also less likely to become motivated in initiating positive change (Arcidiacono, et al., 2008). In the instance where a town is predominantly reliant on the forestry industry, a less educated and lower-skilled community may be more challenged in independently developing new economic opportunities and skill-sets. Therefore, these communities will most likely be in need of external assistance or support.

Another useful indicator is the prevalence of highly vulnerable or at risk minority groups, which may include immigrants and refugees, people with a disability, Indigenous persons, people who do not speak English or elderly persons (aged 65 years and over). A high concentration of vulnerable or at risk minority groups is likely to increase a community's overall vulnerability to significant change and risks. Further to this, recognition of community diversity within and across the towns and region is important when considering how public land is to be used in the future (VEAC, 2006).

Human variables used in this assessment include, but are not limited to:

- post-school qualifications (percentage of persons aged 15 years or over without post-school qualification)
- skills and expertise (percentage of employed persons in low skilled roles)
- minority or vulnerable groups (for example, percentage of total population which is Indigenous, percentage of people aged 65 years or above as a proportion of total population).

Social capital and associated variables

When assessing a community's capacity to adapt to change, it is also important to consider how individuals, groups, organisations and institutions within a community interact and co-operate.

Social capital broadly defines the dynamics and strength of relationships and interactions within a given community (Lochner et al., 1999) and the degree of social cohesion and inter-connectedness between community members.

A key indicator is the degree of community participation, or level of community involvement in processes aimed at maintaining or enhancing community well-being. These processes may include participation in community groups or not-for-profit voluntary activities in addition to professional commitments.

Another useful measure of sense of community is the degree of transience within a given town. Highly transient populations tend to be less socially cohesive. A community with a high proportion of short-term and temporary residents may be less likely to have high levels of community pride, with these residents also likely to be less cohesive in responding to times of adversity or threats to changes in their way of life. In addition, a largely transient population may also be less inclined or likely to contribute towards processes that enhance community well-being, including processes such as voluntary activities, participation in community groups or local governance. This can be measured by assessing the proportion of the population with a different address five years ago.

Social variables used in this assessment include, but are not limited to:

- mobility (percentage of total population with a different address five years ago)
- cultural diversity
- participation in not-for-profit voluntary organisations.

Table 10.14: Indicators, analysis/measurement procedures and data sources

	Indicators	Indicators	Analysis/measurement procedures	Data source
Economic Capital	Household socio-economic status	Home ownership	% of total occupied private dwellings that are renting from government or community organisations.	ABS, 2006
		Income levels	% of households with income of less than $500 per week.	ABS, 2006
		Employment status	% of total persons in the labour force who are unemployed.	ABS, 2006
		Child dependency	Number of dependent aged children as a proportion of employed persons.	ABS, 2006
		Family structure	% of total number of families who comprise one-parent families with dependent children.	ABS, 2006
	Commercial economic activities	Economic diversity	Herfindahl Industry Diversity Index, which squares the market share of commercial and industrial companies, and then sums those squares. Scores range from 0 to 1 (but have been multiplied by 100 for ease of comparison) where 1 indicates high industry concentration and low diversity.	ABS, 2006
		Employment in the forestry industry	Proportion of total employment in relevant urban locality employed by businesses with licences to harvest red gum timber from public land[20].	Survey conducted by NRC and ABS, 2006

[20] A survey was conducted to assess the number of full-time equivalent employees in businesses with a licence to harvest red gum timber from public land.

Table 10.14: Indicators, analysis/measurement procedures and data sources (continued)

	Indicators	Indicators	Analysis/measurement procedure	Data source
Physical capital	Service accessibility	Index of remoteness	ARIA+, which is the standard ABS endorsed measure of remoteness, derived from measures of road distance between populated localities and service centres. It has score values ranging from 0–15 where the higher the score, the more remote a locality.	GISCA Applications
	Information accessibility	Internet access	% of total population who do not have access to the internet.	ABS, 2006
		Accessibility to public library services	Yes or no.	State Libraries of NSW
Human capital	Education	Post-school qualifications	% of persons aged 15 years or over without post-school qualifications.	ABS, 2006
		School completion	% of persons aged 15 years or over who left school before Year 10.	ABS, 2006
		School attendance	% of persons aged 15 years or over who never attended school.	ABS, 2006
	Skills and expertise	Low skilled occupations	% of employed persons over the aged of 15 years who are employed as labourers or community and personal service workers.	ABS, 2006
	At-risk groups	Minority/ vulnerability groups	% of total population who are Indigenous. % of total population who are disabled and require care. % of people aged 65 years or above as proportion of total population. % of people aged over 15 years who provide unpaid care or assistance to people with disabilities.	ABS, 2006
Social capital	Sense of community	Mobility	% of total population with a different address five years ago.	ABS, 2006
		Cultural diversity	% of total population who were not born in Australia who speak English not well or not at all.	ABS, 2006
	Community participation	Participation in not-for-profit voluntary organisations	% of total population who do not provide voluntary services to not-for-profit organisations.	ABS, 2006

Table 10.14 summarises the indicators that have been selected for use in the current study on the basis of a literature review. Variables used to assess each indicator, the analysis or measurement procedure utilised and the data source are also defined. All raw variable scores (e.g. proportions and percentages) have been standardised to enable relative comparison across the seven identified towns with dependencies or linkages to the forestry industry.

10.5.3 Adaptive capacity of towns linked to the red gum forestry industry

Overall, towns in the NSW Riverina bioregion are facing similar pressures to the majority of regional NSW. Over the last decade, the NSW Riverina bioregion has seen a plateau in population growth. Population in the region as a whole was down 0.2 per cent between 2001 and 2006, compared to a 0.3 per cent increase for regional NSW (ABS, 2006). The impact of the current drought on the agricultural industries on which regional economies are based is similar for towns in the Riverina bioregion and those elsewhere in NSW. As discussed in **Section 10.2**, there are a wide range of socio-economic implications of predicted climate change for the Riverina bioregion, and these will be equally applicable to the towns with close ties to the red gum forestry industry. The level of significance of these effects will depend largely on the towns' reliance on those industries most likely to be impacted, particularly those that rely on supply of water, such as irrigation and forestry.

Within this context, the seven towns identified as having close links to the red gum forestry industry reliant on public land appear to vary in their capacity to adjust to further changes. **Table 10.15** displays the results for each of the indicators for the seven towns of interest, as well as for 'outer regional NSW'as it is defined by the ABS. This table enables comparisons between towns on the basis of their raw figures, as well as between each town and the regional average.

It is important to note that Barham and Koondrook appear separately in the statistical analyses only because they are treated separately by the ABS. For all practical purposes, they are interdependent and function as one community with the well-being and survival of one depending on the other. Consequently, while **Table 10.15** list Barham and Koondrook individually, the narrative below focuses on the Barham-Koondrook community.

[21] Indicators are based on the locality of the specific towns identified, as defined by the ABS 2006 Census data.

It is also relevant to consider the distance of each town from major regional centres which may provide access to services and employment opportunities that are not available in the towns themselves[21]. Merbein, in particular, is located 12 kilometres from Mildura and may be considered as a suburb of this regional city. Darlington Point is located 38 kilometres from Griffith and Mathoura is 42 kilometres from Echuca-Moama. Barham-Koondrook and Balranald are 75 kilometres and 92 kilometres respectively from Swan Hill.

A comparison of the adaptive capacity of each of the seven towns, based on the indicators of their economic, human, physical and social capital, is discussed below.

Deniliquin

Based on the indicators of economic capital shown in **Table 10.15**, Deniliquin can be considered the town most resilient to changes in economic resources or industry activity. It has the highest degree of industry diversity and other indicators of economic capital are also relatively strong. Its relatively large size as a regional economic centre with a population of 7,500 (ABS, 2006) suggests it can offer a greater diversity of employment opportunities than some other towns.

Deniliquin has relatively strong indicators of social capital, with a high proportion of the population having completed school and having post-school qualifications. It also has strong indicators of skills and expertise (based on the low levels of the population employed in low skilled occupations). In general, these are comparable to outer regional NSW.

Deniliquin has the lowest reliance on the red gum forestry industry of all the towns linked to the red gum forestry industry. Based on location of employment, employees of businesses with licences to harvest timber from public land account for less than 1 per cent of total employment in the town. This suggests Deniliquin is likely to be able to adapt to changes in the forestry industry.

Balranald

Balranald is also likely to be more resilient to change than other towns. It has similarly strong indicators of economic, physical and human capital to Deniliquin. Of all the towns, Balranald has the strongest indicators of social capital, with the lowest levels of population mobility at 31.5 per cent and the highest proportion of the population involved in volunteering with not-for-profit organisations.

With 4.6 per cent of total employment in the red gum forestry industry, Balranald is likely to be able to adapt to changes in this industry.

Merbein

Merbein has indicators of lower economic and human capital compared to other towns in outer regional NSW. All indicators of economic capital are higher than the average for outer regional NSW, with unemployment at 8.3 per cent being the highest of all the towns (at the same level as Mathoura). Its population has relatively low levels of education with 92 per cent having no post-school qualification. The proportion of the population in low skilled employment is higher than the regional average at 34.8 per cent.

However, being only 12 kilometres from Mildura, it has access to services and employment which will support its capacity to adapt to change.

Merbein has relatively low reliance on the red gum forestry industry on public land. Based on location of employment, employees of businesses with licences to harvest timber from public land account for 3.4 per cent of total employment. This suggests Merbein is likely to be able to adapt to changes in this industry.

Darlington Point

In general, Darlington Point has stronger indicators of economic and human capital than the average for outer regional NSW. It has a low unemployment rate at 4.2 per cent, and at 20.8 per cent, the proportion of the adult population with household income below $500 per week is low compared to the outer regional NSW average of 28.5 per cent.

Darlington Point stands out for its relatively high levels of population mobility, which may suggest low levels of social cohesion. Darlington Point is also notable for its relatively low level of volunteering, compared to the other towns and the outer regional NSW average. These indicators could be due to the population growth of 3.3 per cent experienced in the five years to 2006 (ABS, 2006).

Many residents of Darlington Point are families which have moved to the town in recent years due to its low property prices (GHD, 2009). This is reflected in the significantly younger population compared to other towns, high childhood burden (57.0 per cent) and high proportion of one-parent families (14.7 per cent).

Darlington Point is 38 kilometres from Griffith. It can be considered as a satellite town of this regional centre to which some residents commute for work.

The low levels of employment in the red gum forestry industry on public land (4.6 per cent) suggest Darlington Point is likely to be able to adapt to changes in this industry.

Barham-Koondrook

The twin towns of Barham-Koondrook may be considered less resilient to change than other towns. Their economic capital appears to be low given their high proportion of low income households at an average of 31.6 per cent compared to outer regional NSW at 28.5 per cent. They have lower human capital than the other towns, reflected in a high proportion of individuals without post-school education and relatively high proportions of retirees and unskilled workers.

On the other hand, the towns of Barham-Koondrook have the lowest unemployment rate of all the towns reliant on the red gum forestry industry. Their relatively low population mobility and higher level of participation in volunteer activities than the average for outer regional NSW suggest relatively high levels of social capital.

The two towns are notable for their high dependence on the red gum forestry industry. Based on location of employment, employees of businesses with licences to harvest timber from public land account for 16 per cent of total employment in the combined towns. This suggests these towns may have lower ability to adapt to changes in the red gum forestry industry than the other towns considered.

Table 10.15: Results for CSI indicators for each of the towns as well as the outer regional NSW area

	Barham	Koondrook	Deniliquin	Mathoura	Darlington Point	Balranald	Merbein	Outer regional
Economic capital								
Proportion renting from Government or community organisations	7.0%	5.6%	20.4%	7.7%	23.5%	23.8%	24.2%	15.6%
Proportion of total adult population earning weekly household income of less than $500	28.5%	34.6%	26.1%	38.6%	20.8%	26.7%	33.9%	28.5%
Unemployment rate – Proportion of total adult population who are unemployed	2.2%	4.5%	5.2%	8.3%	4.2%	6.1%	8.3%	7.0%
Childhood burden – Number of dependent aged children as a proportion of employed persons	45.5%	36.1%	47.4%	48.6%	57.0%	47.8%	56.1%	51.8%
Proportion of one-parent families with dependent children	5.6%	7.4%	10.6%	8.5%	14.7%	12.7%	14.1%	9.5%
Herfindahl Industrial Diversity Index (multiplied by 100 for ease of comparison)	2.0	2.2	1.3	3.2	2.4	2.8	2.5	1.3
Dependency on the red gum forestry industry (proportion of total town employment*)	17.2%	15.4%	0.9%	13.8%	4.6%	4.6%	3.4%	N/A
Physical capital								
ARIA+ remoteness	3.1	3.1	2.2	2.7	4.2	4.6	2.6	N/A
No accessibility to the internet	54.2%	61.2%	48.6%	66.9%	53.5%	54.4%	56.7%	46.7%
Accessibility to a public library	Yes	Yes (Barham)	Yes	Yes	No	Yes	Yes	N/A
Human Capital								
Proportion of total adult population with no post-school qualification	87.7%	93.4%	86.2%	94.6%	93.5%	87.8%	92.0%	85.5%
Proportion of total adult population who left school before Year 10	26.1%	30.8%	22.7%	33.0%	28.2%	25.5%	30.7%	22.4%
Proportion who never attended school	0.0%	0.0%	0.5%	1.1%	0.5%	0.6%	0.6%	0.5%
Proportion employed as labourers or related workers	16.1%	23.4%	14.2%	25.0%	31.3%	17.9%	24.9%	14.6%
Proportion employed as community and personal service workers	10.5%	14.6%	10.4%	10.5%	9.2%	11.9%	9.9%	8.6%
Proportion of total population who are Indigenous persons	2.0%	0.0%	2.8%	1.8%	17.2%	8.1%	4.9%	6.0%
Proportion of total population who are disabled and require care	5.1%	5.7%	5.2%	6.0%	5.1%	5.2%	5.5%	5.0%
Proportion of retirees (people aged 65 years and over)	33.2%	25.5%	19.4%	25.2%	12.4%	19.1%	18.1%	16.9%
Proportion who provide unpaid assistance to people with disabilities	8.7%	11.2%	11.2%	10.9%	10.6%	10.2%	11.6%	11.7%
Social capital								
Population mobility – Proportion with a different address five years ago	40.2%	33.4%	38.5%	34.4%	40.5%	31.5%	35.9%	35.5%
Cultural diversity (% of immigrants who do not speak English)	0.0%	7.0%	3.4%	0.0%	0.0%	0.0%	0.0%	4.8%
Proportion who do not volunteer at not-for-profit organisations	57.2%	64.9%	65.1%	64.6%	71.6%	54.8%	67.3%	64.6%

* Surveyed full-time equivalent employees of businesses with licences to harvest timber from public land compared to total employment in the relevant urban locality.

Mathoura

In terms of economic capital, Mathoura has the lowest industry diversity and could be considered the most vulnerable to changes in industry activity. It has the highest proportion of the adult population with a household income of less than $500 per week and a high unemployment rate of 8.3 per cent. However, indicators such as home ownership are strong compared to the outer regional NSW average.

Mathoura may also have lower human capital compared to other towns. It has a greater proportion of the population without school completion (33 per cent) or post-school qualifications (94.6 per cent). Consistent with this, it also has a greater proportion of the population employed in low skilled occupations (35.5 per cent) compared to the outer regional NSW average (23.2 per cent). Mathoura is also notable in that only one-third of the population have access to the internet.

However, Mathoura has relatively strong indicators of social capital. Population mobility is lower than for outer regional NSW. Approximately 35 per cent of the population are involved in volunteer activities.

Mathoura has the second highest dependence on the red gum forestry industry after Barham-Koondrook. Based on location of employment, employees of businesses with licences to harvest timber from public land account for 13.8 per cent of total employment in the town. It could therefore be considered reasonably vulnerable to changes in this industry.

Millewa State Forest

10.6 Building adaptive capacity of communities in the Riverina bioregion

Given the expected general socio-economic impacts of climate change, and the predicted localised impacts of changes in water availability on the forestry industry, communities in the Riverina bioregion face a future quite different from what has been experienced in the past. In general, a sustainable future for the region will depend on the development of less water-dependent industries. The ability of the region's communities to address the impacts of climate change, and transition to a new water-scarce future will depend on their resilience and adaptive capacity. Both communities and governments have roles in working through this transition.

In situations of transformation, communities have choices. On the one hand, they can resist change and attempt to maintain the status quo. In general, water-dependent industries can be expected to try to retain their profitability, and communities can be expected to resist change to retain their quality of life. This may be possible over short time scales, however over longer time scales, this position is not sustainable. The alternative is that communities prepare for and adapt to a future with less water. This is a more viable alternative over the longer term, which can be facilitated by government support for building adaptive capacity to assist a smoother transition to alternative states.

In situations of structural change due to policy decisions, governments have historically taken a role in assisting the transformation of industries and the communities that rely upon them. Structural adjustment policy in the past has generally been focused on facilitating industry exit and compensation. However, a variety of approaches is possible. Structural adjustment could focus on building adaptive capacity in communities, through continual and iterative processes.

Building adaptive capacity gives communities the ability to cope with sudden or gradual changes and to take advantage of potential market opportunities that may arise as a result of changes. Adaptive capacity can be targeted at industry, local government or community levels. It means fostering flexibility, localised solutions and leadership, strong networks and linkages, and diversity in socio-economic systems.

The capacity of industries in the Riverina and their dependent communities to adapt to climate change could be supported through a variety of approaches. These include information provision, skills and capacity development, and investment in infrastructure and programs to support regional development. These are discussed further below.

10.6.1 Information provision

There is currently a limited understanding of how climate change may potentially affect local environments and community way of life. Governments can play a key role in addressing this knowledge gap by providing relevant, frequent and timely information regarding the projected impacts of climate change. This can assist the development of effective adaptive capacity at a local and regional level and assist industry in making appropriate business decisions.

Specific initiatives which may be relevant include:

- development of a community risk assessment framework that can be applied at a local government level, to assess the implications of climate change on local communities
- adoption of a regional approach to climate change, whereby various local government bodies within a region come together to engage in the implementation of adaptation actions and to share resources and knowledge
- formation of partnerships between industry and Government, e.g. private industries partnering with different levels of government to establish a localised climate change action fund, which would assist regional

and remote communities in further optimising their capital towards effective climate change adaptation

- improved modelling of climate change scenarios at a scale relevant to local communities
- assessment of community understanding of climate change and use the outcomes to design education/information materials to promote greater awareness of the issue and its impacts
- infrastructure and support to enhance the capacity of communities to deal with extreme weather and fire events that may occur as a result of climate variability and predicted climate change.

The NSW Government, through DECCW, is commencing a cross-sectoral Integrated Regional Vulnerability Assessment for climate change in the south-west of NSW. As the part of NSW most likely to be impacted by climate change, the study will seek to work with local government, industry and the community of south-western NSW to identify those sectors and communities most vulnerable to climate change, and ultimately lead to the identification of adaptation strategies designed to reduce regional vulnerability. This study and the subsequent adaptation strategies will build on the strengths of the region to develop communities with greater capacity to adapt and grow in the face of change.

10.6.2 Skills and capacity development

Small towns can be assisted to become more resilient and economically sustainable in the face of climate change impacts through alternate skills development and employment opportunities (NSW Department of Planning, 2009). Providing improved training opportunities can encourage workforce skill diversity and facilitate greater industrial diversification. This would assist members of the community to be more flexible in their employment – and better able to flexibly respond to new employment and business opportunities.

River red gum logs ready for milling

Beckley et al., (2002) in discussing a community's capacity to cope with, and subsequently adapt to, resource management changes, placed a particular emphasis on human and social capital. These authors highlighted the important role that these capital play in determining overall community capacity. They suggest that more strategic investments in formal and informal education and support for social networks and infrastructure that links community and industry leaders across different localities, is a fundamental element of community capacity building.

Regional and local programs could be identified and/or implemented that emphasise development of local social and human capital and facilitate the development of strong networks and partnerships among key stakeholders. This would further develop a community's adaptive and ongoing capacity to manage change.

10.6.3 Diversification of industry

In general, the ability of the Riverina bioregion to adapt to the impacts of climate change can be enhanced by the diversification of industry through the investment in infrastructure and technology to optimise the use of available water and through the development of less water-dependent industries. To address this issue, strategies may include diversification of commercial activities away from highly vulnerable environmental assets, and into areas that are unlikely to move in the same direction at the same time.

Governments can assist communities to develop a greater diversity of industries by providing infrastructure and programs to encourage private sector development. Regional development initiatives may include:

- training programs, incentives for industry to diversify or investments in intensification of higher value production systems
- enhanced water management infrastructure and support for the development of water efficiency technologies and practices
- strategies to increase the tourism industry such as promoting of regional NSW as a tourist destination, improving road infrastructure, providing opportunities for private sector investment in tourist accommodation and developing specific events as tourism attractions.