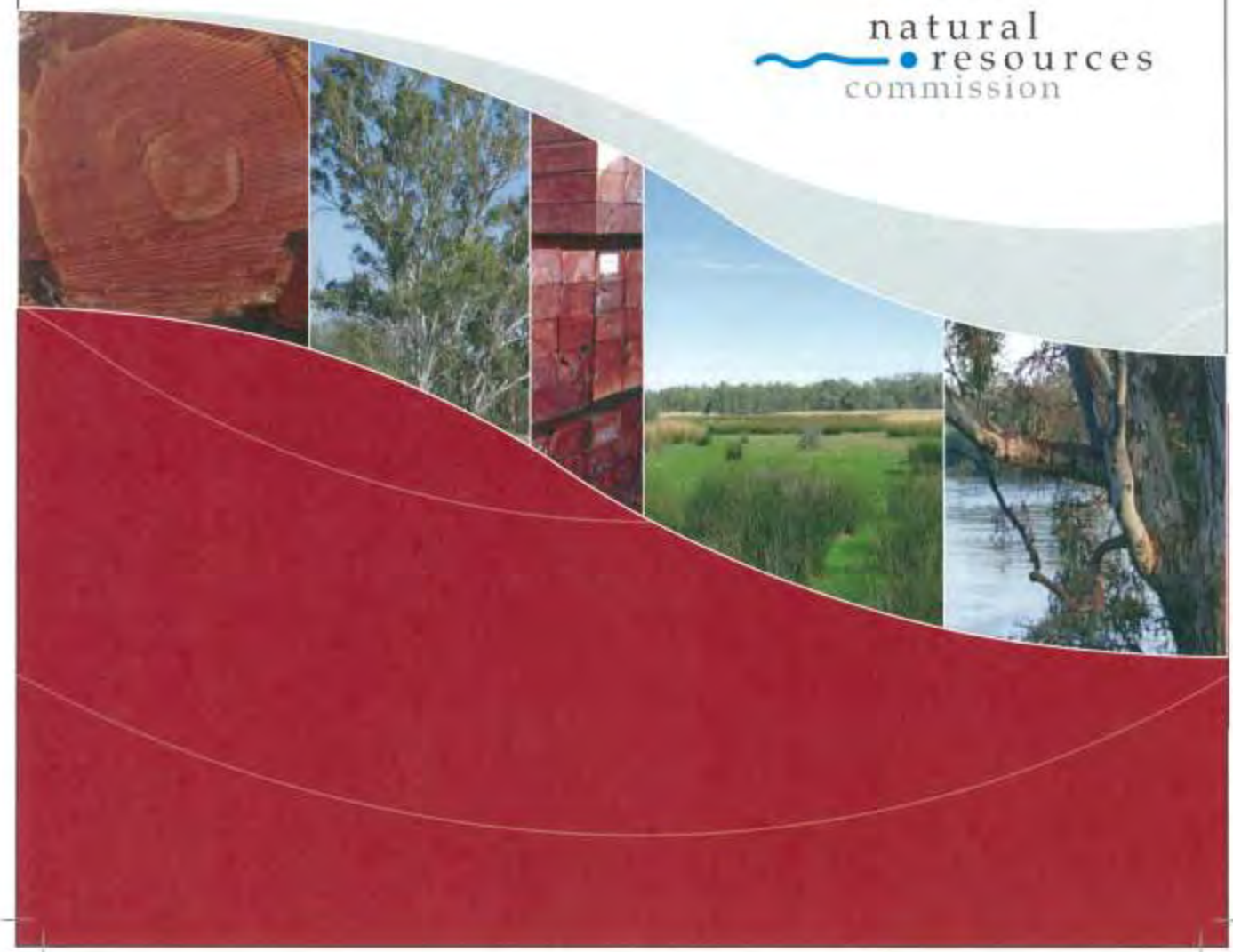
SEPTEMBER 2009

PRELIMINARY ASSESSMENT REPORT

RIVERINA BIOREGION
REGIONAL FOREST ASSESSMENT
RIVER RED GUMS AND WOODLAND FORESTS



natural resources commission

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Regional Forest Assessment
River red gum and other woodland forests

30 September 2009

Enquiries

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Submissions

Submissions in response to this preliminary assessment report are due to the NRC by **23 October 2009.**

There is no standard format for submissions. Submissions may range from a short letter outlining your views on a particular topic to a more comprehensive document covering a range of issues. Where possible you should provide evidence, such as relevant data and documentation, to support your views. While every submission is welcome, multiple, identical submissions do not carry more weight than the merits of an argument in a single submission.

Submissions may be sent by email, fax, or mail. An electronic copy would be appreciated either by email or on disk. The electronic version can be either a text document (.doc, .txt) or Adobe Portable Format (.pdf).

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*If you do not receive notification of receipt of an email message you have sent to the Commission within two working days of sending, please contact Felicity Calvert (see above).

Unless clearly marked confidential, the NRC treats all submissions as public and makes them available on our website (www.nrc.nsw.gov.au). Claims for access to confidential submissions will be determined in accordance with the *Freedom of Information Act 1989.* All submissions will be treated in accordance with the *Privacy and Personal Information Act 1998*. Any personal information you give us will not be used for any other purpose.

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Foreword

River red gums are Australian icons. They are immortalised in Australian art, poetry and song. For Aboriginal people the river red gum forests in the Riverina are a cultural landscape with rich archaeological sites and ongoing spiritual and cultural significance. The fabric of the land itself is culturally important to them.

The river red gum forests in all their different structural forms are important to a wide range of people from very different social, economic and cultural groups in our society and we derive a variety of uses, values and amenities from the forests in the Riverina region.

The question before us is how best to conserve, protect, use and manage this most valuable asset into the future for all Australians.

The forms these forests take along the Murray, Murrumbidgee and Lachlan rivers are the consequence of active human intervention. This has occurred through manipulation of flooding and flow patterns as a consequence of dam and weir construction and water extraction from these rivers; long standing forestry operations providing timber, conservation outcomes and recreational uses; grazing of cattle and sheep; and the way fire has been managed. All these activities have interacted with our highly variable climate to produce the diversity of forms and conditions that we now witness.

The forests today are the habitat for many important species of animals and plants with many of them under increasing threat. Within them are internationally important Ramsar wetlands and icon sites, including for The Living Murray program of the Murray Darling Basin Authority.

The primary purpose of this preliminary assessment report is to set down the economic, social and available scientific knowledge we have about these forests and their current management.

Through the release of this report and the public inquiry consultation will follow, the final NRC report will make recommendations to the Premier that are based on a well understood and transparent knowledge platform for these forests and our communities.

Some issues relevant to this assessment are better documented than others and some of the documentation understandably reflects the particular focus of the person or organisation preparing the original material the NRC has sourced. I encourage you to review this report carefully for errors of fact, omission and interpretation and I welcome any alternative data and sources of information.

I look forward to receiving submissions on this preliminary report and to hearing from interested parties at one of the public forums that will be held during October 2009.

Sincerely

John Williams
Commissioner

Typical crown of Riverina red gum

Contents

1 Introduction

The NSW Government has asked the Natural Resources Commission (NRC) to assess the river red gum and woodland forests in the Riverina bioregion, and the cypress forests in south-western NSW, so that Government can then make a forest agreement "to determine conservation outcomes and a sustainable future for the forests, the forestry industry and local communities".

This preliminary assessment report draws together the available science and information on the river red gum and other woodland forests of the Riverina bioregion. Based on the data available, it explains how the forests were formed, their current health and management, their broad uses and values, and how projected climate change may affect the forests and the values they support.

The NRC hopes that this information can help all interested parties make submissions to the NRC on how Government can best promote conservation outcomes and a sustainable future for these forests, the forest industry and local communities in the region. The NRC has identified nine key issues upon which it is seeking submissions, but welcomes input on all issues which stakeholders feel are relevant to the NRC's terms of reference (Attachment 1).

Importantly, the NRC hopes that public consultation on this preliminary assessment report can provide a richer picture of the breadth and depth of values people place on the forests.

The NRC will hold further discussions and public forums in October 2009 to seek input and ideas prior to making its recommendations to Government by 30 November 2009 on the management of the forests into the future.

1.1 Terms of reference

The NRC must report by 30 November 2009 on the river red gum and woodland forests in the Riverina bioregion, and separately on the south-western cypress forests by 28 February 2010. The terms of reference (Attachment 1) require the NRC to:

1. Assess the environment and heritage values (including Indigenous heritage), economic and social values, ecologically sustainable forest management, timber resources, and otherwise meet the assessment requirements of the *Environment Protection and Biodiversity Conservation Act 1999 (C'th)* as determined in discussion with DEWHA.
2. Recommend conservation, protection, economic and ecological sustainable use of public land in the bioregion.
3. Recommend water management and flooding requirements to sustain the forests and identified values and uses under the range of projected impacts of climate change.

This preliminary assessment report deals substantially with term of reference 1, namely the assessment of the values, uses, management and timber resources of the bioregion. It also outlines some of the key issues the NRC sees as relevant to making recommendations on the future of the forests as required in the second and third terms of reference.

On 30 November, the NRC will report to Government on the full terms of reference as they relate to the Riverina bioregion, making recommendations on the future management and uses of the forests.

1.2 What is a regional forest assessment?

NSW forest agreements are formal agreements between the NSW Ministers for Environment and Primary Industries setting out how forests in particular regions will be managed by DECCW as part of the NSW reserve system or by Forests NSW as state forests.

The NSW Ministers may only negotiate a forest agreement following a 'regional forest assessment' by the NRC, which must include an assessment of:

(a) environment and heritage values (including Indigenous heritage)

(b) economic and social values

(c) ecologically sustainable forest management

(d) timber resources.

NSW forest agreements must contain certain minimum provisions and are intended to frame an Integrated Forestry Operations Approval (IFOA) under which Forests NSW then carries on its harvesting operations. An IFOA[1] describes the permitted forestry operations in the area covered, and the conditions imposed[2] (*Forestry and National Parks Estate Act, 1998* NSW).

The terms of reference also require the assessment to meet the assessment requirements of the *Environment Protection and Biodiversity Conservation Act 1999 (C'wealth)*. The matters that must be considered to satisfy the Commonwealth legislation are similar in nature to those required of a regional forest assessment.

1.3 NRC tours of the river red gums forests in the Riverina

To better understand the issues facing the river red gum forests in the Riverina and the communities which use and manage them, the NRC team visited the region twice during late August and September 2009.

The forest industry, local government, state agencies and community representatives from many walks of life gave generously of their time and expertise. This built the NRC's appreciation of the social, economic and environmental issues around the future of river red gum forests. We received a very large body of information and had some opportunity to directly observe the forest ecology, floodplain and river hydrology, silvicultural practices, and mill operations, including timber processing to generate high value wood products in

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1 There are currently four IFOAs. The Upper North East, Lower North East, and Eden IFOAs commenced on the 1 January 2000 and another for the Southern Region commenced on the 13 May 2002. An IFOA for the Brigalow and Nandewar Community Conservation Area is currently being developed.

2 The approval may contain the terms of a licence under the *Protection of the Environment Operations Act 1997*, the *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994*. Enforcement of the licences rests with DECCW or DPI – Fisheries.

furniture timber veneers. We saw red gum furniture and how the industry and community are closely interwoven to build human capital and community resilience.

The NRC also toured Yanga National Park, witnessing the health of the forests when water is available, and management to protect habitat for threatened species. In adjacent non-flooded areas we saw drought-stressed trees, and the legacy of large tracts of dead and dying trees from previous dry conditions.

We had some opportunity to meet with Aboriginal people, and saw Aboriginal heritage valued and protected. We look forward to better understanding Aboriginal peoples' perspectives and the values they place on the forests.

We saw the importance of tourism and family recreation in camping, fishing and bushwalking in these forests and floodplains. We saw interpretative centres educating the community on heritage and history of early community life and social values derived from these rivers and forests.

Overall, the tours confirmed a picture of forests in a dynamic state, facing significant drought-related stress and that water management, climate variability and climate change will be critical factors in the long-term management of the red gum forests of the Riverina.

The NRC gained insight into the diversity and recent evolution of the forests, the impacts and interaction of flooding history, forest silviculture, fire and grazing. These visits and the resultant discussions and observations helped the NRC shape a framework for the issues that must be resolved in order for the NRC to make its recommendations to Government in November 2009.

The NRC acknowledges the contribution of many agencies, individuals and organisations in the provision of information, data and views for this report. In particular we are grateful for the expediency with which NSW and Australian government departments and non-government organisations were able to provide information to us. This includes the Victorian Environment and Assessment Council, Forests NSW, the Department of Environment, Climate Change and Water, Land and Property Information Authority, the Murray Darling Basin Authority, CSIRO, Water Tech, GHD, the Forests Products Association, and the National Parks Association.

We are also grateful to the Technical Review Panel, see Attachment 7, for their participation at the Technical Roundtable, their input on the design of the assessment, and review of the scientific analysis.

The preparation of the socio-economic analysis could not have been possible without the cooperation of individuals and companies within the forestry industry, and we thank them for their willingness to be interviewed.

1.4 How will the NRC make its recommendations to Government?

The NRC has developed an analytical framework setting out how it intends to make recommendations to Government. This framework is explained in the following pages.

As with previous forest assessments, the central task is to identify and recommend forest tenure and management arrangements to promote an appropriate balance between the environmental, social, economic and heritage values that these forests can provide.

Previous regional assessments have applied nationally agreed criteria for establishing a comprehensive, adequate and representative reserve system for forests in Australia (JANIS, 1997). Typically these assessments targeted reservation of set percentages of pre-European extent of particular forest ecosystems and vegetation classes, and reserves were designed around old-growth and wilderness areas, and viable habitat values.

However, unlike previous assessments[3] these flood-dependent red gum forests have been highly modified by historic water management and silvicultural practices. The extent of old-growth and wilderness areas has not been assessed, but is believed to be largely absent. The current extent and condition of forests is a direct result of 75 years of river regulation and 120 years of silviculture.

The projected impacts of climate change and future decisions on water management in the Murray Darling Basin will be key determinants of the potential values that these forests can support and how they should be managed.

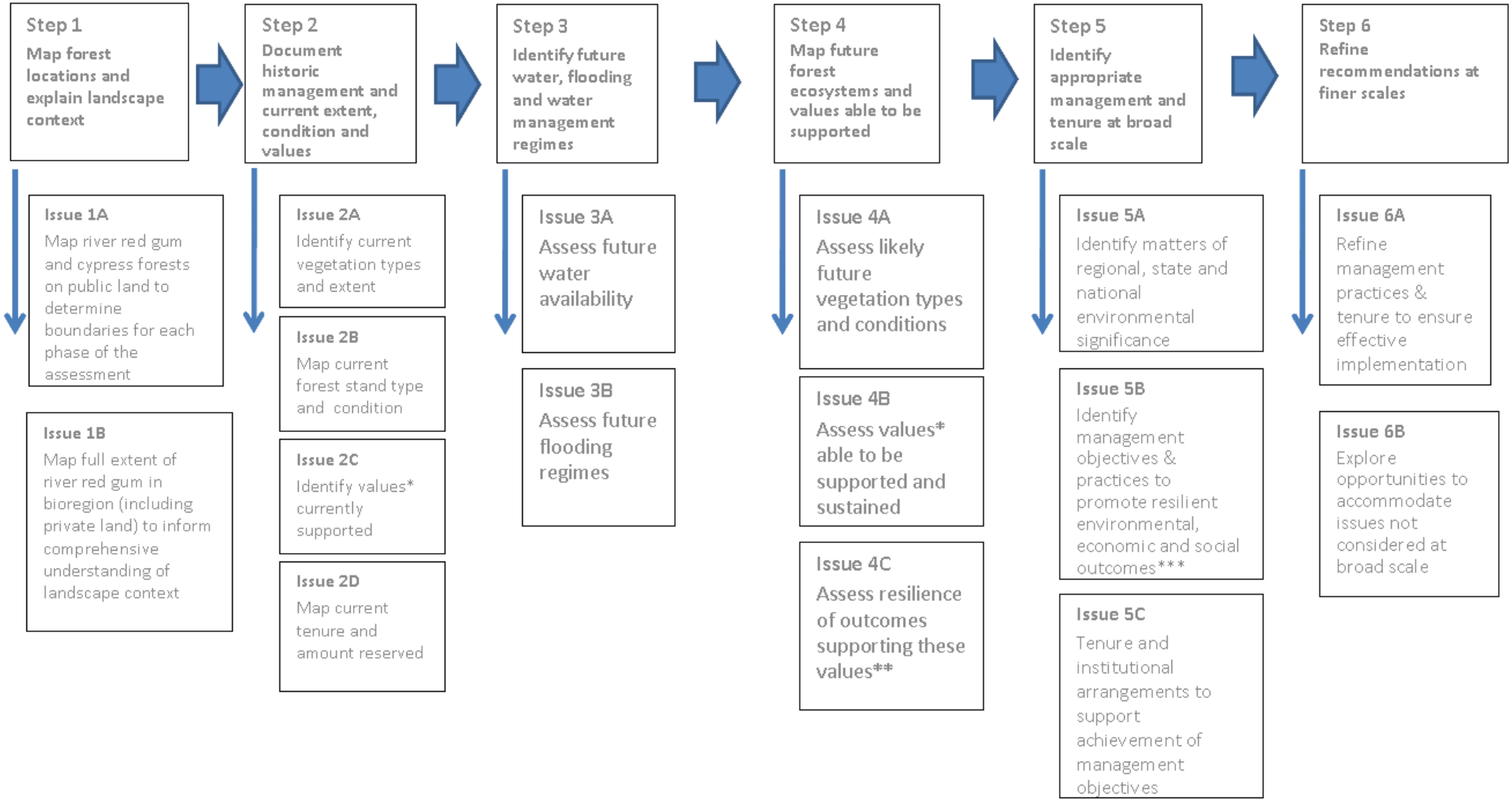
The principles of creating reserves that are comprehensive, adequate and representative remain valid and are applicable. However, a sustainable future for the forests in this region will also require consideration of the resilience of 'socio-ecological systems', forest industries and communities of the region - and how they can be maintained or transformed to cope with the likely impacts of drought, changes in river regulation policy, and the projected impacts of climate change.

The NRC's broad approach is to:

- characterise the landscape context, historic (flooding and silvicultural) management, and current condition of these forests, and link this to the values they currently support
- project how the forests and associated ecosystems (and hence) values may change under future climate change projections, water management regimes, and possible forest management regimes
- consider synergies and trade-offs to recommend how different parts of the forests and associated ecosystems should be managed (and hence under what tenure) to best promote resilient environmental, economic and social outcomes in line with the Government's stated objective of a forest agreement delivering "conservation outcomes and a sustainable future for the forests, the forestry industry and local communities".

In Figure 1 the NRC has developed this broad approach into six steps and a number of sub-steps to guide its analysis. These are explained in more detail on the following pages.

[3] The nationally agreed criteria do recognise the potential need for active management to preserve and restore ecological value, and this was a feature of the last assessment in the Brigalow bioregion. However, the scale of landscape modification and the need for active management of forests is likely to be at a wholly unprecedented level in the current Riverina assessment.



* Environmental, heritage (including indigenous heritage), economic and social values will be considered
** Regard will be given to nationally agreed criteria for a comprehensive, adequate and representative reserve system and to other complementary methodologies for protecting conservation values
*** Regard will be given to appropriate forest management practices to promote long term productivity & health and to international or intergovernmental obligations, agreements or arrangements

Figure 1 Analytical framework for making recommendations to Government for NSW Riverina IBRA

In line with Figure 1, the NRC's analytical framework has six steps:

Step 1 – Map forest locations and explain landscape context

The river red gum and cypress forests co-exist in some parts of the region and are distinct landscape types in others. The NRC has defined which forests to assess first within the Riverina bioregion, and which to assess later as the South-Western Cypress State Forests. Both forest types will be described in the context of public and private land to ensure ecological linkages are clear.

Step 2 – Document historic management and current extent, condition and values.

The red gum forests have been managed and modified over a lengthy period. Documenting the baseline of how historic management has shaped forest extent and condition and resultant values will satisfy term of reference 1 (a) at a broad scale using existing information and expert opinion. Public consultation on the preliminary assessment report will generate finer scale information on forest uses and values.

Step 3 – Identify likely future water, flooding and water management regimes

Climate variability and climate change is projected to reduce rainfall, river flow and flooding. Basin-wide and local water management will differentially affect flooding timing, frequency and duration, and hence forest health. This step will define the 'future water scenarios' considered within the assessment and anticipate how this might affect flooding patterns in particular forest groups.

Step 4 – Map future forest ecosystems and values able to be supported

Based on likely future flooding patterns, possible changes to vegetation types and ecosystems will be characterised and mapped, and changes to the values they are likely to support will be described. Nationally agreed criteria for reserve systems plus more recent work on resilience of socio-ecological systems will be used to nominate parameters to describe and gauge the 'resilience' of particular environmental, economic and social outcomes and values. The NRC will attempt to identify likely 'tipping points' beyond which further changes in a parameter (say flooding frequency) will cause a step change in the vegetation types (say from river red gum forest to open river red gum woodland or box woodland) and the values and uses that that vegetation type is able to support. The NRC's approach to resilience is informed by recent work which explores how this concept might be incorporated into land use and sustainability decision-making (e.g. Cork 2009, Fischer et al 2009, Walker et al 2009).

Step 5 – Identify appropriate management and tenure at broad scale

This step will determine the most appropriate mix of landscape management and tenure options to achieve conservation outcomes and a sustainable future for the forests, forestry industry and local communities. High priority environmental values will be identified and mapped at an appropriate scale, which should address the EPBC requirements in term of reference 1(b). Potential synergies and tradeoffs between environmental, economic and social outcomes and values will then be identified and mapped at a coarse scale to identify preferred management regimes to promote resilient outcomes. Preferred management regimes will be used to recommend a relatively broad scale mosaic of tenure and associated management arrangements.

Step 6 – Refine recommendations at finer scales

Through engagement, consultation, and finer scale assessment (local/site scale) the NRC will refine its recommendations, adjust tenure boundaries at the margins and refine management practices within different zones. Any remaining gaps to satisfy EPBC requirements will be addressed by specific survey work. Where existing knowledge allows, the NRC will recommend adaptive management regimes for water, silvicultural, and industry practices to promote resilience.

This preliminary assessment report covers the available science and information on steps 1 to 4B and step 5A of the analytical framework only. The NRC seeks submissions and further input from all parties to enrich the information available on steps 2, 3 and 4, and assist the NRC to complete steps 4C, 5B, 5C and 6.

1.5 What does this report indicate about the forests?

The river red gum and other woodland forests in the Riverina bioregion have a long history of active silviculture and water management. The current extent, condition and values supported by the forests are strongly influenced by the way in which they have been managed and the amount and duration of flooding that has occurred.

Under Aboriginal management, red gum forests are believed to have been more open than they are today. Over time these open red gum forests and woodlands have gradually been transformed to denser stands of regrowth due to harvesting of timber, ring-barking of mature trees to promote regeneration, an altered fire regime, and changes in the extent, duration and frequency of flooding.

In accordance with the *Forestry Act 1916* (NSW), Forests NSW actively manage the forests for timber production; preservation of soil resources, water catchment capabilities and flora; and conservation of birds and animals. The Ramsar listed wetland areas of the Central Murray State Forests are recognised for their intrinsic ecological values after almost 150 years of management for multiple uses. Forest Management Zones identify significant environmental assets and direct how these should be managed, including to protect habitat for particular threatened species.

By comparison, the surrounding woodland landscapes on private land have been generally over-cleared of woody vegetation as agriculture has established across the region. The resulting landscape mosaic is one of dense stands of red gum forests on public land and considerable areas on private land, separated by large tracts of predominantly cleared agricultural land, with fragmented remnants of native woodland vegetation.

This preliminary assessment report presents the available science and information on the current health, uses and values of the forests and demonstrates that the present extended drought has profoundly affected the health of river red gum forest stands. Many of the trees are highly stressed, dying or dead, and without a return to a wet period the future of the forests in their current form looks bleak.

If the current drought conditions continues in line with the 'step change' prediction of climate change, then much of the existing river red gums forests will not persist in their present extent, structure and condition. Many of the most productive red gum forests may revert to a less productive condition. Some currently less productive stands may transition

to mixed river red gum and box woodlands or derived scrublands as dryland species begin to dominate.

These changes are having, and will continue to have, profound impacts on the ecology of the forest, the viability of the forestry industry, and the social and economic well-being of the local communities.

1.6 Key issues for submissions

The overriding message from this preliminary assessment report is that these forest ecosystems are experiencing, and will continue to face, unprecedented levels of long-term change associated with river regulation, climate variability and climate change. This provides a crucial backdrop to the key issues that the NRC will need to consider in making recommendations to Government on the future of the forests. The NRC seeks input from all parties on the following key issues:

Current forest values

The principal focus of the preliminary assessment report is to characterise the current values of the forests to the local, state, national and international communities.

Issue 1: Have the values supported by the forests been adequately described?

Issue 2: What other information is available to inform the assessment, particularly on areas outside the Central Murray?

Future forest values under river regulation, climate variability and climate change

The preliminary assessment report demonstrates the significance of river regulation and likely significance of climate variability and climate change to forests.

Issue 3: How will river regulation, climate variability and climate change affect the forests and the values they can support in the future?

Issue 4: What are the key forest values and core ecological processes we should seek to maintain in this dynamic context?

Conserving and sustaining forest values

The forests now exist in landscapes which are highly altered from their pre-European condition, and which will change further in the future.

Issue 5: What approaches should we take to maintaining the forest values and processes through the transitions that seem inevitable?

A sustainable future for the forests, the forestry industry and local communities

The forests, forestry industries and local communities of the Riverina are challenged by a future with less water than for much of the past. The preliminary assessment suggests that this future will see less red gum growth, and probably less red gum forest. This will inevitably mean less red gum timber.

Issue 6: What are the key features of a sustainable future for the forests, forest industries and the local communities?

Issue 7: How can local communities transform to cope with less water?

Issue 8: How can forestry industries respond to declining wood yields?

Issue 9: What are the appropriate policies and institutional arrangements to manage these forests through such a challenging and uncertain future?

Submissions on other matters relevant to the terms of reference are also welcome.

1.7 What are the key dates and how can you have your say?

In preparing its 30 November report and recommendations to Government the NRC will seek public input. The NRC will visit a cross section of interested parties, call for written submissions, convene discussions with key stakeholders, organise public forums, and canvass expert views.

Table 1 Key dates for assessment of river red gums and woodlands in Riverina bioregion

Key steps in the assessment of the Riverina bioregion	Dates
NRC tour of the Central Murray forests	*20, 21, 22 August 2009*
Submissions on Terms of Reference close	*28 August 2009*
NRC tours of the Murrumbidgee, Lachlan forests and Murray region	*10 – 16 September 2009*
Technical roundtable and Technical Review Panel workshop	*21 and 22 September 2009*
Assessment report on river red gum forests in the Riverina	*30 September 2009*
Submissions on the forest assessment close	23 October 2009
Public forums	26 – 29 October 2009
Final report on river red gum forests in the Riverina	30 November 2009

1.8 Structure of this report

The remainder of this preliminary assessment report outlines how climate variability and climate change is likely to affect the health and values of the forests in the Riverina bioregion, and seeks input on how the forests should be managed given those impacts:

- Chapter 2: The bioregion - landscape context
- Chapter 3: Current forest extent, condition, management and values
- Chapter 4: Trajectory of climate change
- Chapter 5: Implications of climate variability and climate change.

2 The bioregion - landscape context

This chapter provides an overview of:

- the bio-physical, and institutional context for this assessment, at the broad landscape (bioregion) scale
- landscape evolution and the history of forest development across the bioregion
- the current presence of river red gum forests across the landscape
- the main water management areas across the region and associated forest stands.

The Riverina bioregion is an extensive area covering the south-west of NSW and parts of Victoria, with a diversity of environmental, social and economic values. River red gum forests are associated with most of the major channels and floodplains in the Riverina. Approximately half the total area of river red gum forests in the NSW portion of the bioregion is located in State Forests, the remainder is largely on private land and Western Lands Leases (and some National Parks). The majority of river red gum forest is associated with the NSW Central Murray Forests Ramsar site, which includes the Millewa Forests, Koondrook-Pericoota and Campbells Island Forests, and Werai Forests.

The current extent and condition of river red gum forests across the NSW Riverina bioregion are products of past decisions associated with water and silviculture management. Forest management has transitioned from unrestricted use of the resource to support settlement and early industry, through a period of formal forest management and river regulation, to now incorporating a focus on protection of environmental values in partnership with sustainable commercial use of timber resources. Several of these forests have high ecological values which has resulted in Ramsar listing as Wetlands of International Importance (Millewa, Koondrook-Perricoota, Werai).

The quality and species composition of river red gum forests is sensitive to the extent, frequency, timing and duration of floods. Changes to the flow regime over time have the potential to significantly alter river red gum forest communities. These forests are important for a range of ecological processes and linkages in the landscape, including habitat provision at local scales (e.g. breeding and foraging) and also at the catchment scale (e.g. corridor provision for migratory movements). River red gum forests also have a range of cultural and social values, including significance for Aboriginal cultures and for recreation.

The distribution of river red gum forest and woodland across the Riverina bioregion can be considered in relation to several water management units (WMUs) and their associated forest stands. These areas have been defined in Section 2.7, and form the basis for more detailed assessments of flooding requirements and implications of climate variability and climate change later in the report.

2.1 Bio-physical context

2.1.1 Location, landuse and climate

The Riverina bioregion is located in the south west of NSW and covers an area of about 9.7 million hectares, of which 77% (7.0 million hectares) lies in NSW (Thackway and Cresswell, 1995). The remainder occurs in Victoria (2.5 million ha) and South Australia (0.2 million hectares). The bioregion consists of six subregions;

- Lachlan River
- Murrumbidgee
- Murray Fans
- Victorian Riverina
- Robinvale Plains, and
- Murray Scroll Belt.

Over 60% of the bioregion has been cleared for agriculture, and grazing on native pastures is the dominant landuse in the area. There are also large irrigation developments for rice and horticultural crops within the region. Ongoing water shortages and rising salinity are threatening agriculture and remnant vegetation.

The Riverina bioregion is dominated by a persistently dry semi-arid climate and characterised by hot summers and cool winters. Seasonal temperatures vary little across the bioregion, although in the north both summer and winter temperatures tend to be higher (Stern et al, 2000). Rainfall occurs mainly in May and September and annual rainfall tends to increase from west to east and from north to south.

2.1.2 Landforms and soils

The landform of the Riverina bioregion is dominated by river channels, floodplains, backplains, swamps, lakes and lunettes that are all of Quaternary age (less than 2 million years old). The region covers the alluvial fans of the Lachlan, Murrumbidgee and Murray Rivers west of the Great Dividing Range and extends down the Murray (NSW NPWS, 2003). The catchments of the Edward and Wakool Rivers and their floodplains are also contained in the region. The characteristics of each alluvial fan differ slightly due to the variation in discharge between the streams. The Lachlan fan is predominantly clay because it is a smaller stream and therefore does not have the flow capacity to transport sand. The other two fans are similar except that the Murray is more confined and has more active anabranch channels where it is forced to flow around the Cadell Fault near Echuca. During flood events the different streams can cross the fan surfaces and enter the channel of another system (DEWHA, 2009).

Soils of the bioregion reflect past patterns of sedimentation and the current flooding regime. Sandy soils are found in belts along the older stream channels, these sandy soils also form levees, dunes and lunettes. Modern river channels consist mostly of sandy soils and more saline heavy grey and brown clays towards the outer perimeter of the floodplains on the higher rarely flooded terraces (NSW NPWS, 2003). The red-brown and grey clays in the bioregion support grassland communities that are nationally significant. Calcareous, sandy soils, which tend to be a feature of adjacent bioregions, are also present in the Riverina bioregion (NSW NPWS, 2003).

2.1.3 Special environmental values

Special values of the bioregion include the mallee remnants, found in places through the bioregion, and providing refuges for mallee-dependent species. Wetland areas including the Lowbidgee and Mid-Murrumbidgee wetlands, the Booligal Wetlands and the Great Cumbung Swamp, and the Murray River red gum forests contain a range of habitat areas and act as major drought refuge for waterbirds (NSW NPWS, 2003).

2.1.4 Forest types

River red gum forests, and associated box woodlands and white cypress, are located throughout the NSW Riverina bioregion. Figure 2 shows the extent of river red gum forests located within State Forests and other public lands and private land. It also shows small stands of white cypress located on public land within river red gum forests which are considered in this assessment. Larger singular areas of white cypress in the Riverina bioregion are to be assessed in a separate report looking specifically at the South-Western Cypress State Forests.

Open red gum forests on the Murray River
Photo: Industry & Investment NSW

Closed forest with thicket development

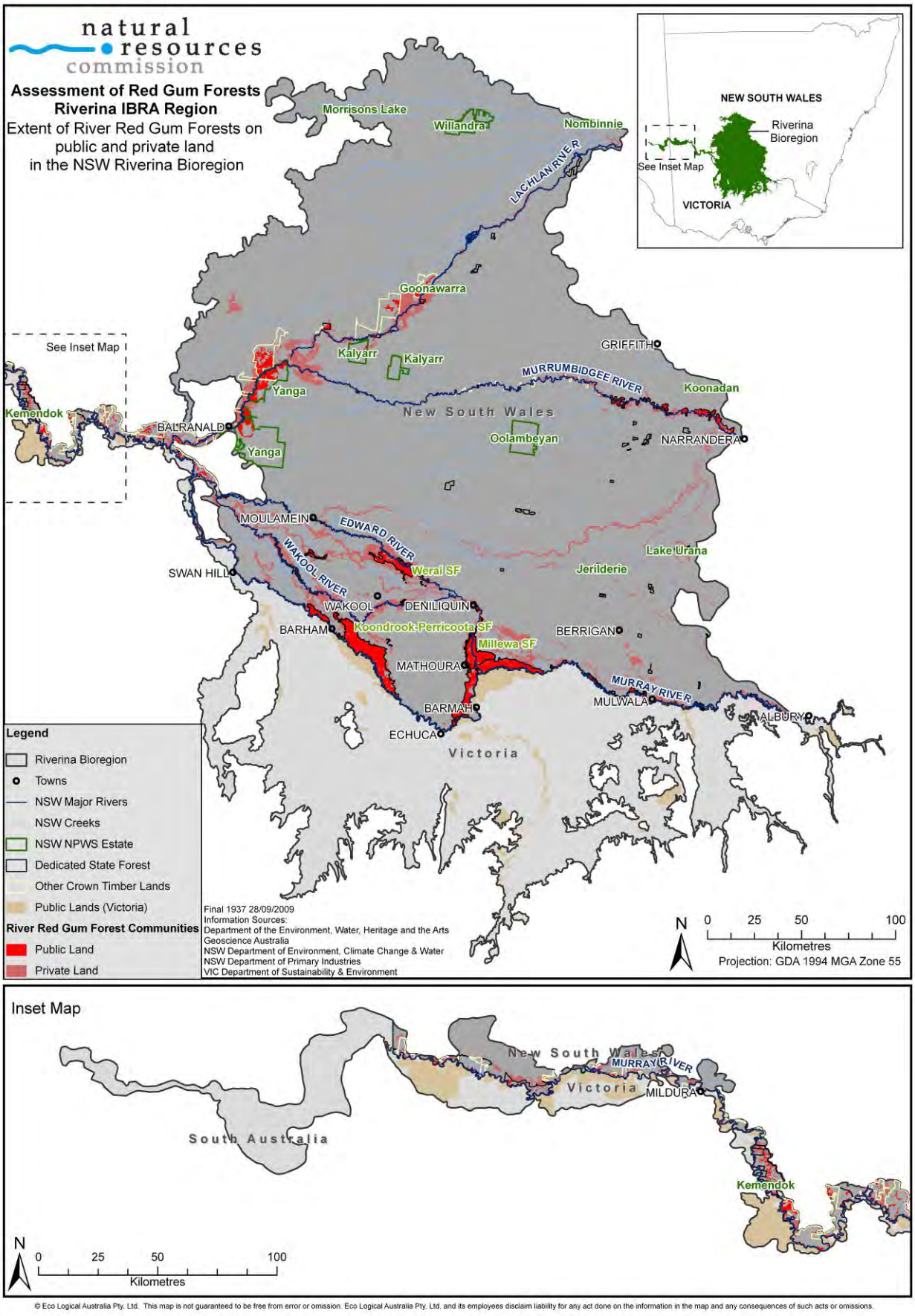


Figure 2 **Extent of river red gum forests on public and private land in the NSW Riverina bioregion**

2.2 Institutional arrangements

The Riverina bioregion extends from Ivanhoe in the Murray Darling Depression bioregion south to Bendigo, and from Narrandera in the east to Balranald in the west. Within its boundaries lie the towns of Hay, Coleambally, Deniliquin, Leeton, Hillston, Booligal and Wentworth. Other major towns of Griffith, Ivanhoe, Narrandera and Albury lie just outside its boundary in neighbouring bioregions.

The bioregion is characterised by a number of waterways. Towards the north of the region the Willandra, Moolbong, Merrowie, Mirrool creeks form tributaries and distributaries of the Lachlan river which in turn outfalls into the Murrumbidgee River. In the southern section of the bioregion in NSW, Billabong creek flows into the Edward River which travels north-west through river red gum forest before reaching Deniliquin. It then joins the Wakool River before re-entering the Murray.

The bioregion is managed under various institutional arrangements which include Local, State and Federal Governments, along with private landholders.

2.2.1 Local Government

Local government works with statutory agencies to protect biodiversity of the native fauna and flora. Depending on the local government policies, they manage relatively minor issues of timber removal, weed control for land under local government control (an obligation under the *Noxious Weeds Act 1993)* and in the case of the Victorian authorities, native vegetation retention controls. Local government areas for the NSW part of the bioregion are shown in Figure 3.

2.2.2 State Government

NSW state government involvement in management of the Riverina bioregion is represented by Forest NSW, the Department of Environment Climate Change and Water (DECCW), and the Catchment Management Authorities (CMAs). DECCW includes the NSW Office of Water. Forests NSW has the key role in the management of the river red gum (and other) State Forests. Forests NSW is responsible for licensing mills and harvest contractors, and providing allocations of timber volumes to mills.

DECCW undertakes biodiversity management planning to provide information and co-ordinated action for the conservation of the natural environment of NSW. A Property Vegetation Plan must be approved by the DECCW to harvest timber from private lands.

At a regional level, the NSW CMAs have a number of functions in relation to biodiversity and water under the *Water Management Act 2000* (NSW) and the *Catchment Management Authorities Act 2003* (NSW).

Key to the delivery of these responsibilities is that the CMAs produce a Catchment Action Plan (CAP) to provide a strategic framework for investment in the catchment's natural resources for the next ten years. The CAP is a statutory, but non-regulatory, plan approved by the Minister for Environment and Climate Change.

Water is also managed at a number of levels. NSW State Water undertakes the bulk water delivery functions to water infrastructure operators who service the irrigation areas in the region. These include Murray Irrigation Limited, Western Murray Irrigation Limited,

Coleambally Irrigation Cooperative Limited, Murrumbidgee Irrigation Limited, and Jemalong Irrigation Limited.

The NSW Office of Water is responsible for water management planning, water allocation and regulation under the *NSW Water Management Act 2000* (NSW). DECCW is responsible for managing environmental water allocations and licences held by the NSW Government. The Minister for Climate Change and Environment has a concurrence role in the making of water management plans.

2.2.3 Australian Government

There are a number of agencies with responsibilities across the bioregion at a federal level, primarily:

- Department of Environment, Water, Heritage and the Arts (DEWHA)
- Murray Darling Basin Authority (MDBA)
- National Water Commission (NWC)

Many cross-jurisdictional matters are managed through the Natural Resource Management Ministerial Council (NRMMC). The NRMMC is the peak government forum for consultation, coordination and, where appropriate, integration of action by governments on natural resource management issues.

Department of Environment, Water, Heritage and the Arts (DEWHA)

DEWHA develops and implements national policy, programs and legislation to protect and conserve Australia's environment and heritage and to promote Australian arts and culture.

The *Environment Protection and Biodiversity Conservation Act 1999* (C'wealth) (EPBC Act) is the Australian Government's key piece of environmental legislation. The EPBC Act focuses Australian Government interests on the protection of matters of national environmental significance, with the states and territories having responsibility for matters of state and local significance.

DEWHA is the administrative authority within Australia for the Ramsar Convention on Wetlands of International Importance. The Australian Government meets its obligations under the Ramsar Convention by providing national wetland policy leadership and direction, working with state and territory governments through the NRMMC, implementation of the EPBC Act, and through the development of programs with the goal of improving the management of wetlands.

Murray Darling Basin Authority (MDBA)

The *Water Act 2007* (C'wealth) created new governance arrangements for the waters of the Murray-Darling Basin, previously governed by a combination of the Murray Darling Basin Commission and sate agencies. The Australian Government Minister for Climate Change and Water, on advice of the Murray Darling Basin Authority (MDBA), is now responsible for setting the framework for Basin-wide planning and management of water resources across the Basin.

The MDBA is responsible for developing a Basin Plan under the *Water Act 2007* (C'wealth), with the first Plan to be made by 2011. Key elements of the Plan include Sustainable Diversion Limits at both a Basin-wide and catchment level to protect environmental assets

(values and functions) and an environmental watering plan. The Murray-Darling Basin Ministerial Council has an advisory role in the preparation of the Basin Plan (refer to Section 4.4.3 for more detail on the Basin Plan).

The MDBA also administers the *Living Murray Program* on behalf of the NSW, Victorian, South Australian and ACT governments. The program focuses on recovering water for the Murray River specifically for the benefit of plants, animals and the millions of Australians it supports, along with improving the environment at six icon sites. The icon sites, chosen for their high ecological, cultural, recreational, heritage and economic value, are: Barmah–Millewa Forest, Gunbower–Koondrook–Perricoota Forest, Hattah Lakes, Chowilla Floodplain and Lindsay–Wallpolla Islands, Lower Lakes, Coorong and Murray Mouth, and the Murray River Channel.

Through the Commonwealth Environmental Water Holder, the Australian Government is also purchasing water under its *Water for the Future Program* which must be managed in accordance with the Basin Plan.

National Water Commission (NWC)

The NWC is the lead Australian Government agency for driving national water reform under the *National Water Initiative* - Australia's blueprint for how water will be managed into the future. The NWC manages the *Raising National Water Standards Program* and the *National Groundwater Action Plan*.

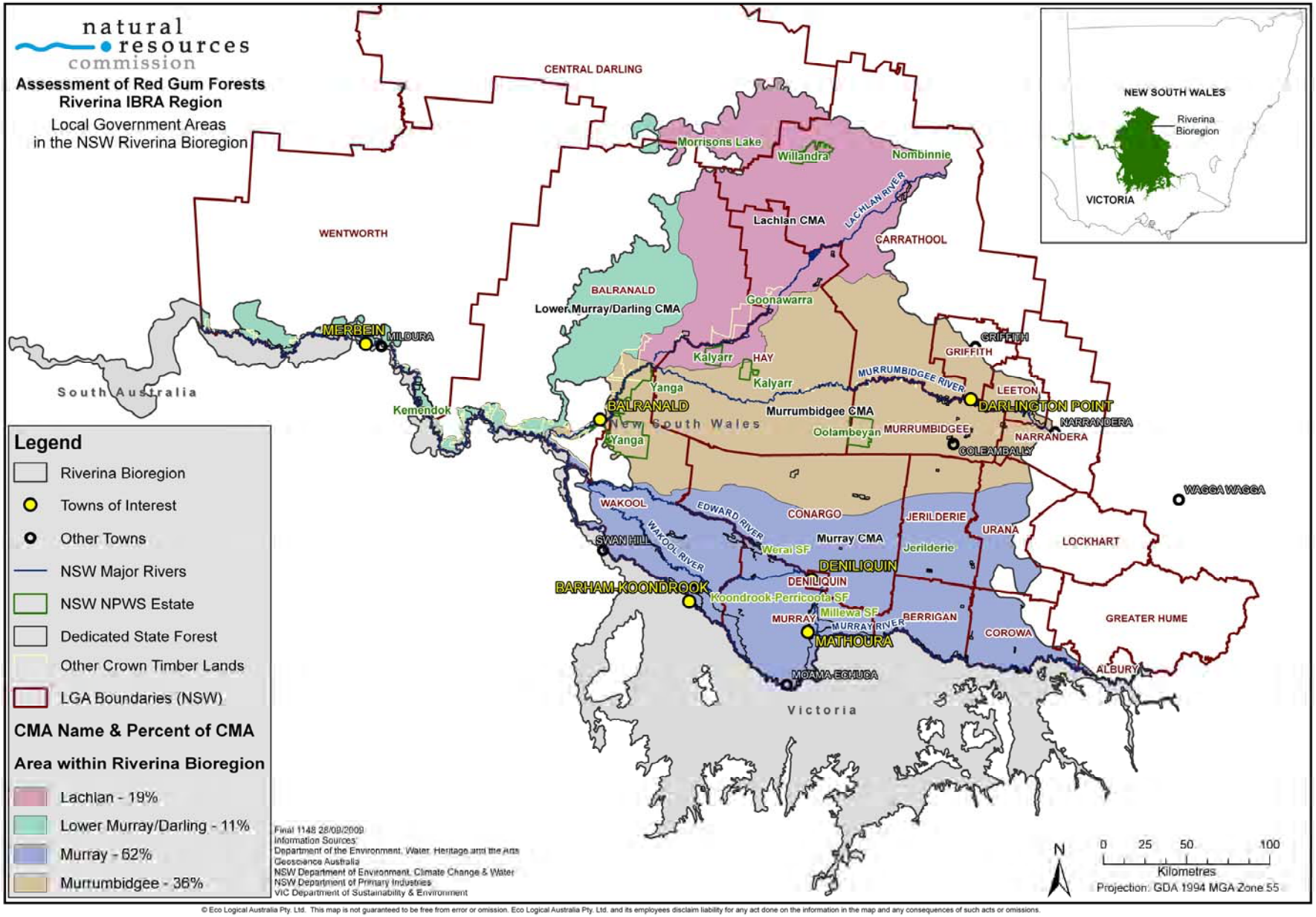


Figure 3 Local Government Areas in the NSW Riverina bioregion

2.3 Landscape evolution

2.3.1 Geomorphic setting

The major river red gum communities within the NSW portion of the bioregion are located in Central Murray State Forests, Millewa and Perricoota on the Murray River, and Werai on the Edward River. These rivers and their associated anabranches have been shaped by Quaternary geological and geomorphic processes and are composed of alluvial sediments laid down in this period. The Cadell Fault and the Barmah Choke are key geological and geomorphic determinants of the hydrology of this area, which in turn supports wetland plants and animals. These features dictate where in the landscape water flows and, in conjunction with water management of the region, have determined the hydrological conditions of a frequently inundated floodplain. Without this inundation, these forest communities could not be sustained in an area of such low rainfall.

River red gum is physiologically dependent upon floodwaters to maintain sufficient soil moisture to sustain its metabolism, growth and reproduction. The extent, frequency, timing and duration of floods thus impose major limitations on the distribution (Roberts and Marston, 2000), species composition (Benson et al, 2006) and silvicultural `quality' of river red gum forests (Di Stefano, 2001). The relationship between vegetation associations, geomorphic setting and flood regime is shown in Figure 4**.**

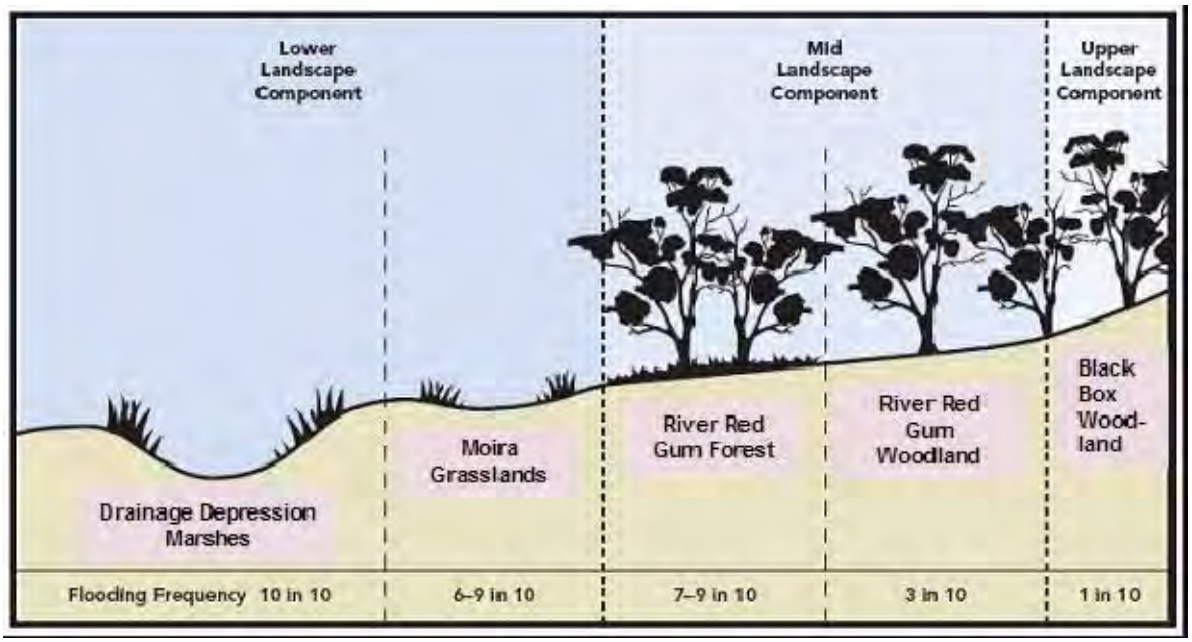


Figure 4 Vegetation associations, geomorphic setting and flood regime (adapted from MDBC, 2007b)

Soils at the site have formed through geomorphic and hydrological processes and influence the distribution of vegetation communities, with river red gum forests on alluvial sediments, Moira grasslands and floodplain depressions on water-retentive clay soils in lowest parts of the landscape, and drier woodlands (river red gum and box communities) on sand dunes and the surrounding Riverina Plain. The shape of the rivers and floodplain also influence fish passage and the abundance of migratory and breeding wetland birds (GHD, 2009).

2.3.2 Hydrologic setting

The vegetation and associated ecology of the NSW Riverina bioregion has evolved over time in response to water availability within the context of the geomorphic setting.

Australian rivers have variable flow regimes. In particular, the Murray River has a relatively low average discharge by comparison with similar size catchments worldwide (Table 2). Understanding and managing flows in this context presents a considerable challenge.

Table 2 Murray River average discharge compared to other rivers worldwide

River	Drainage area (km²)	Average discharge (m³/s)
Amazon	6,915,000	219,000
Congo	3,680,000	41,800
Nile	3,400,000	2,830
Missouri	2,980,000	16,200
Lena	2,490,000	17,100
Niger	2,090,000	9,570
Ganges	1,500,000	33,470
Volga	1,380,000	8,060
Murray	1,061,469	767
Orinoco	880,000	31,900
Danube	817,000	7,130
Mekong	810,000	16,000
Rio Negro	691,000	29,300
Rhine	170,002	2,290
Thames	12,935	65.8

The average annual rainfall of 404 mm and mean annual deficit of 1075 mm between rainfall and evaporation mean that floodwater contributions are required to support the moisture requirements of forests and wetlands (Leslie, 2001). As a consequence of the geomorphic setting, intermittent flooding of the Murray River, the Edward River and associated creeks and channels provides this soil moisture. Accordingly climatic conditions in the catchment for the Murray River and its tributaries are of much greater importance to the site than local rainfall.

Another important component of the hydrologic setting is river regulation which commenced in 1936 with the completion of the Hume Dam. Regulation for the delivery of irrigation has considerably altered the magnitude, timing and duration of flood flows to the river red gum forests. The effect of river regulation on flooding for the various forest stands is described further in Chapter 5.

The hydrologic setting is also likely to shift into the future with the intensification of climate change effects. The magnitude, timing and duration of floods which sustain the river red gum forests are likely to change significantly into the future. The expected changes and implications for the forests are further described in Chapters 4 and 5.

2.3.3 European settlement

European settlement has also been a major driver of landscape evolution, and the associated extents of river red gum communities. Towns developed along rivers, utilising wood sources from the forests. River regulation commenced to secure water supplies for towns and agriculture, and the Snowy Mountains Hydro-Electric Scheme was constructed for power and irrigation. The response of the river red gum forests to human interventions since European settlement is detailed in the following section.

2.4 History of forest development

The river red gum forests of the Murray have been used as a source of timber and other products since the early 1800s. Management has transitioned through many stages, from early cutting and ringbarking of the 1800s, to flood-responsive silvicultural management of regrowth in recent decades. Forest management is more challenging in these forests than in any other forest in NSW, as it is intrinsically interwoven with flood dependency. This section provides a brief summary of forest development in the Murray river red gum forests, from early utility to Ramsar listing.

Exploration

The river red gum forests of the Riverina region were first explored by Europeans in the early 1800s. Oxley explored the Lachlan in 1817, Sturt explored the Murrumbidgee and Murray in 1829-30 and Mitchell explored the Lachlan, Murray and Murrumbidgee in 1836. The structure of pre-European forests is contested due to the limited data available. Jurskis (2009) suggests that, due in part to frequent burning carried out by Aboriginal people, the river red gum forests assumed a relatively open structure prior to European settlement, with little shrub cover, fallen dead timber or regrowth. Benson and Redpath (1997) have alternative views.

The following history is largely drawn from the Draft Ecological Character Description Report (GHD, 2009) unless stated otherwise.

1825 – 1900: Settlement, industry development and grazing

- In the first period up to 1900 the river red gum forests were used ostensibly to support settlement and early industry, with timber cut for bridges, mining, railway sleepers, slab huts, posts and firewood.

- Use of fire was replaced by widespread grazing of domestic stock (sheep and cattle), and ringbarking was carried out to open up pastures.

- Major flooding in the early 1870s resulted in a significant change to forest structure as a thick understorey of natural regeneration developed in newly cleared areas and in the absence of fire, and larger trees continued to be removed through timber cutting and ringbarking.

- Grazing was formalised towards the end of the 1800s by granting leases across the forests, and the first attempt to allocate forests to product classes was undertaken through designation of Timber Reserves and appointment of Forest Rangers.

1901 – 1980: Forestry and river regulation

- The second major period, from 1900 to 1980, witnessed the formalisation of forest management in the region.
    - The *Forestry Act 1916* (NSW) was enacted, timber reserves were designated as State Forest, timber cutting and apiary use was regulated through licensing under the Act, and forest type mapping commenced in the early 1900s.
    - Regulation of river red gum timber yield was guided by the first Murray Management Plan.
- Even-aged regenerative response to the 1870s floods was changing the structure of the forests in the 1900s from open savannah-like woodland dominated by mature trees to a dense multi-aged forest.
- Introduction of Improved Utilisation logging in 1947 was designed to remove a high proportion of the remaining mature to over-mature red gum trees by logging or ring barking and also thinning the re-growth from the 1870s floods for timber products.
- Major flooding in the 1950s and 1970s stimulated further episodes of red gum regeneration.
- The mid-1900s witnessed the onset of river regulation, which was to have a profound impact on long-term health of the river red gum forests.
    - River regulation commenced with the completion of Hume Weir in 1936.
    - The first stage of Eildon Weir was completed in 1929 and a series of enlargements were completed in 1955.
    - Small regulators were constructed in the Millewa Forests upstream of Picnic Point to prevent loss of regulated flows in the Murray River.
    - Construction of Dartmouth Storage was completed in 1979, introducing further impacts from river regulation.
    - Changes to flooding regimes in response to Dartmouth resulted in river red gum seedling invasion of the grass plains, and regeneration that established since construction of Hume weir (i.e. in response to the 1950s floods) developed into full forest cover on areas that were previously native grass plains (e.g. Moira State forest).

1981 – present: Forest management

- A shift in forest dynamics in relation to changing hydrology compounded by climate change, and responsive forest management, have characterized the final period from 1980s to the present.
- The past 30 years have witnessed cessation of logging and ringbarking of non-commercial trees, dedication of flora reserves, and commencement of monitoring of wetland dependent water birds in response to river regulation.

- Forest Management Zones (FMZs) were delineated which differentiated between areas of State Forests specifically set aside for conservation and those that available for other activities, including timber harvesting.

- The second Murray Management Plan was published in 1985, under which harvest plans were developed which governed site specific controls such as exclusion zones along riparian areas, habitat zones, retention of hollow bearing trees, and aspects of native fish management.

- Managed flooding of site specific wetlands commenced to protect low-lying communities such as reed beds, with site specific plans developed with the Murray Wetlands Working Group for Reed Beds Wetland and Moira Lake Complex Wetlands.

- River regulation works continued, with the construction of Mary Ada Regulator and upgrade of Millewa and Werai regulators.

- Construction of an additional 15 regulators along the Edward River was undertaken to prevent unseasonable flooding of wetlands along the Edward and the adjacent forests.

- Desilting of the Swan Lagoon and Burrumbarry Creek within Toorangabby freehold property was undertaken to facilitate natural flooding of the Koondrook Forests.

- A Code of Practice for Harvesting in Native Forests and Soil Conservation Measures was also implemented.

2003: Ramsar listing

Standard prescriptions put in place since the mid 1970s to protect large mature trees have ensured that the NSW Central Murray State Forests retain pre-European age trees and hollow-bearing habitat trees (GHD 2009). While a reduction in the overall number of hollow-bearing trees has occurred as a result of stand improvement in the past 100 years, the overall condition and intrinsic values of these the NSW Central Murray Forests (Millewa, Koondrook and Werai Forests), and the various wetlands types within, resulted in their collective nomination and listing in 2003 as a "Wetland of International Importance" under the Ramsar Convention.

The Ramsar site included nearly 84,000 ha as the 'Central Murray State Forests Ramsar Wetlands' under the Convention on Wetlands of International Importance especially as waterfowl habitat. The broad aims of the Ramsar Convention are to halt, and where possible, reverse the worldwide loss of wetlands and to conserve those that remain, through 'wise use' and management. The Ramsar listing of the NSW Central Murray State Forests is based on the inherent ecological values of the wetlands, but also acknowledges the significant social, cultural and economic resources of the site and its long history of management for multiple uses (Wetlands International).

Since the Ramsar listing, the Riverina has been exposed to the worst drought on record, with climate change acknowledged to be a major contributing factor. A major question is whether floods on the scale of the 1870s, 1950s or 1970s events will occur again, and in their absence how will water be managed across the Ramsar system, and how will silviculture need to adapt, within the framework of management, to help prevent loss of these forested wetlands. In little over eight years the dry period has had a profound impact on the health

of the Ramsar forests, with a large proportion of the forest under stress or in poor health as a result of lack of flooding.

Some areas of river red gum badly affected by drought have been thinned to test the validity of reducing basal areas to allow trees and coppice to survive. Following some success in Campbells Island State Forest and the Koondrook Forests, targeted thinning has also been implemented in Perricoota and other parts of the Koondrook group.

2007: Yanga National Park

For over 160 years, Yanga was a working pastoral, cropping, irrigation and forestry property in the Riverina bioregion of south-western NSW. In 2005 the NSW Department of Environment and Conservation purchased the 80,000 hectare property for its natural and cultural heritage values (DECCW website, Park Management).

Yanga forms part of the Lower Murrumbidgee Floodplain and includes over 100km of Murrumbidgee River frontage as well as wetlands and lakes. The floodplain supports some of Australia's largest and most important waterbird breeding colonies and the state's largest known population of the highly endangered southern bell frog. Other threatened species recorded on the property include the blue-billed duck, freckled duck, Australasian bittern, major mitchell's cockatoo and regent parrot as well as many threatened plants (Minister of Climate Change and Environment, Media release: *65,000 ha Yanga National Park yours to explore*).

The area includes a diverse range of habitats including approximately 76,000 ha of river red gum forest, black box floodplain vegetation as well as various shrub land and open woodland vegetation types (DECCW website, Yanga Park). Yanga also has important Aboriginal and historic heritage values such as scar trees, ovens, middens and other artefacts and historic buildings.

The Yanga National Park was created in 2007 and opened to visitors in mid 2009.

Flooded red gum forest, Yanga National Park Murrumbidgee Floodplain

2.5 River red gum forests in the NSW bioregion

2.5.1 Landscape location

River red gum forests are associated with most of the major channels and floodplains in the Riverina (See Figure 2). The total area of river red gum forests within the NSW portion of the Riverina bioregion is about 236,000 ha. Of this total area:

- Approximately 121,600 ha (52 percent) is associated with State Forests on public land
- The remainder (48 percent) is located within Western Lands Leases and private land, with some also reserved in Yanga National Park.

These figures do not include river red gum/box types, of which there is an additional 162,000 ha in the NSW Riverina, of which 22,700 ha (about 14 percent) is in State Forest. Figure 2 shows the extent of river red gum forest in the NSW Riverina bioregion.

Given the flood dependent nature of river red gum vegetation communities, all of the major communities are located either adjacent to, or in close proximity of major watercourses. The majority of the extent of river red gum on public land and shown in Figure 2 can be found within three areas along the Murray and Edward Rivers in the Millewa, Koondrook-Perricoota and Werai Forests which form the NSW Central Murray State Forests (and Ramsar site) (Figure 5).

Flow delivery to areas of river red gum state forest is constrained by the need to minimise impact on adjacent private land. For example, current easement constraints associated with private land limit the delivery of large floods to the Millewa Forests, and old privately built levees exist around Koondrook-Perricoota Forests to keep floods out of adjacent cleared land.

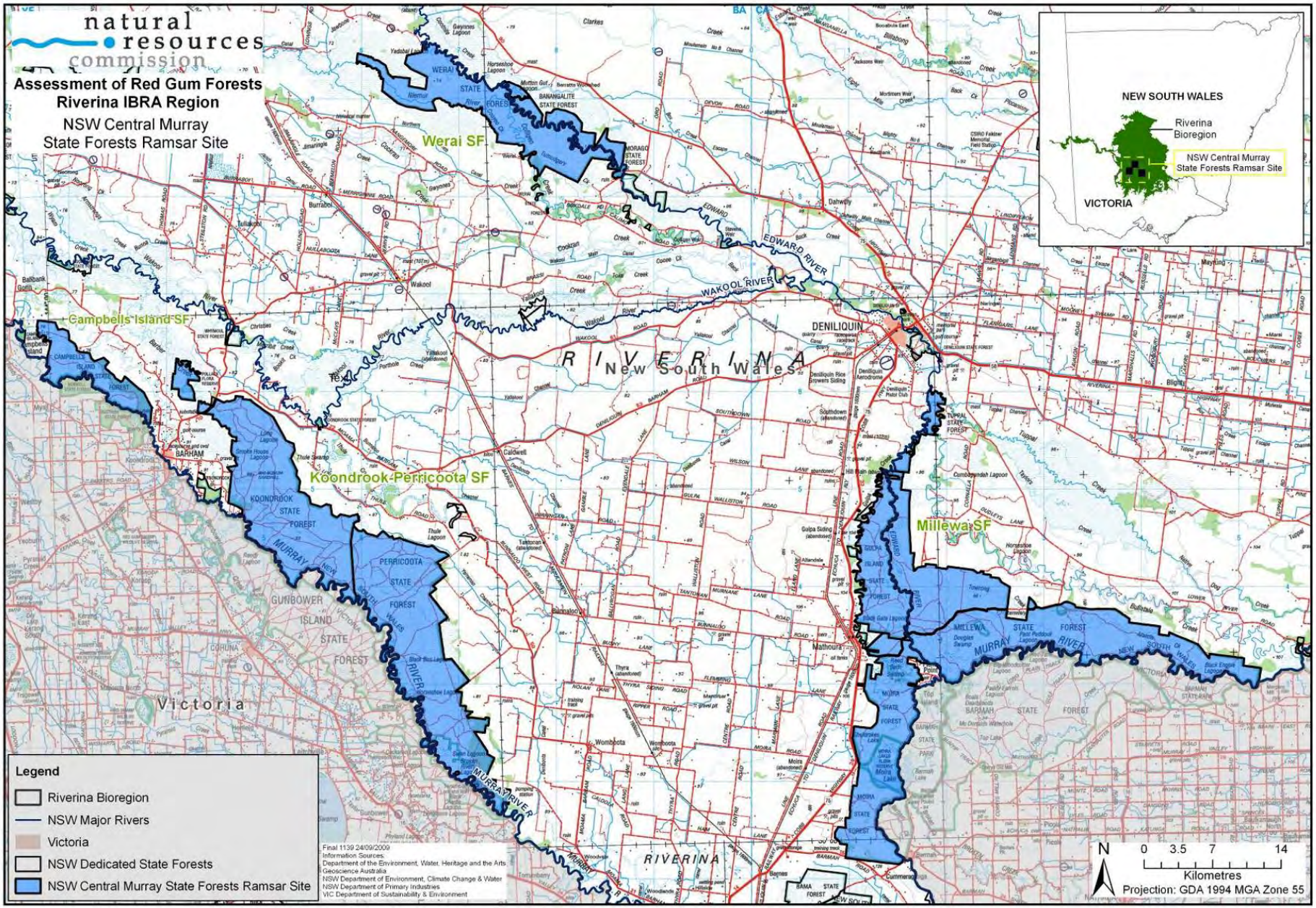


Figure 5 NSW Central Murray State Forests Ramsar site

2.6 Summary of values

The Murray River and its river red gum lined tributaries and anabranches have high cultural value for Aboriginal and non-Aboriginal Australians. Not only were they a source of food and fire wood, they also provided the 'highways' that allowed the Aboriginal peoples to travel through south eastern Australia. There is widespread evidence of Aboriginal occupation along the rivers, in the form of middens, mounds, burial grounds and scar trees. The large trees found in the red gum forest provided the ideal material to make fishing platforms. Aboriginal peoples also used the trees for medicinal remedies. The young leaves of the red gums were turned into liniment which was used for pain relief from general aches and flu symptoms.

The red gum forests also have a high cultural value to non-Aboriginal people. Since European settlement the river red gum forests and woodlands have become iconic Australian landscapes, immortalised in art and literature. In addition to their aesthetic and cultural values, the forests have also provided significant recreational value. The forests provide the ideal location for camping, where a wide range of activities can be undertaken, such as bird-watching, canoeing and fishing. Tourism is a major industry in the Murray region, and the river red gum forests and the recreational activities they support are a major attraction for tourists.

The flood dependant river red gum forests also support a wide range of environmental values across the landscape. These forests provide habitat and refuge and migratory pathways for a range of flora and fauna species. More detail on specific environmental values supported by the river red gum forests in the Riverina bioregion is provided in Chapter 3.

Today, the iconic river red gum forests have a range of social and environmental values, with a complexity of significance to different groups of people, and to various flora and fauna species.

Murray River near Swan Hill

2.7 Water management units

From a management perspective, river red gum communities situated in State Forests across the NSW portion of the Riverina bioregion are generally considered in terms of several logical water management units (WMUs) and their associated forest stands. WMUs are relatively discrete geographical areas that have varying restrictions on flow delivery and manipulation, and have associated stands of high value forest.

WMUs defined for this assessment have been based on information provided by Forests NSW (G. Rodda [Forests NSW] pers. comm. 11 Sep 2009). The following WMUs (Table 3, also shown in Figure 6) form the basis for assessment of future water availability and implications in Chapter 5 of this assessment.

Table 3 Water Management Units

Water Management Unit	
1.	Millewa Forests
2.	Koondrook-Perricoota and Campbells Island
3.	Werai Forests
4.	Murrumbidgee River a. Downstream of Narrandera b. Lowbidgee/Yanga region
5.	Lachlan River a. Booligal Wetlands b. Great Cumbung Swamp
6.	Upper Murray River riparian zone
7.	Wakool and Edward Rivers riparian zone
8.	Lower Murray River riparian zone

A brief summary of each WMU and associated forest groups is provided in the following discussion.

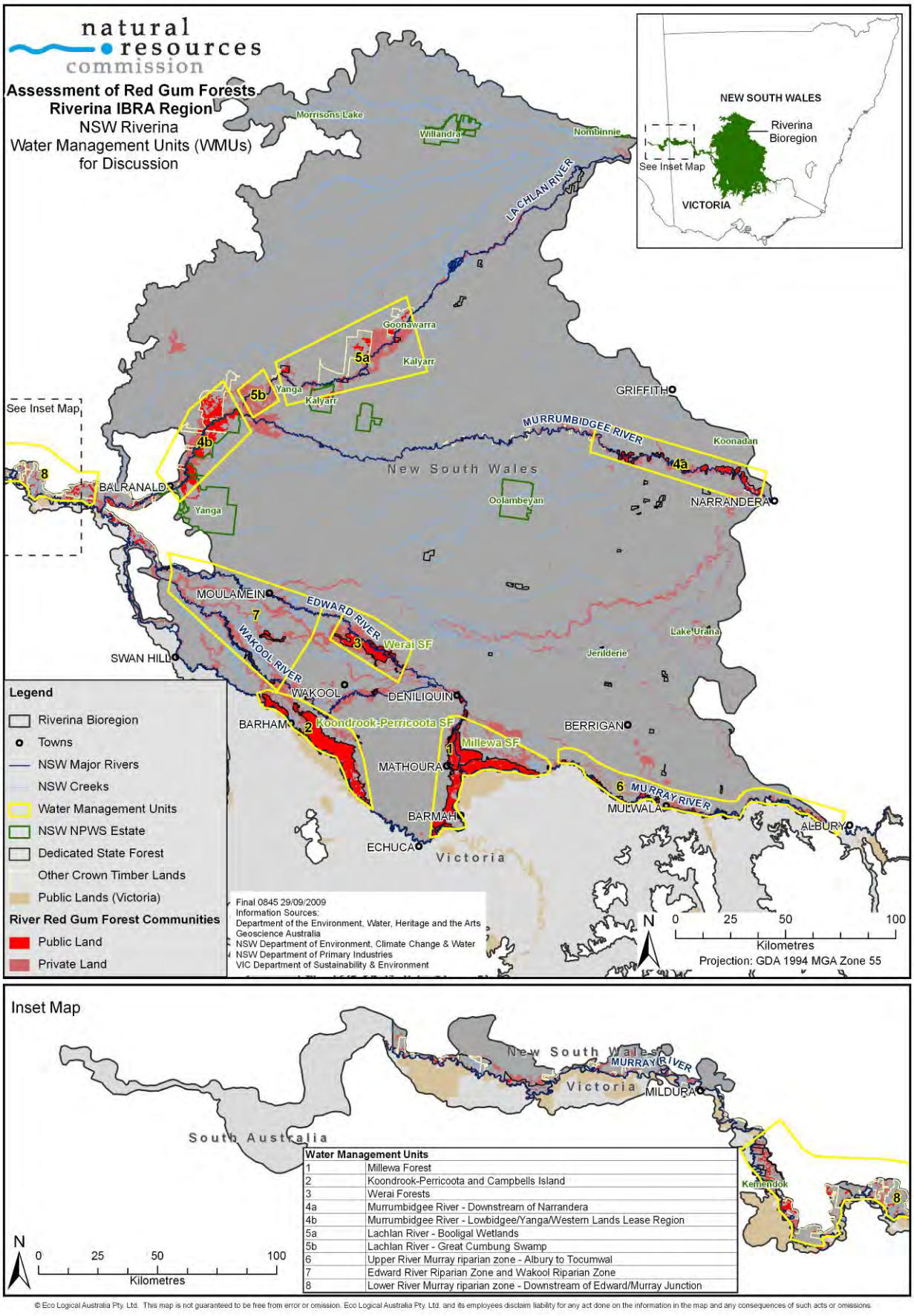


Figure 6 NSW Riverina Water Management Units (WMUs) for discussion

2.8 Major forests

2.8.1 Millewa Forests

The Millewa group of forests covers approximately 38,100 hectares and incorporates the Millewa, Moira, Gulpa Island and Tuppal State Forests. The main channel of the Murray River defines the southern boundary of the forest and discharges water into the forest via the Edward River, Gulpa Creek and smaller channels and overbank flow (GHD, 2009).

The Barmah Forest lies immediately to the south of the Murray River on the Victorian side of the state border. The combined Barmah-Millewa Forests have been recognised as a highly significant wetland complex, jointly containing the largest area of river red gum forest in the world (O'Connor et al 2006). The Barmah-Millewa Forests form one of six Icon Sites defined under the Living Murray program.

2.8.2 Koondrook-Perricoota and Campbells Island

The combined Koondrook-Perricoota State Forests cover an area of approximately 34,546 hectares (including Campbells Island). The main channel of the Murray River comprises the southern border of the forest and discharges water into the forest via Swan Lagoon and Burrumbury Creek (GHD, 2009). The Gunbower Forest is located immediately south of Koondrook State Forest, on the Victorian side of the border. The Gunbower-Koondrook-Perricoota red gum forests form another of the six Icon Sites defined under the Living Murray Program.

The two major forest groups associated with this WMU are the Perricoota forest group, which incorporates the second largest area of river red gum forest after Millewa, and the Campbells Island forest group.

2.8.3 Werai Forests

The Werai Forests occupy an area of 11,403 hectares, including the Werai State Forest and Barratta Creek State Forest (GHD, 2009). The Werai group of forests are situated on the floodplain of the Edward and Niemur Rivers between Yadabal Lagoon and Morago (GHD, 2009). While this site is not one of the Living Murray Icon Sites, it has Ramsar-listed wetlands of international significance, including areas of red gum forest. The Werai Forests are hydrologically linked to the Millewa Forests and during large flow events in the Murray River substantial volumes of water are diverted to the Edward River, and ultimately the Werai Forest.

Entry point to Werai State Forest

2.8.4 Murrumbidgee River

The Murrumbidgee region is located within southern NSW and covers 87,348 km² or 8.2 percent of the Murray Darling Basin. The Murrumbidgee region contains a total of 33 sites listed as wetlands of national significance, and two of these sites are Ramsar listed as Wetlands of International Importance (Fivebough and Tuckerbill Swamps). The two large lowland areas in the Murrumbidgee Catchment are the Mid Murrumbidgee Wetlands and Lowbidgee Floodplain Wetlands.

The Mid Murrumbidgee Wetlands are an assemblage of lagoons and billabongs along the Murrumbidgee River from Narrandera to Carrathool, with an estimated total area of 2,500 hectares. River red gum forest and woodlands dominate the vegetation of the area with black box woodland being more marginal on the floodplain (CSIRO 2008b, Environment Victoria 2001).

The Lowbidgee Floodplain is around the lower Murrumbidgee River downstream of Maude and covers some 200,000 hectares. The broader Lowbidgee is sub-divided into the Nimmie-Pollen-Caira system near Maude Weir, and the Redbank-Yanga system further downstream. The Redbank-Yanga system is covered by river red gum forest and woodlands, with black box on the floodplain margins (CSIRO 2008b, Environment Victoria 2001).

Red gum forests along the Murrumbidgee River

2.8.5 Lachlan River

The Lachlan region is located within central western NSW and covers 85,532 km² or 8 percent of the Murray Darling Basin. The Lachlan group of forests contains several important and large wetlands of national significance, supporting a diversity of vegetation types including river red gum. Of most notable significance are the Booligal Wetlands and Great Cumbung Swamp.

The Booligal Wetlands cover approximately 5,000 hectares on the lower Lachlan River, including the Booligal Swamp and Little Gum Swamp, the latter of which has a dominant over-storey of river red gum (CSIRO 2008c, Magrath 1992).

The Great Cumbung Swamp is around 16,000 ha at the terminus of the Lachlan River and is adjacent to the Murrumbidgee River and the Lowbidgee Wetlands. River red gum and black box cover large areas of the swamp (CSIRO 2008c).

2.9 Other forests and riparian zones

2.9.1 Upper Murray River riparian zone

The Upper Murray River riparian zone is located between Albury and Tocumwal. The flow regime of this zone is heavily modified by the storages of Hume Dam, Yarrawonga Weir and the Snowy Mountains Scheme. The Barooga group of forests along the upper Murray is known to be in good condition on account of their relatively regular flooding (due to irrigation releases). These forests are the most eastern in the NSW Riverina and are comprised almost entirely of river red gum of varying site quality.

2.9.2 Wakool and Edward Rivers

At the 'Barmah Choke' near Mathoura, the Edward River leaves the Murray River and flows in a north-westerly direction, joining the Wakool River before flowing back into the Murray 500 km downstream from the divergence point (MDBC 2006c). In major flood events the Edward River takes over half of the Murray flows which pass Tocumwal (MCMA 2006).

The Wakool River is enclosed between the Edward and Murray Rivers, and is part of an extensive network of high level anabranches. During major flood conditions approximately 50 percent of the total flow passing Deniliquin leaves the Edward River via the Wakool and Yallakool Rivers (MCMA 2006c). Parts of the Wakool River system adjoin the Koondrook-Perricoota Forest, one of The Living Murray six Icon Sites, and comprises hundreds of kilometres of rivers and creeks. The river system and adjoining forest are recognised as having high ecological value and feature the iconic river red gum (MDBC 2007). The Wakool Group of forests along the Wakool River are little surveyed. They comprise river red gum woodland, box-river red gum woodland and box woodland.

2.9.3 Lower Murray River riparian zone

The Lower Murray River riparian zone extends downstream from the confluence of the Edward and Murray Rivers (to the boarder of the bioregion). The hydrological regime of this section has been significantly changed. Less than half the natural median annual discharge now reaches the border with South Australia (Gippel et al 2002). Periods of prolonged low flow are more frequent. The frequency, duration and magnitude of all but the largest floods have been reduced (Gippel et al 2002).

The western group of forests are located on the lower reaches of the Murray, with some located downstream of the Darling confluence. These forests support a diversity of communities, with river red gum forests, river red gum - box woodlands, mallee woodlands and semi-arid acacia woodlands represented.

3 Current forest extent, condition, management and values

The purpose of this chapter is to provide an overview of:

- the current vegetation types and extent across the bioregion
- vegetation condition
- forest management
- environmental values
- cultural heritage (including Aboriginal) values and contemporary Aboriginal values and uses of the forests
- economic and social values associated with forest and other primary industries
- recreational and tourism values supported by the forests.

A diverse range of vegetation communities, types and groups have been identified across the NSW section of the Riverina bioregion. The distribution of vegetation groups, including river red gum groups, has been mapped for this assessment across the NSW portion of the Riverina bioregion, and also for the larger individual forest groups.

The general condition of river red gum forests across the bioregion is understood to be relatively poor. River red gum in many of the state forests has been observed to be heavily stressed. Condition is likely to continue declining, and the forests are in need of water and possibly active silviculture to survive the current drought.

The declining condition of river red gum communities poses a significant threat to the range of values supported by the current forest groups. Biodiversity values include a wide range of flora and fauna, with several threatened species (mapped for this assessment), plus the wider range of social and economic values of these forests.

The river red gum forests support both intrinsic and direct use values for a diverse range of communities and groups. These include communities with direct economic and employment links to the timber industry, timber mill owners and operators, local and regional landholders, Aboriginal communities, recreational users and tourism operators. The values supported by the forests include Aboriginal and European cultural heritage, natural heritage, social and economic security, cultural uses of the forest by Aboriginal communities, and recreational and tourism use by local, state and inter-state residents.

There is a rich cultural heritage associated with the Riverina region that reflects both the historical and continuing interactions between communities and forests. Aboriginal cultural heritage relates to places with traditional significance. These are often tied to the context of a site within the landscape or to stories of recent and Dreaming ancestors.

The contemporary uses, values and aspirations of Aboriginal people across the Riverina are diverse. Consultation conducted on behalf of Forests NSW, as well as the small number of individual consultations conducted by the NRC to date indicates that key issues such as management of Aboriginal sites, reporting on sensitive information, direct consultation and Aboriginal participation in land management will need to be considered and managed.

European cultural heritage is related mainly to the historical connections between the river red gum and woodland forests and the development of the Riverina region. While relatively few significant sites and structures remain as testament to this history, modern day communities have long-standing connections with the river red gum forests that form part of the cultural heritage of the region.

Economic and social values associated with forest industries are most significant at the individual town level, where the relative contribution of the timber industry is much greater than at a regional or state scale. Forest management today draws on a significant body of institutional and local knowledge developed since European settlement began in the 1820s, and more recently on traditional knowledge of Aboriginal communities. An adaptive approach to sustainable forest management has allowed the forests to continue to support social, economic and community interests, and to protect and promote environmental and heritage values.

The state forests of the Riverina bioregion support a wide range of recreational and tourism activities. Easy access through a network of roads allows for activities as diverse as camping, water-skiing, fishing, four-wheel driving and nature photography to occur relatively freely throughout the forests. The recreational opportunities provided by the forests are of great value to local communities. The forests also support tourism operations which contribute to the local economy by drawing in visitors from other parts of NSW, Victoria and further afield.

Recreational fishing near Kyalite

3.1 Current vegetation type and extent

3.1.1 Major vegetation communities

A rich diversity of native vegetation extends across the Riverina bioregion, from water dependent forested wetlands occurring along the main channels and inner floodplains, dominated by river red gum (*Eucalyptus camaldulensis*), to semi arid woodlands, mallee, shrublands and grasslands on the dry rangelands. The following information is summarised from Rowe (2002) unless stated otherwise.

River red gum forest occurs along the major rivers, creeks, lakes and floodplains in the region where intermittent soil saturation by floodwaters supplements the sparse annual rainfall

enough to saturate the root zone. They are typically found on grey soil, and comprise a scant shrub layer and dense ground cover. Black box woodlands occur along ephemeral watercourses and depressions, but are less frequently flooded than river red gum forests. There is often a more established shrub layer and less dense ground cover in this community. Ephemeral wetlands are contained within both river red gum and black box communities. They comprise nitre goosefoot, canegrass cumbungi and other reedbeds that are filled with water for extended periods of time.

Above the periodically inundated communities are a range of other eucalypt woodland types that include western grey box woodland, bimble box woodland, and white cypress pine-inland grey box woodlands. There is a close association between these community types, with the dominant species influenced by soil type, soil fertility and topography. Several other canopy species co-occur, such as yellow box, bulloak, belah, dwyers mallee gum, kurrajong and black cypress pine. These communities also vary from grassy woodlands to dry forests with a scant ground cover and healthy understorey.

On the gently undulating plains, boree woodland is common, and is likely to have been a dominant community prior to broad scale clearing for grazing and irrigation. The community occurs on a range of soil types, from red-brown earths to grey and brown clays. Boree woodland is subject to periodic inundation in high rainfall events where there is little relief. Boree is a favoured source of drought fodder for stock. Grazing has reduced the recruitment of boree in this community. Mallee woodlands are found on the sandy dune and plains in the northern parts of the bioregion. They are typically diverse in flora and fauna, comprising a distinct shrub and ground layer.

In the western parts of the bioregion, extensive rangelands of saltbush and bluebush are common. These chenopod communities extend beyond the bioregion, but are also one of the most dominant vegetation types within the Riverina. However, many of these characteristic species have suffered from ongoing grazing and much of the chenopod shrublands have converted to derived grasslands. Vast areas of the Riverina bioregion comprise grassland, including both natural and derived grasslands (McDougall 2008). The extent of natural grassland is poorly known, but natural grasslands are thought to have been widespread in the Deniliquin, Conargo, Jerilderie and Urana regions (McDougall 2008).

3.1.2 Vegetation types and extent

The NSW Vegetation Classification and Assessment (NSWVCA) (Benson 2006, 2008; Benson *et al*. 2006) provides the most recent classification of vegetation in the Riverina. Each type is described in terms of its structural nature, diagnostic species and landscape context, with sections on threats and management actions. Pre-European, extant and reserved area estimates and accompanying IUCN threat status categories are listed.

Forests NSW recently mapped the spatial extent of 'woody' NSWVCA types within State Forests of the Riverina using a compilation of recent mapping datasets (Binns unpubl. data) to accompany work being undertaken for the Environmental Impact Statement (Forests NSW, 2009a) and Draft Ecological Character Description (GHD, 2009) projects. These NSWVCA types are listed in Table 4.

DECCW subsequently mapped the distribution of these types within National Parks and Nature Reserves in the Riverina using improved mapping datasets (e.g. McCosker 2008), thus improving NSWVCA reserved area statistics published by Benson (2006) and Benson et al (2008) which were partly informed by reserves outside the Riverina. Table 4 includes pre-

European and current area estimates (Benson et al 2006; Benson 2008) and reserved areas estimates (DECCW unpubl data) for each NSWVCA type mapped in State Forest.

Area estimates reported in the NSWVCA database (and listed in Table 4) were informed by existing vegetation maps where available, and field reconnaissance where not available (Benson 2006). For example, areas of several river red gum types occurring along the Murray River were calculated directly from vegetation mapping undertaken by Margules (1990), but total areas had to be expertly revised (with input from rapid field survey) to account for unmapped areas along the Murrumbidgee and Lachlan Rivers (John Benson pers comm). Thus the NSWVCA uses all available mapping and reconnaissance data to estimate the area of vegetation types in the absence of complete and consistent mapping. It also provides the most recent published and peer reviewed area estimates for all vegetation types in the NSW Riverina (Benson 2006, 2008; Benson et al 2006) and has been adopted as the basis for area analyses in this report. Due to the composite nature of the datasets used to compile these figures, they are estimated to be accurate to plus or minus 30%.

Table 4 Total NSW area estimates for VCAs which occur in State Forests in NSW

		Area (ha)		
NSWVCA No.	NSWVCA Name	Pre-European	Current	Reserved
2	River Red Gum-sedge dominated very tall open forest in frequently flooded sites along major rivers and floodplains in south-western NSW	35,000	30,000	5,700
5	River Red Gum herbaceous-grassy very tall open forest on inner floodplains in the lower slopes sub-region of the NSW South West Slopes Bioregion and the eastern Riverina Bioregion	15,000	9,000	0
7	River Red Gum - Warrego Grass - herbaceous riparian tall open forest mainly in the Riverina Bioregion	100,000	85,000	3,800
8 *	River Red Gum - Warrego Grass - Couch Grass riparian tall woodland of the semi-arid (warm) climate zone (Riverina and Murray Darling Depression Bioregions)	30,000	25,000	100
9	River Red Gum - wallaby grass tall woodland on the outer River Red Gum zone mainly in the Riverina Bioregion	35,000	12,000	0
10	River Red Gum - Black Box woodland of the semi-arid (warm) climatic zone (mainly Riverina and Murray Darling Depression Bioregions)	70,000	40,000	100
11	River Red Gum - Lignum very tall open forest or woodland on floodplains of semi-arid (warm) climate zone (mainly Riverina and Murray Darling Depression Bioregions)	60,000	35,000	12,600
13	Black Box - Lignum woodland of the inner floodplains in the semi-arid (warm) climate zone (mainly Riverina and Murray Darling Depression Bioregions)	350,000	150,000	8,100
15	Black Box open woodland with chenopod understorey mainly on the outer floodplains in south-western NSW (mainly Riverina and Murray Darling Depression Bioregions)	500,000	25,000	9,100

		Area (ha)		
NSWVCA No.	NSWVCA Name	Pre-European	Current	Reserved
16	Black Box grassy open woodland of rarely flooded depressions in south western NSW (mainly Riverina and Murray Darling Depression Bioregions)	200,000	100,000	0
17	Lignum shrubland of the semi-arid (warm) plains (mainly Riverina and Murray Darling Depression Bioregions)	400,000	150,000	3,600
19	Cypress Pine woodland of source-bordering dunes mainly on the Murray and Murrumbidgee River floodplains	1,000	300	0
21	Slender Cypress Pine - Sugarwood - Western Rosewood open woodland on sandy rises mainly in the Riverina and Murray Darling Depression Bioregions	4,000	800	0
26	Weeping Myall open woodland of the Riverina and NSW South-western Slopes Bioregions	1,600,000	160,000	800
28	White Cypress Pine open woodland of sand plains, prior streams and dunes mainly of the semi-arid (warm) climate zone	300,000	8,000	1,600
57	Belah/Black Oak - Western Rosewood - Wilga woodland of central NSW including the Cobar Peneplain Bioregion	350,000	200,000	0
70	White Cypress Pine woodland of central NSW	200,000	70,000	0
74	Yellow Box - River Red Gum tall grassy riverine woodland of NSW South West Slopes and Riverina Bioregions	30,000	8,000	0
75	Yellow Box - White Cypress Pine grassy woodland on deep sandy-loam alluvial soils of the eastern Riverina and western NSW South-western Slopes Bioregions	100,000	8,000	300
80	Inland Grey Box - White Cypress Pine tall woodland on loam soil on alluvial plains of NSW South-western Slopes and Riverina Bioregions	800,000	140,000	400
153	Black Bluebush low open shrubland of the alluvial plains and sandplains of the arid and semi-arid zones	1,500,000	900,000	8,100
157	Bladder Saltbush shrubland on alluvial plains in the semi-arid (warm) zone including Riverina Bioregion	1,500,000	600,000	2,500
160	Nitre Goosefoot shrubland on clays of the inland floodplains	50,000	100,000	8,200
164	Cotton Bush open shrubland of the semi-arid (warm) zone	50,000	460,000	7,200
237	Riverine Inland Grey Box grassy woodland of the semi-arid (warm) climate zone	15,000	4,000	0
249 *	River Red Gum grass - swamp woodland to open woodland on cowals (lakes) and associated flood channels in central NSW	6,500	3,000	100
336	Rush - Sedge - Common Reed mainly lentic channel wetland of the Upper Murray and mid-Murrumbidgee River floodplains in the NSW South-western Slopes Bioregion	3,000	1,500	0

* River red gum type occurring in Riverina, but not mapped in SF.

3.1.3 Distribution of vegetation groups

NSWVCA vegetation types occurring in the Riverina were collated into broader 'vegetation groups' for the purpose of reporting and mapping within State Forests and Western Land Leases. Table 5 lists vegetation groups in the Riverina and their associated NSWVCA types. There are three main vegetation groups for river red gum dominated forest and woodland, each of which is mapped as a site quality (SQ) class by Forests NSW. The NSWVCA types which relate to each SQ class are:

SQ1 = NSWVCA 2;

SQ2 = NSWVCA 5, 7

SQ3 = NSWVCA 8, 9, 11 and 249

Two other vegetation groups have significant proportions of river red gums. The river red gum – box woodland vegetation group includes NSWVCA types 10, 13, 74 and 237. The Riverine Box Woodland group is dominated by black box in the absence of river red gum and includes NSWVCA types 15 and 16 (Table 5).

Table 5 Vegetation Groups identified in the Riverina Bioregion

Vegetation Group	Equivalent NSWVCA No(s)
Box - White Cypress Woodland	75, 76, 80, 86
Chenopod Shrubland	18, 63, 152, 153, 154, 157, 159, 160, 163, 164, 166, 216, 236
Freshwater Wetlands	12, 53, 182, 238, 336
Ironbark Shrubby Woodland	217, 243
Mallee Woodland	190
River Red Gum Very Tall Forest (SQ1)	2
River Red Gum Tall Open Forest (SQ2)	5, 7
River Red Gum Woodland (SQ3)	8, 9, 11, 249
River Red Gum - Box Woodland	10, 13, 74, 237
Riverine Box Woodland	15, 16
Riverine Shrubland	17, 240
Semi-arid Acacia Woodland	23, 26, 134, 139
Semi-arid Oak Woodland	20, 57, 58
Slender Cypress Woodland	21
Swamp Grassland	24, 47, 181, 242
Tussock Grassland	44, 45, 46, 50, 165, 250
White Cypress Woodland	19, 28, 48, 70

* grey text associated with NSWVCAs know to occur in Riverina, but not mapped in State Forests

The distribution of all vegetation groups has been mapped across all state forests in the NSW Riverina Bioregion (based on Binns mapping, Figure 7), and also specifically for the following individual major forest groups:

- Millewa Forests (Figure 8)
- Koondrook-Perricoota Forests (Figure 9)
- Werai Forests (Figure 10)
- Lachlan region (Figure 11)
- Murrumbidgee region (Figure 12).

The extent of each vegetation group is explained in section 3.4.2 below.

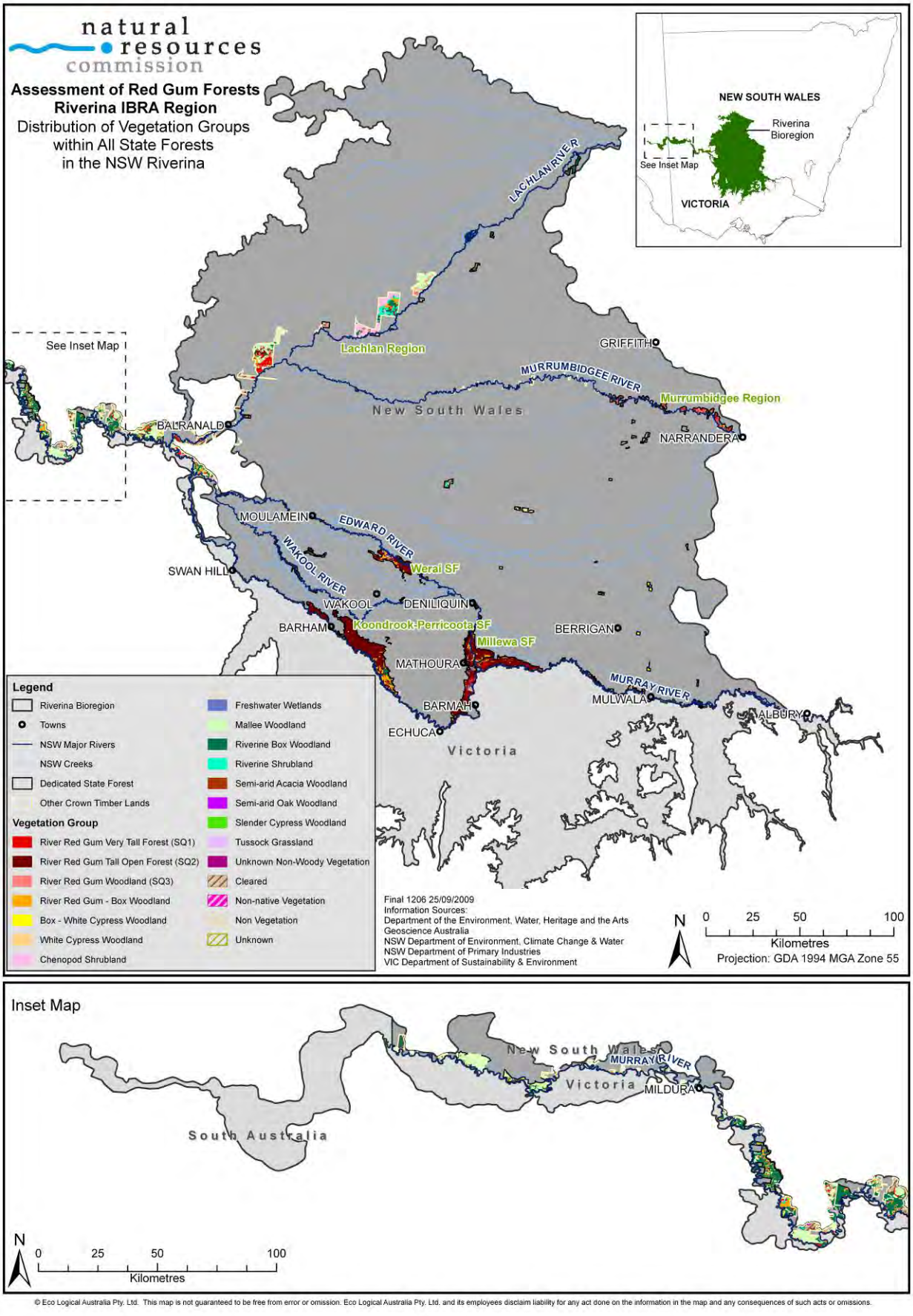


Figure 7 Distribution of vegetation groups within all state forests in the NSW Riverina

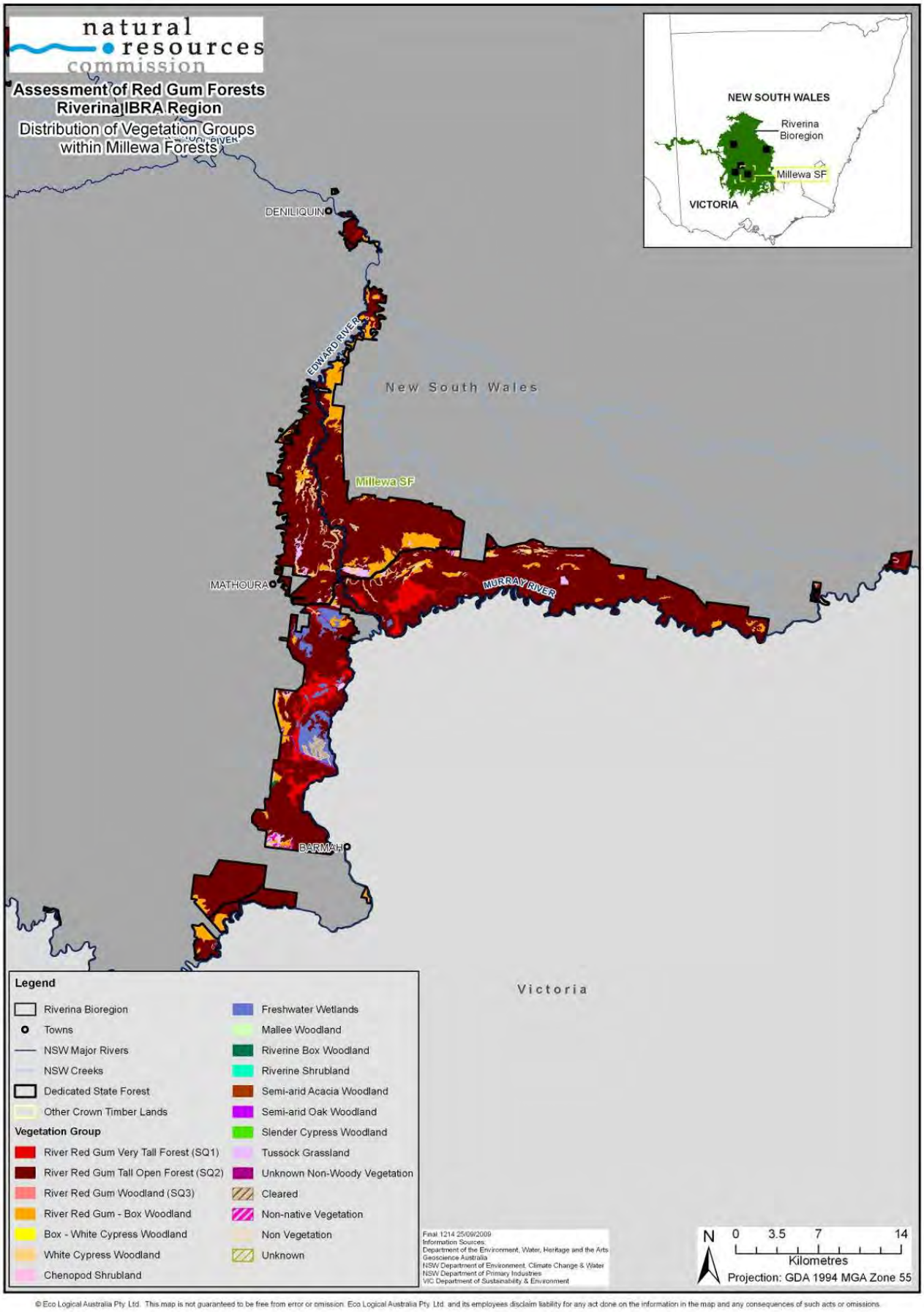


Figure 8 Distribution of vegetation groups within Millewa State Forests

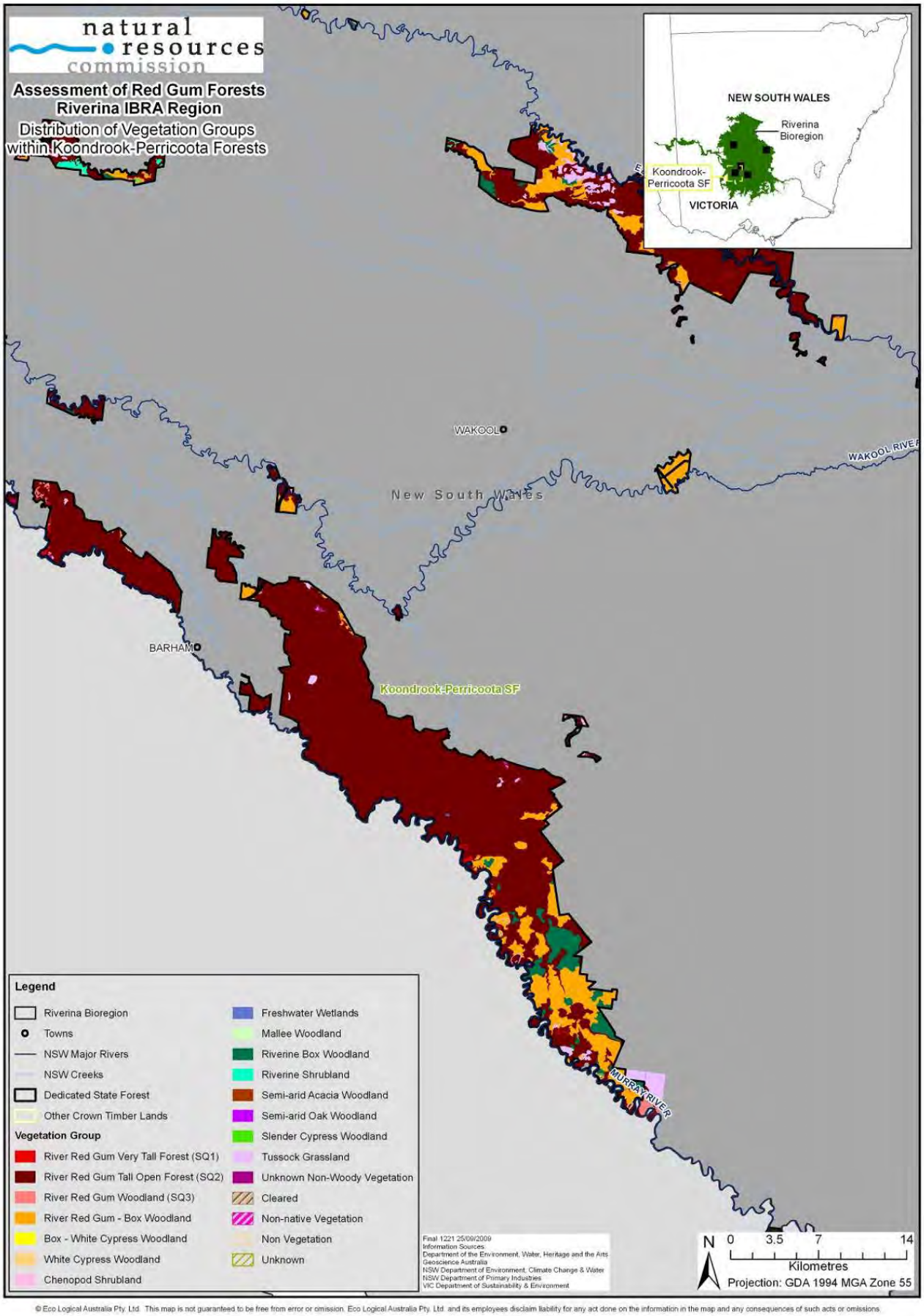


Figure 9 Distribution of vegetation groups within Koondrook-Perricoota State Forests

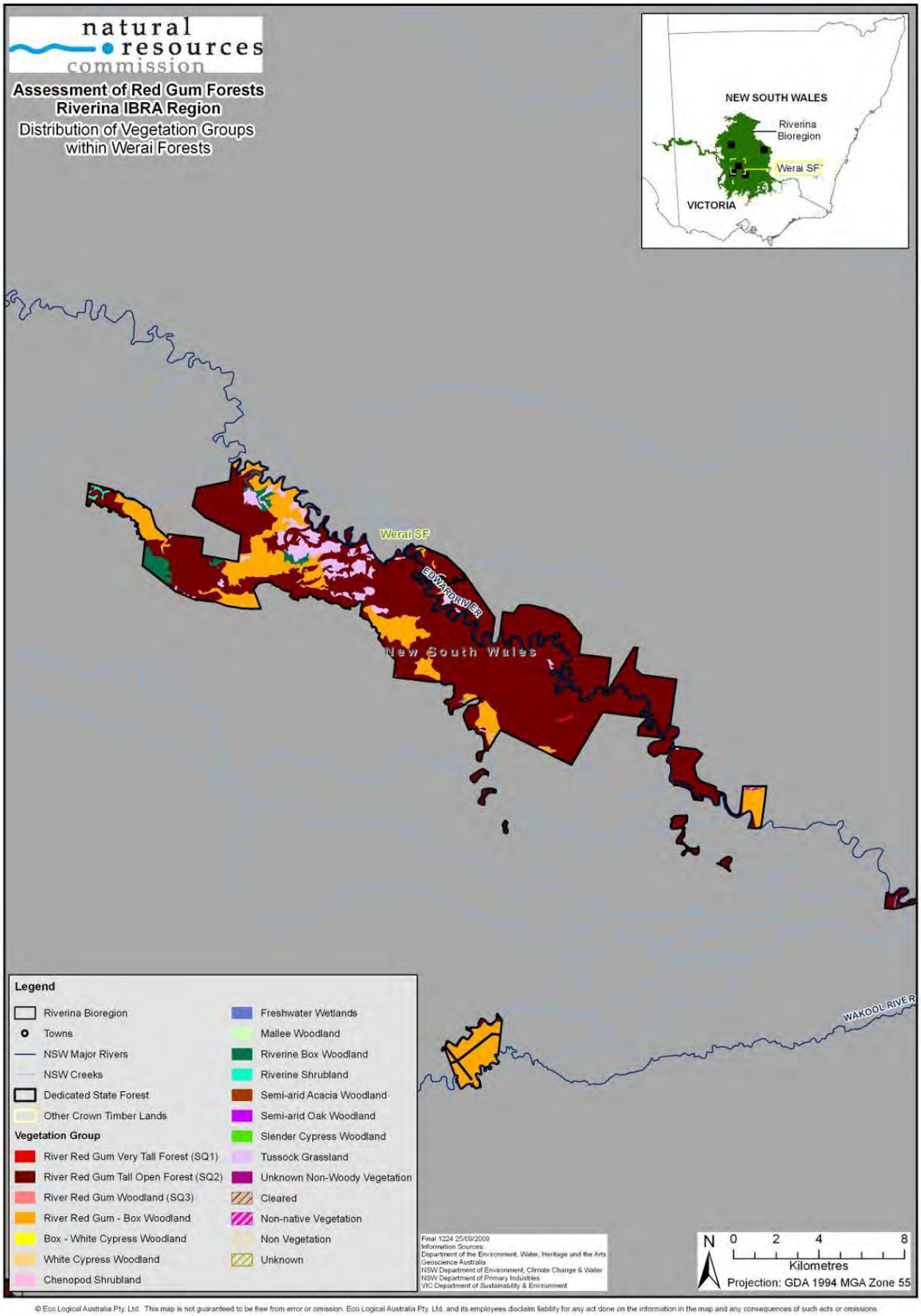


Figure 10 Distribution of vegetation groups within Werai State Forests

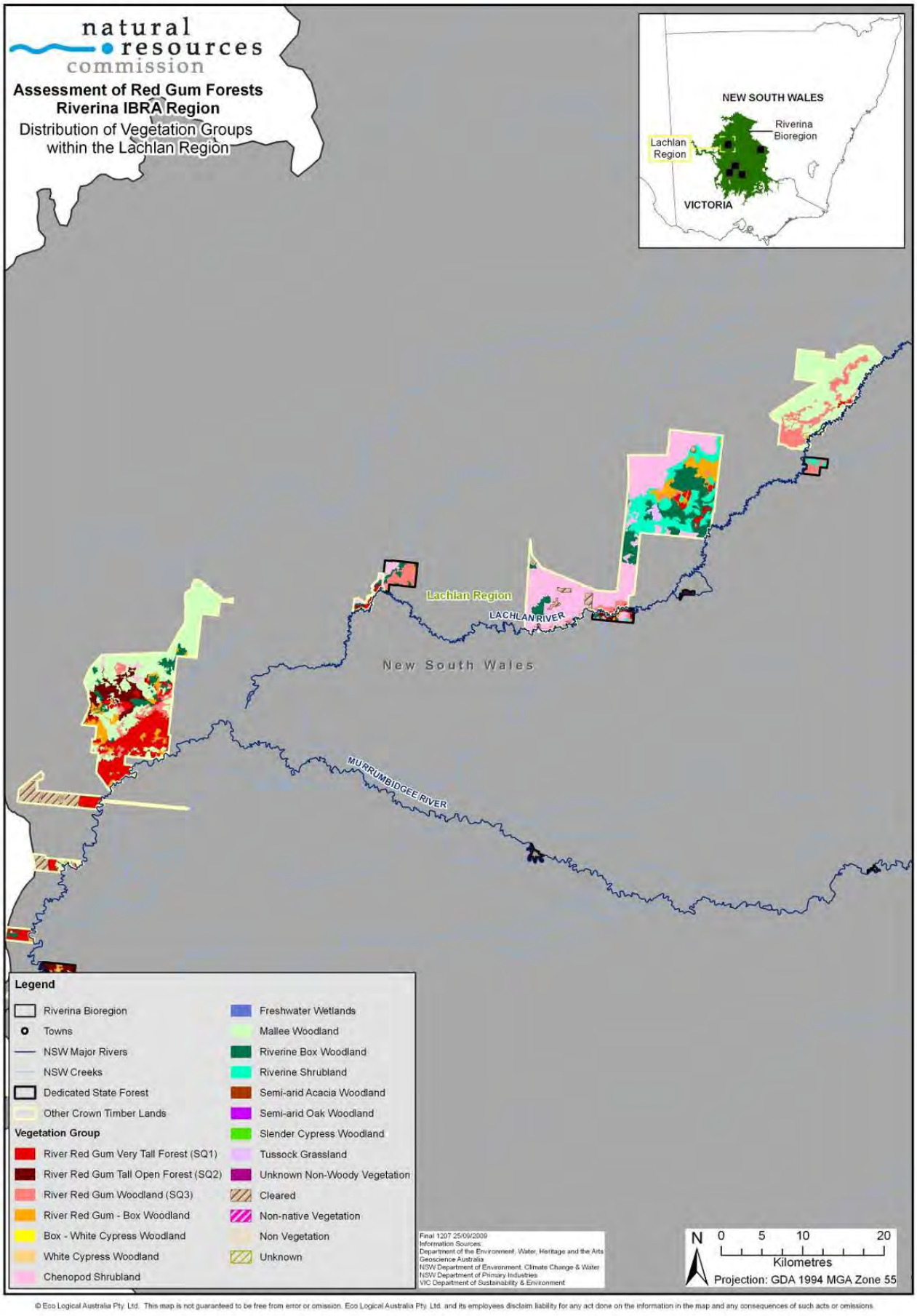


Figure 11 Distribution of vegetation groups within the Lachlan region State Forests

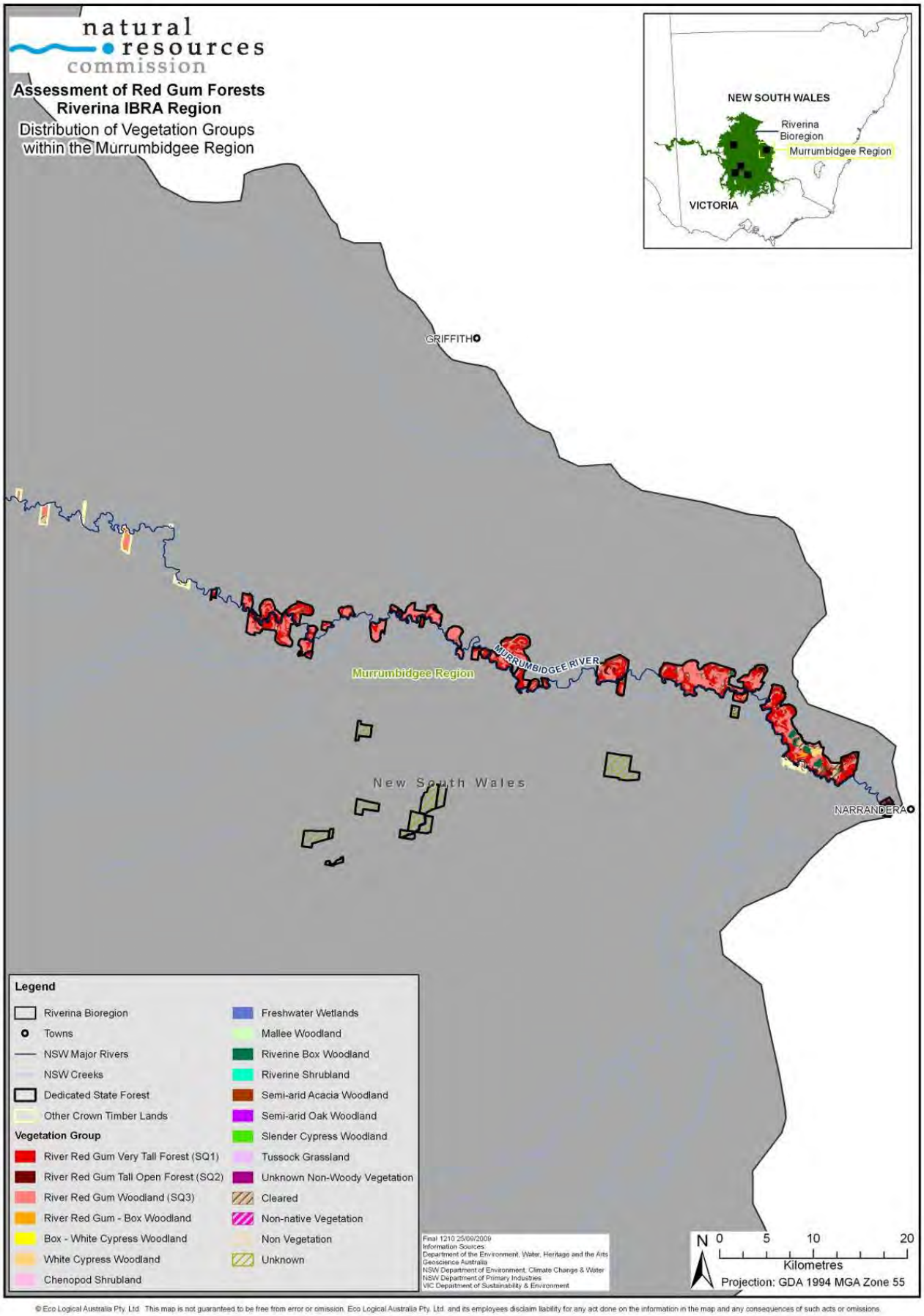


Figure 12 Distribution of vegetation groups within the Murrumbidgee region State Forests

3.2 Vegetation condition

3.2.1 Reference condition

The condition of any vegetation type is simply its departure from a 'benchmark' or 'reference' vegetation condition, a term which commonly refers to the condition of an undisturbed or minimally disturbed patch of vegetation. It is usually derived for individual vegetation types by sampling a set of ecological parameters in vegetation exhibiting no apparent or minimum disturbance. Attributes sampled relate to state, persistence and functioning of vegetation communities, and normally include species diversity, percentage cover, recruitment of canopy species and groundcover variables. Once established, the condition of any other stand of vegetation of that type can be 'referenced' against the benchmark by sampling and comparing the same set of ecological parameters.

Floodplain Riparian Woodland (EVC 56) occurs in the Victorian Riverina and is a close relative of river red gum types in NSW. Benchmark stands of EVC 56 exhibit the following characteristics:

- support about 15 large trees (> 80cm dbh) per hectare
- support regenerating red gum saplings
- possess a projected canopy cover of about 25%
- comprise a total species richness of 23+ taxa (all natives, no weeds), and
- support a total length of 300m of fallen logs per hectare (DSE 2004).

Any river red gum stand in the Riverina which resembles this structure would be considered to be in good condition.

3.2.2 Condition of river red gum in the NSW Riverina

The condition of river red gum within state forests and elsewhere of the Riverina is generally in decline as a result of substantially reduced flows due to river regulation and compounded by climate change. Condition may also be reduced immediately following harvesting, although long term decline in condition has not been linked to forestry activities specifically.

There have been a number of condition studies of late which portray a bleak picture regarding the condition of Riverina red gums. Cunningham *et al*. (2007) presented a quantitative assessment of the stand condition of river red gum along the Murray River floodplain in Victoria. Based on the results of 140 sites surveyed they found that:

- 30% of river red gum stands across the study area were in good condition
- a downstream decline in the stand condition of river red gum forests along the study area was evident, and
- the only region in Victoria where the majority of river gum stands were in good condition was the Victorian Riverina area.

The findings of this work suggest that current watering regimes (rainfall and flooding) below the Yarrawonga Weir are insufficient to maintain the majority of river red gum stands in good condition.

Forests NSW performed a similar assessment of the health of the NSW Central Murray State Forests (Millewa, Werai and Koondrook areas) in 2005. Most of the 1843 eucalypts assessed on the NSW side of the border were severely stressed (701) or stressed (500). Only 11% were healthy and 1% was dead. Black box was relatively healthy compared to the river red gum where high levels of stress were apparent on low quality sites, unthinned sites, in old trees and in sub-dominant trees (Jurskis et al. 2005). Black box is more resilient to drought and is able to persist on limited supplies of soil moisture tightly bound in clay soils, whereas red gum relies on groundwater in lenses of sand and gravel. It should be noted that dieback from drought stress in otherwise healthy trees is a protective mechanism to reduce water loss. For example, the recovery of trees in a very low rainfall area at Wangumma State Forest after good spring rains in 2006 was proportional to their initial degree of dieback (Jurskis, 2008).

More recently Turner and Kathuria (2008) used satellite imagery techniques to assess forest health condition across 48,000 ha of native river red gum forests in the Gunbower Koondrook Perricoota Icon Site along the NSW – Victorian border. The key findings of this assessment supported the observation that black box and grey box stands are generally healthier than river red gum stands, and that most of the river red gum plots (87%) exhibited either an unhealthy status (<25% of original canopy remaining) or stressed (25-50% of original canopy remaining). A total of 56% of river red gums in the Icon Site were unhealthy.

The distribution of forest health within the Gunbower-Koondrook Pericoota Forests Icon Site was also modeled by Turner and Kathuria (2008) using remote sensing techniques employing satellite multi-spectral imagery, supported by quantitative ground-truthing. The resultant mapping (GHD 2009) illustrated that the proportion of the forest in an unhealthy condition is currently far greater in the Koondrook Forests, north of the Murray River than the Icon Site as a whole because the Koondrook did not receive flooding in 2005/2006. This reinforces the critical role of floodplain geomorphology and hydrology in forest health as the Koondrook Forests have high commence to flow levels to achieve floodplain inundation, and have experienced little or no flooding over the last decade.

The NSW Central Murray State Forest Ramsar Site Draft Ecological Character Description report (GHD, 2009) cites data from the Murray Darling Basin Authority which suggest that only 20% of the river red gum forests in the Millewa block are in healthy condition, with 75% in a state of decline and 5% unhealthy. The Koondrook forests are found to be in very poor condition, with 71% of trees either stressed, near dead or dead. The forests have not been extensively flooded since 2001 and so health is continuing to deteriorate. In the Werai block, the majority of stands were considered to be unhealthy, including 92% of SQ2 stands.

The Draft ECD report suggests that the above observations represent a snapshot within a period of 'extreme drought'. The Murray Darling Basin Authority is currently managing the South Eastern Australian Climate Initiative (SEACI) which is a government/industry partnership to investigate the causes and impacts of climate variability across south eastern Australia. The SEACI recently concluded through extensive research that there are firm signals that the current drought correlates with future projections of reduced rainfall in southern Australia (SEACI, May 2009).

Dead and dying red gums in Yanga National Park

Flooded river red gums in Yanga National Park

3.3 Forest management

This section provides an overview of forest management policies, systems and operational procedures. Information is largely drawn from the EIS (GHD, 2009) unless stated otherwise.

Forests NSW in the Riverina bioregion manage 410,000[4] hectares of river red gum in state forest and on other Crown-timber lands for both timber production and conservation of other natural values (Forests NSW, 2008, p. 27). Harvesting operations are offset over space and time within the study area, with less than 5% of the forests subject to timber harvesting per annum. Areas of forest are set aside from harvesting and managed specifically for conservation and other management objectives. This results in a net harvestable area of approximately 111,000 hectares (Forests NSW, pers. comm.).

Harvesting occurs within a externally verified sustainable forest management framework that consists of five stages from strategic planning at the Riverina regional level through to post-harvest monitoring and reporting (GHD, 2009).

Conservation and other management objectives are set at a strategic level and implemented by allocating specific areas to Forest Management Zones, and through application of silvicultural practices and through management prescriptions which specify how harvesting operations should be implemented.

3.3.1 Ecologically Sustainable Forest Management Framework

Harvesting occurs within externally verified sustainable forest management framework that consists of five stages, as summarised in Table 6 (GHD, 2009).

Table 6 Stages of Forests NSW Ecologically Sustainable Forest Management Framework

Stage	Explanation
Strategic planning	Strategic planning for sustainable forest management is conducted in accordance with Forests NSW statutory and policy requirements. The output from this stage is the Riverina Region Ecologically Sustainable Forestry Management Plan and supplementary plans.
Scheduling of harvesting operations	The output from this stage is a 3 month Plan of Operations which indicates the compartments and volumes of timber to be harvested for each of three Management Areas within the Riverina Region.
Operational assessment and planning of harvest events	The output from this stage is a Harvesting Plan for each harvest area which documents how strategic requirements and constraints are to be applied. Site specific environmental assessments are also prepared at a compartment/ multiple compartment level.
Management of harvesting operations	Timber harvesting occurs on a selective harvest basis by timber operators or contractors who are generally engaged or employed by timber mills and overseen by Forests NSW staff. The outputs from this stage are Supervising Forest Officer audit reports.

[4] This area includes both State Forests and selected Western Lands Leases. The area managed by State Forests is covered with a mix of vegetation groups, so the aerial extent does not correlate with the current extent of river red gum in table 8, section 3.4.3.

Stage	Explanation
Post harvest assessment and reporting	Forests NSW monitors both the volume of timber products harvested and the area harvested. The outputs from this stage are Supervising Forest Officer audit reports and post harvest inspection and certification.

Progress toward sustainable forest management is monitored using indicators that are consistent with the Montreal criteria. Indicators are selected on the basis of a nationally agreed framework (Montreal Process Implementation Group, 2008), those that are mostly readily measurable or describable, and that provide a uniform, objective method of reporting.

Forests NSW reports on selected indicators at regional, national and international levels through:

- Annual Management Plan reports under Ecologically Sustainable Forest Management plans
- Annual Seeing Reports on social, environmental and economic responsibilities
- NSW State of the Environment Reports
- National State of the Forests Reports
- Triennial reports under the Ramsar Convention for the Central Murray State Forests, and
- Approximation Reports for the Montreal Process.

Mill logs

Forests NSW forest management also has third party certification under the Australian Forestry Certification Scheme's Australian Forestry Standards, and internationally by the Program for the Endorsement of Forest Certification schemes. Forests NSW has an ISO 14001

externally certified Environmental Management System, which provides a systematic and accountable approach to measuring, monitoring and reporting performance related to ecological sustainability.

Strategic planning

Strategies and objectives to achieve sustainable forest management are documented in a publicly available Ecologically Sustainable Forest Management Plan which covers a five year period. Figure 13 provides an overview of the planning tools and strategic information that is incorporated in the Ecologically Sustainable Forest Management plan.

Strategic Planning - ESFM			
Tools/ source	**Strategic Information**		
Legislation/ contracts	Land base and supply contract commitments		- A five year plan establishing the blueprint for achieving the principles of ESFM. - Establishes the broad strategies, performance indicators, and measurable outcomes in the region over a five year period. - Involves stakeholder consultation and public exhibition. - Freely available to public via internet.
Forest Management Zoning	Formal and informal conservation reserves		
Social, economic and environmental policies	Service delivery goals and strategies for social, economic and environmental programs		
Forest Resource and Management Evaluation System	Sustainable timber supply	➔	
Silviculture manual	Systems and practices to deliver the Social, Economic and Environmental outcomes required.		
Supplementary plans and procedures	Road, Fire, Weed, Pest Animal, Grazing, and Flora Reserve Management Plans.		

Figure 13 Strategic planning framework - ESFM

Scheduling of harvesting operations

Harvesting operations are scheduled in three monthly Plans of Operation which nominate the compartments of the forest to be harvested and the volumes allocated for harvesting. These plans are generally compiled at a sub regional, or Management Area level.

A preliminary assessment is undertaken of each proposed timber harvesting area to determine its suitability for harvesting. This includes a review of compartment history and management information to determine if there are any areas to be excluded because of threatened species considerations, endangered ecological communities, cultural heritage issues, access or other site issues. Estimated timber volumes to be allocated for harvesting are developed using Forests NSW strategic forest inventory, historic yield data for the forest area, and a visual assessment.

Plans of Operations are prepared as three monthly work schedules, but are sensitive to changes in the operating environment and may require revision at short notice. Factors

influencing the location of harvesting activities include prolonged wet weather, flooding, market fluctuations, changes in industry requirements, and adaptive management.

Operational assessment and planning

This stage involves selecting the area to be harvested and planning the harvesting event. The output from this stage is a Harvesting Plan that documents where and how harvesting will be undertaken, and provides the basis for authorising and auditing of the activity.

The Harvesting Plan is the key control document for each timber harvesting operation and is utilised by licensed timber contractors, operators, and Forests NSW field supervisors and foresters. Each plan is subject to internal and external audits as part of Forests NSW ISO14001 certified EMS, and can be viewed by the public at the local office in which it was prepared.

The Harvesting Plan details:

- the Forest Management Zone which indicates differing management intents and exclusions for each part of the forest based on the values present
- prescriptions for how harvesting and other site management operations are to be carried out to protect threatened species, key habitat features and other environmental protection measures such as erosion control
- marking symbols for trees to be cut or retained, exclusion areas and other operational features as required, and
- silvicultural practice to be applied within the areas available for timber harvesting and the expected timber volumes and product mix.

Management of harvesting operations

Timber harvesting in river red gum forests is conducted by timber operators or contractors who are generally engaged or employed by timber mills. A Supervising Forest Officer employed by Forests NSW is responsible for identifying individual or groups of trees to be harvested or retained. The Supervising Forest Officer also ensures that timber operators or contractors are licensed and are aware of the Harvesting Plan that applies to each site and of the protection measures that must be applied.

Individual or groups of trees to be harvested or retained are assessed and selected in accord with Forests NSW Silvicultural Manual. Silvicultural systems used in Red Gum forests are described in Section 3.3.3 below. They are manually marked by the Supervising Forest Officer following guidelines outlined in the Forest Practices Code for Timber Harvesting in Native Forests and the requirements of the individual Harvest Plan for a given site.

Standard tree marking specifications identify trees to be removed, exclusion areas and boundaries, trees to be retained including habitat trees, timber extraction routes, fauna and flora features, cultural heritage sites and other operational features. The Supervising Forest Officer ensures the contractors comply with the requirements of the Harvesting Plan by supervising operations and undertaking regular site monitoring. This includes reviewing timber felling and utilisation to minimise the damage to retained vegetation or the cut log, and ensuring that each log is sorted and trimmed to attain the highest value end product.

Vegetation is retained within and adjacent to harvesting areas through formal forest management zoning, licence conditions or silvicultural prescriptions. A significant proportion of the over-storey is retained even within the harvestable area to meet ecological,

stream protection, cultural heritage or aesthetic objectives, or elements of the stand retained to meet legislative or policy requirements.

Post harvest assessment and reporting

Forests NSW monitors both the volume of timber products harvested and the area harvested. Achievement of prescribed silvicultural and environmental outcomes is assessed after harvesting and this may be based on sampling representative areas. Data collected during and following harvesting assists in refining and developing future timber yield estimates.

3.3.2 Forest Management Zones

The Forest Management Zone system was developed in consultation with a range of government departments and community groups. It is based on a nationally agreed reserve criteria that clearly differentiates between those areas of State forests that are specifically set aside and offset with Ministerial approval for conservation, and those that are available for other activities and objectives including timber harvesting.

Forest Management Zones assist regional planning and provide confidence that the management intentions nominated in the Ecologically Sustainable Forest Management plan will continue in perpetuity by maintaining a mosaic of habitat opportunities across the landscape at suitable scales and in the context of other reserves. All State forest areas have been allocated to a Forest Management Zone.

Forests NSW has defined eight Forest Management Zone categories, five of which (Zone 1-4 and 8) are relevant to areas of river red gum forests.

Table 7 shows the relative areas of the Riverina Region forests that are included in each zone and provides a brief description of how each Forest Management Zone is managed.

Table 7 Areas by Forest Management Zones in the Riverina region

Forest Management Zone (FMZ)	Area (ha)	Percent	Description of FMZ
Harvesting excluded			
FMZ 1 – Special prescription	3,607	0.9%	Dedicated reserves set aside under Section 25A of *Forestry Management Act, 1916*
FMZ 2: Special management - harvesting excluded	0	0.0%	Specific management and protection of natural and cultural conservation values
FMZ 3a: Harvesting excluded	98,713	24.0%	Managed for conservation
Subtotal	**102,320**	**24.9%**	
Available for harvesting			
FMZ 3b: Special prescriptions - available for harvest	11,738	2.9%	Intensity of harvesting modified to protect identified values
FMZ 4: General management – available for harvest	294,706	71.8%	Management for timber production under a range of prescriptions to protect specific

Forest Management Zone (FMZ)	Area (ha)	Percent	Description of FMZ
			values
Subtotal	**306,444**	**74.6%**	
Other areas			
FMZ 5: Hardwood plantations	151	0.0%	
FMZ 6: Softwood plantations	114	0.0%	
FMZ 7: Non-forestry uses	314	0.1%	
FMZ 8: Further investigation	1,399	0.3%	
Subtotal	**1,978**	**0.5%**	
Total	**410,716**	**100.0%**	

Source: Forests NSW, 2008, p. 27

3.3.3 Silvicultural systems

Forests NSW silvicultural systems associated with forest harvesting are intended to reduce competition between trees for water, promote tree regeneration and encourage the growth of tall, straight trees that are valuable for timber. The three silvicultural systems applied are:

- Single Tree Selection – single trees within mixed age or mixed species stands are marked for harvesting to create canopy openings which may allow retained trees to grow
- Australian Group Selection – areas of at least three crown widths of a mature tree are cleared to create large canopy openings to reduce the suppressive influence of larger trees on young trees, and
- Thinning – 'sub-dominant' trees, with poor growth or commercial potential are removed to promote the growth of retained trees.

In the water deficient environment typical of river red gum forests, competition is a key influence on tree regeneration success and stand mortality. Mature trees can out-compete new seedlings for soil moisture, and suppress seedlings to an extent of approximately two crown widths from each larger tree. This situation can be reversed once regenerating trees have developed extensive root systems where, in times of reduced soil moisture, younger trees are able to survive on levels that are insufficient for larger trees. Reducing the number of trees through any of the three silvicultural systems above may reduce tree mortality due to competition for water and improve the regeneration prospects of retained and thinned trees.

Silvicultural systems are also used to improve stand quality for wood production and produce a higher proportion of trees that are suitable for high value uses. In river red gum, one of the key silvicultural issues for wood production is that, in the absence of competition to force vertical growth and restrict branch development and forking, regrowth stems typically fork or branch early in their growth and retain low branching, tending to poor sawlog form. One of the key management approaches in river red gum is to grow the

regeneration in reasonably dense clumps to force vertical growth and restrict branch development as straighter trunks and fewer branches are more suitable for harvesting timber for high value uses. Once trees are about 20 to 30 centimetres in diameter, thinning may be conducted to reduce competition.

Single Tree Selection (STS)

The primary objective of STS is to minimise harvesting disturbance to other forest values. This silvicultural method is usually applied in mixed aged or mixed species stands to conserve useful growing stock. It may also be applied where there is growing stock scattered amongst a mature stand or where mature trees are scattered amongst a well stocked regrowth stand.

STS is only applicable where the stand structure and floristics permit successful regeneration in canopy openings created by removing single trees. It is sometimes applied in mature stands of low timber value where less intolerant species can regenerate successfully after limited canopy opening.

Figure 14 and Figure 15 provide a schematic view of how STS is applied to stands. Figure 14 indicates that single trees within a stand are marked for removal or retention. Figure 15 indicates the composition of the stand following removal of the selected trees.

Figure 14 Trees marked for removal or retention using STS

Figure 15 Indicative stand composition following removal of trees using STS

Australian Group Selection

AGS is a system applied to mixed aged eucalypt forests and involves harvesting groups of commercially mature trees to create canopy openings that permit effective regeneration. The objective of the system is to harvest groups of commercially mature trees whilst retaining groups of effective growing stock from previous selective logging operations (Jacobs 1955).

AGS maintains an irregular forest at a patch scale and can be applied to more uniform stands to create a more mixed aged forest to enhance diversity. This method was developed as a compromise between: the need to conserve immature growing stock; regeneration requirements of intolerant species; and the need to consider values other than efficient timber production (Florence 1996). Figure 16 indicates that groups of trees within a stand are marked for removal or retention. Figure 17 indicates the composition of the stand following removal of the selected trees.

The maximum area of individual AGS patches in river red gum state forests has been 0.8 ha, with the constraint that AGS could not be applied over more than 30% of any harvest area. Subsequent to a Land & Environment Court decision of 2008, the maximum AGS patch area was reduced to 0.6 ha and the proportion of area harvested under AGS to 20% (National Parks Association of NSW, pers. comm.)

Figure 16 Trees marked for retention or removal using AGS

Figure 17 Indicative stand composition following removal of trees using AGS

Regeneration following AGS

Thinning

Forests NSW practices 'thinning from below', where trees with the poorest growth or commercial potential (usually subdominant trees) are removed to promote the growth of retained trees. This practice is intended to realise some future high value product and/ or to produce trees of a specified size in a shorter period of time. It also allows trees which would otherwise soon die, through competition and moisture stresses, to be commercially utilised. Thinning enhances the opportunity for the retained trees to grow.

3.3.4 Management prescriptions

Management prescriptions are an important component of Forests NSW's Ecologically Sustainable Forest Management system and have been designed to maintain forest structural diversity to retain and enhance flora and fauna habitat, protect and maintain soil and water quality, while providing a sustainable timber supply (Forests NSW, 2008).

There are two types of prescriptions generally applied during forestry operations. Tier 1 comprises general, forest wide prescriptions such as riparian buffers and a suite of habitat tree protection measures), which are designed to protect key habitat across the landscape. Tier 1 prescriptions are supplemented by Tier 2 threatened species specific prescriptions which are designed to maintain habitat for particular species. An example threatened species prescription for the Squirrel Glider is provided in Figure 18.

Prescriptions to protect threatened species include practices such as:

- retention of mistletoe
- retention of habitat trees, viz. mature trees likely to contain hollows that may be used as nesting sites
- retention of Recruitment Trees, viz. trees which have the potential to contain hollows
- protection of shrubby understorey

- exclusion zones along waterbodies, and
- no harvest zones around dens or nest sites.

Threatened Species Prescriptions – Squirrel Glider *(Petaurus norfolcensis)*

Trees with glider feeding marks must be retained and not be damaged by the harvesting operation (river red gum).

Apply a 100m no-harvest zone around den/ nest sites as located. Retain all trees with "V-notch" or other incisions (white cypress)

Retention of Mistletoe: Across the entire net harvest area, a minimum of two trees carrying mistletoe, where present, must be retained per hectare. Retained habitat and recruitment trees may be counted toward this prescription.

Protection of shrubby understorey: Except in regeneration openings, harvesting must minimise disturbance to the shrubby understorey. Where practicable, regeneration openings, log dumps, processing sites, tracks and roads must be located so as to avoid areas with a dense understorey.

Habitat Tree Retention - Across the net harvest area (except where more stringent S120 conditions apply), a minimum of two Habitat trees and two Recruitment trees per hectare must be retained. Where there are insufficient numbers of Habitat trees to achieve this level, all existing Habitat trees must be retained and Recruitment trees must be retained in sufficient number to ensure a level of at least 4 retained Habitat/ Recruitment trees per hectare.

Along waterbodies - An exclusion zone, a minimum of 20m wide, must be established around and adjacent to each large permanent or semi-permanent waterbody or nominated waterway (stream, runnel, swamp and lagoon). A modified harvesting zone, a minimum of 30m wide, must be established around and adjacent to each exclusion zone, in which at least five Habitat trees and five Recruitment trees must be retained per hectare. Where insufficient Habitat trees exist to achieve this level, all existing Habitat trees must be retained and Recruitment trees must be retained in sufficient numbers to ensure a level of at least 10 retained Habitat/ Recruitment trees per hectare.

The 20m wide exclusion zone must be measured perpendicular to and from the bank of the waterbody or waterway.

Nominated waterways are those identified by State Forests and shown on the relevant harvesting plan or as otherwise identified by DECC

Source: GHD, 2009a

Figure 18 Threatened Species Prescriptions for Squirrel Glider *(Petaurus norfolcensis)*

The prescriptions of relevance to the river red gum have been developed, approved and licensed by the DECC under Section 120 of the *National Parks and Wildlife Act, 1974* (NSW). DECC has the statutory responsibility for administering the *Threatened Species Conservation Act, 1995* (NSW).

Superb parrot habitat tree

3.4 Environmental values

3.4.1 National and State policy context

The relevant National and State policies[5] for conservation planning focus on creating a 'comprehensive, adequate and representative' National Reserve System[6] where:

1. **comprehensive** means reserves should sample all forest ecosystems
2. **representative** means the full variability of biodiversity should be protected with replication across landscapes to insure against catastrophic local events
3. **adequacy** is the long-term capacity or resilience of a protected area to sustain the biodiversity it supports.

The NSW National Parks Establishment Plan 2008 identifies riverine forest communities in the Lower Murray, Murrumbidgee, Lachlan and Darling rivers as priorities for reservation. The conservation significance of the forests is due to their scarcity, representation of historic ecosystems and current ecosystem services.

5 See Intergovernmental Agreement on the Environment 1992, National Strategy for the Conservation of Australia's Biological Diversity 1996, National Forest Policy Statement 1992, National Reserve System Directions Statement, NSW National Parks Establishment Plan 2008.

6 The National Reserve System includes all protected areas which meet the World Conservation Union (IUCN) standard of protected area, which is "an area of land (and/or sea) especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (IUCN 1994)

3.4.2 Current reservation of river red gum types

NSW area estimates for the SQ1, SQ2, SQ3, river red gum/box and Riverine box groups are shown in Table 8 and 9 in Section 3.4.3 below. Combined area estimates for NSW and Victoria are included for context. These were derived by establishing equivalence between NSWVCA types and 'Ecological Vegetation Classes' (EVCs) which are described and mapped in Victoria, and drawing on EVC area statistics in Victoria (VEAC 2008).

The estimated current area of river red gum dominant and co-dominant forest and woodland in the NSW Riverina is 401,000 ha (from Benson et al 2006; Benson 2008). Of this, an estimated 30,400 ha is reserved in National Parks and Nature Reserves.

The estimated current area of river red gum dominant and co-dominant forest and woodland in the combined NSW and Victorian Riverina is 582,400 ha (from Benson et al 2006; Benson 2008; VEAC 2008). Of this, an estimated 123,000 ha is reserved in National Parks and Nature Reserves in NSW and Victoria.

There has been minimal land clearing of the high productivity river red gum types along the Murray and adjoining channels and inner floodplains. This is likely because the dominant land clearing pressure in the bioregion has been for cropping and pastoralism which are not viable on regularly inundated land. Less than 20% of site quality 1 (SQ1) and SQ2 river red gum stands have been cleared in the past.

In contrast, the lower productivity stands occurring on the higher floodplains (site quality 3 (SQ3) river red gum and the river red gum-box types), have been cleared to a much greater degree. About 60% of river red gum box - woodlands of the floodplains, which often contain river red gum as a co-dominant, has been removed for broadscale agriculture.

The level of reservation of river red gum box stands in the bioregion has been greatly enhanced by the recent Victorian reservation decision. For example, only 4.1% of the pre-European extent of SQ1, 2 and 3 river red gum stands has been protected in NSW, largely in Yanga National Park. Meanwhile 11.6% have been protected when accounting for equivalent types in Victoria.

The Black Box floodplain communities are relatively poorly reserved throughout their natural range, with just over 2.7% reserved to date in NSW and Victoria combined.

3.4.3 Current reservation of other woodland types

It is evident from Table 9 that all of the extensive woodlands of the semi-arid Riverina have had more than 50% of their former extent removed, mainly for grazing with some cropping in the south-east of the bioregion. Most impacted have been the:

- Box – cypress woodlands dominated by yellow box (*Eucalyptus melliodora*) and inland grey box (*E. largiflorens*)
- Acacia woodlands, most notably those dominated by myall (*Acacia pendula*), and
- White cypress woodlands.

The overall level of reservation is about 2%, considerably lower than that of river red gum forests and woodlands. The level of reservations is similar in NSW and Victoria.

Table 8 Area statistics (ha) for river red gum stands in the Riverina

		NSW only					NSW and Victoria **				
	Site Quality	Pre-European	Current	Reserved *	%-cleared	*** % Reserved	Pre-European	Current	Reserved	%-cleared	*** % Reserved
River Red Gum	SQ1	35,000	30,000	5,700	14.3	16.3	72,000	62,400	20,700	13.3	28.8
	SQ2	115,000	94,000	3,800	18.3	3.3	162,000	134,000	23,500	17.3	14.5
	SQ3	131,500	75,000	12,700	43.0	9.7	222,000	116,400	30,000	47.6	13.5
River Red Gum - Box	na	465,000	202,000	8,200	56.6	1.8	602,000	269,600	48,800	55.2	8.1
All River Red Gum types		***746,500***	***401,000***	***30,400***	***46.3***	***4.1***	*1,058,000*	*582,400*	*123,000*	*45.0*	*11.6*
Black Box	na	700,000	350,000	9,100	50.0	1.3	839,000	417,700	22,600	50.2	2.7
ALL		***1,446,500***	***751,000***	***39,500***	***48.1***	***2.7***	*1,897,000*	*1,000,100*	*145,600*	*47.3*	*7.7*

Table 9 Area statistics (ha) for other woodland types in the Riverina

Other woodland types	NSW only					NSW and Victoria				
	Pre-European	Current	Reserved	%-cleared	% Reserved	Pre-European	Current	Reserved	%-cleared	% Reserved
Box - White Cypress	1,400,800	188,200	900	86.6	0.1	1,518,000	202,400	1,700	86.7	0.1
Ironbark Shrubby	120,000	50,000	5,100	58.3	4.3	120,000	50,000	5,100	58.3	4.3
Mallee	500	240	100	52.0	20.0	2,000	700	200	65.0	10.0
Semi-arid Acacia	2,242,000	678,500	38,800	69.7	1.7	2,242,000	678,500	38,800	69.7	1.7
Semi-arid Oak	1,358,000	701,000	47,100	48.4	3.5	1,458,000	749,400	67,700	48.6	4.6
Slender Cypress	4,000	800	0	80.0	0.0	15,000	2,500	0	83.3	0.0
White Cypress	506,000	150,800	1,600	70.2	0.3	513,000	153,100	2,500	70.2	0.5
ALL	5,631,300	1,769,540	93,600	68.6	1.7	5,868,000	1,836,600	116,000	68.8	2.0

* Informed by DECCW vegetation mapping in National Parks and reserves of the Riverina bioregion
** Also informed by VEAC (2009) EVC area data. Includes draft proposal reservation areas in reserved extent
*** Percent of pre European extent

3.4.4 Applying JANIS reservation targets to river red gum forests

The comprehensive, adequate and representative (CAR) conservation planning principles are central to National and State policies for preserving a core of Australia's pre-European biodiversity and natural forest ecosystems. They focus on retaining viable, functioning areas of historic ecosystems, and protecting them from threatening process.

However, the challenges and uncertainty facing the river red gum forests in the Riverina forests call for more strategic and dynamic conservation planning. Recent CSIRO (2008) work on reserve design to improve viability under changed climatic conditions advocates for:

- a shift in objective from preventing ecological change to managing change in ways that minimise biodiversity loss
- greater emphasis on identifying and protecting significant corridors and linkages to improve species and habitat migration, and
- coordination of a wide variety of conservation programs across the whole landscape.

In addition, concern about the implications of climate change are stimulating policy makers to put greater focus on future viability and resilience of conservation reserves.[7]

In the case of flood dependent forests of the Riverina, the impacts of climate change are doubly important. Climate change seems to require a 'step change' increase in the focus we give to future viability, and the role we conceive for adaptive management of forest ecosystems to help them transition to a new climatic regime.

3.4.5 Native fauna in different forest groupings

Figure 19 shows the current extent of derived and natural grasslands (i.e. former woodlands and shrublands) and cropping, which together account for over 90% of the Riverina. Major areas of river red gum forest on state forest, and to a lesser extent western land leases and private land, are now the remaining strongholds of native forest and woodlands in the bioregion. For this reason, conservation values are reported in this section on the basis of major groups of forests. These major groups of forests correspond with the WMUs defined previously in Chapter 2 as shown in Table 10. These forest groups which are used for the conservation value assessment are also shown in Figure 20.

Table 10 Forest groups discussed for each Water Management Unit

Water Management Unit	Forest groups
1. Millewa Forests	• **Millewa group**, on the Murray River south of Deniliquin between Tocumwal and Moama
2. Koondrook-Perricoota and Campbell's Island	• **Perricoota group**, on the Murray River downstream of Millewa west of Moama • **Campbell's Island group**, on the Murray River west of Barham
3. Werai Forests	• **Werai group**, on the Edwards River west of Deniliquin
4. Murrumbidgee River	• **Murrumbidgee group**, between Narrandera and Hay on the Murrumbidgee River

[7] National Biodiversity Strategy Review Task Group, Australia's Biodiversity Conservation Strategy, Consultation Draft, March 2009.

Water Management Unit	Forest groups
5. Lachlan River	• **Lachlan group**, a series of small forests along the extent of the Lachlan upstream of its confluence with the Murrumbidgee
6. Upper Murray River riparian zone	• **Barooga group**, on the Murray River immediately west of Albury
7. Wakool and Edwards Rivers riparian zone	• **Wakool group**, on the Wakool River, east of Swan Hill.
8. Lower Murray River riparian zone	• **Far Western group**, on the Murray, from west of Balranald to the NSW-SA border

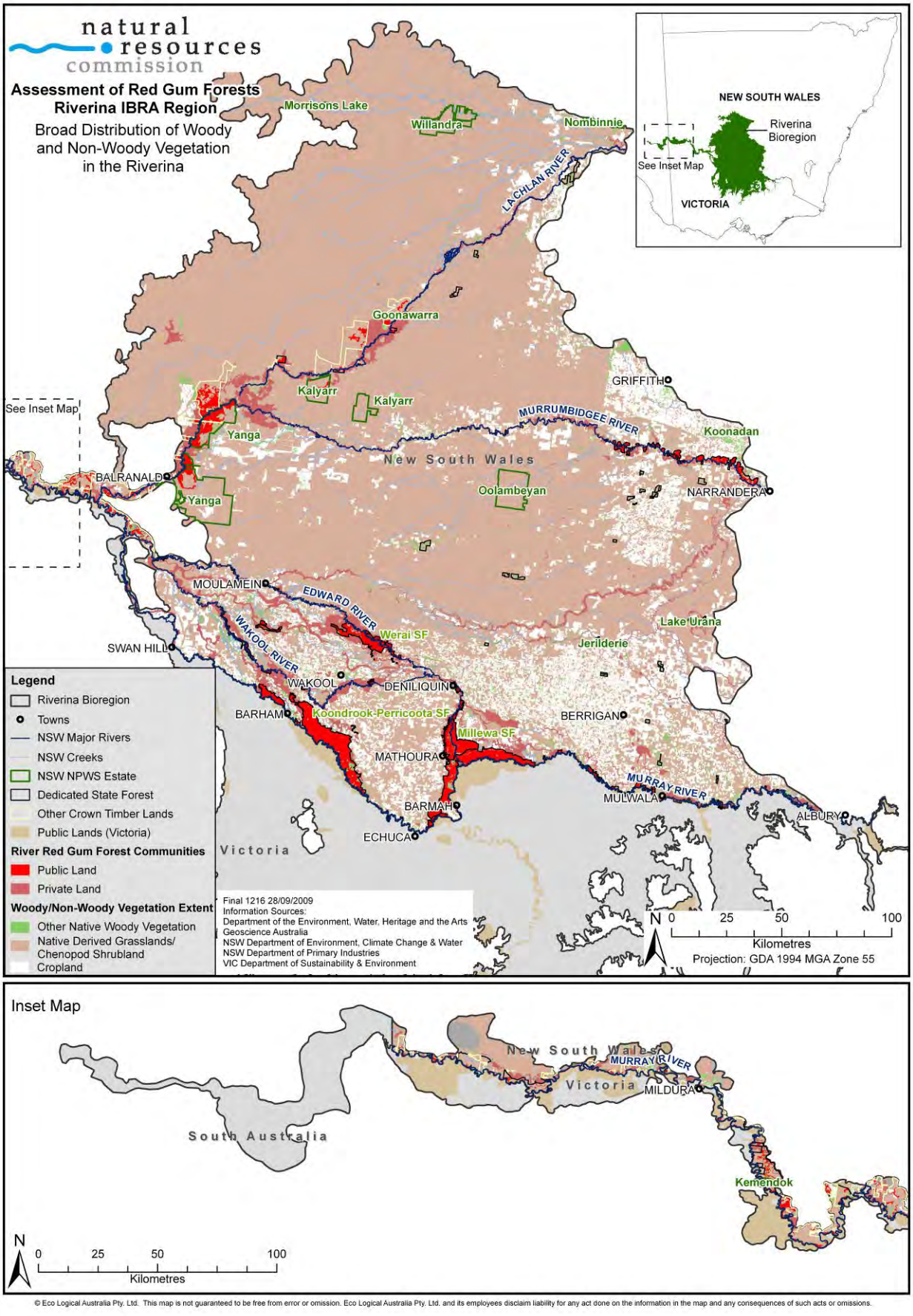


Figure 19 Broad distribution of woody and non-woody vegetation in the Riverina

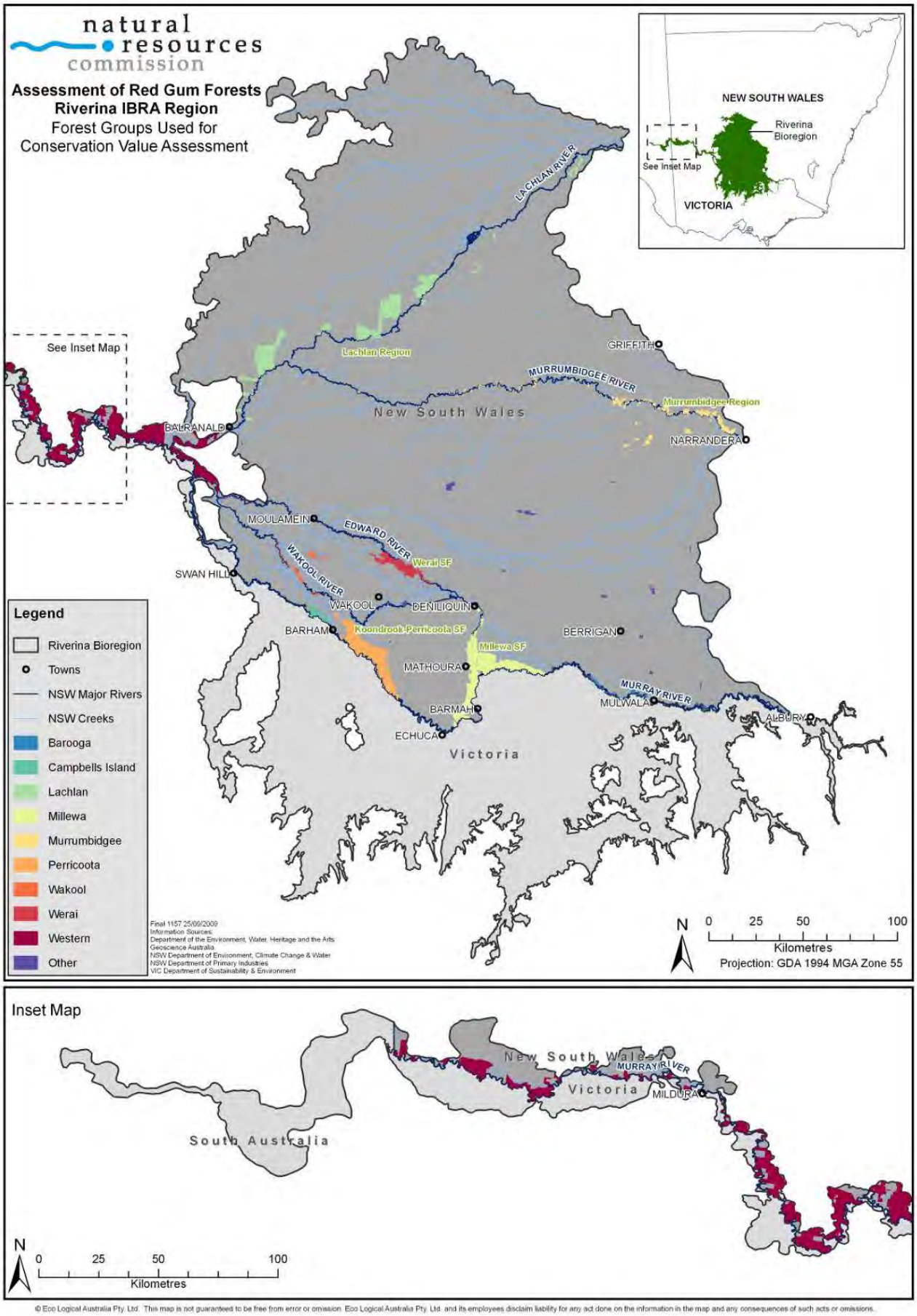


Figure 20 Forest Groups used for conservation value assessment

The forest groups listed in Table 10 support a diversity of fauna, flora and vegetation types (e.g. Roberts 2004; Webster et al 2003). These include a number threatened species, populations and communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and/or the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Fauna and flora species listed under the TSC Act and/or the EPBC Act are shown in Tables 11 and 12.

Of the 51 fauna species or populations listed in Table 11, six are considered to be dependent on wetlands within the river red gum forests, and are locally threatened by absence of floods: Australian bittern; Australian painted snipe; brolga; blue-billed duck; freckled duck; and southern bell frog. A further seven species are considered to use river red gum forest and woodland as their primary habitat: barking owl; gilbert's whistler, regent parrot, superb parrot, squirrel glider, large-footed myotis; and sloane's froglet. The remaining 38 fauna species are known to use river red gum forest and woodland, although it is not considered to be their preferred habitat, or they have been recorded in the Riverina but are not known to use river red gum forest and woodland.

A total of 13 fauna species in Table 11 are listed as either vulnerable or endangered under the EPBC Act, and are thus considered to be Matters of National Environmental Significance (NES). Several freshwater fish species including Trout Cod and Murray Cod, and a number of migratory birds are also listed under the EPBC Act and are matters of NES.

The EPBC Act provides for recovery plans to be drafted for threatened species or ecological communities. Recovery plans have been completed for five EPBC-listed fauna species in Table 11 and are enforced by the Act. These recovery plans are for malleefowlr Regent honeyeater, swift parrot, thick-billed grasswren, and northern hairy-nosed wombat which is now presumed extinct from the Deniliquin region. A further seven recovery plans are under preparation.

Table 11 TSC and EPBC listed fauna species of the Riverina

Scientific Name	Common Name	NSW Status	EPBC Status
Amytornis textilis ssp modestus	Thick-billed Grass-wren (eastern subspecies)	E1	V
Botaurus poiciloptilus	Australasian Bittern	V	-
Burhinus grallarius	Bush Stone-curlew	E1	-
Cacatua leadbeateri	Major Mitchell's Cockatoo	V	-
Calyptorhynchus lathami	Glossy Black-cockatoo	V	-
Cinclosoma castanotus	Chestnut Quail-thrush	V	-
Climacteris picumnus victoriae	Brown Treecreeper (eastern subsp.)	V	-
Crinia sloanei	Sloane's Froglet	V	-
Dasyurus maculatus	Spotted-tailed Quoll	V	E
Falco hypoleucos	Grey Falcon	V	-
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	V	-
Glossy Black-cockatoo population in the Riverina		Endangered Population	-

Scientific Name	Common Name	NSW Status	EPBC Status
Grantiella picta	Painted Honeyeater	V	-
Grus rubicunda	Brolga	V	-
Hamirostra melanosternon	Black-breasted Buzzard	V	-
Hylacola cauta	Shy Heathwren	V	-
*Lasiorhinus krefftii**	Northern Hairy-nosed Wombat	Presumed extinct	E
Lathamus discolor	Swift Parrot	E1	E
Leipoa ocellata	Malleefowl	E1	V
Litoria raniformis	Southern Bell Frog	E1	V
Lophoictinia isura	Square-tailed Kite	V	-
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	-
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-
Myotis adversus	Large-footed Myotis	V	-
Neobatrachus pictus	Painted Burrowing Frog	E1	-
Neophema pulchella	Turquoise Parrot	V	-
Ninox connivens	Barking Owl	V	-
Nyctophilus timoriensis	Greater Long-eared Bat (south eastern form)	V	V
Oxyura australis	Blue-billed Duck	V	-
Pachycephala inornata	Gilbert's Whistler	V	-
Pachycephala rufogularis	Red-lored Whistler	-	V
Pedionomus torquatus	Plains-wanderer	E1	V
Petaurus norfolcensis	Squirrel Glider	V	-
Petroica rodinogaster	Pink Robin	V	-
Phascogale tapoatafa	Brush-tailed Phascogale	V	-
Phascolarctos cinereus	Koala	V	-
Polytelis anthopeplus monarchoides	Regent Parrot (eastern subspecies)	E1	V
Polytelis swainsonii	Superb Parrot	V	V
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-
Pyrrholaemus sagittatus	Speckled Warbler	V	-
Rostratula australis	Australian Painted Snipe	E	V
Saccolaimus flaviventris	Yellow-bellied Sheathtail bat	V	-

Scientific Name	Common Name	NSW Status	EPBC Status
Squirrel Glider population in the Wagga Wagga LGA		Endangered Population	-
Stagonopleura guttata	Diamond Firetail	V	-
Stictonetta naevosa	Freckled Duck	V	-
Stiputurus mallee	Mallee Emu-wren	-	E
Tiliqua occipitalis	Western Blue-tongued Lizard	V	-
Tyto novaehollandiae	Masked Owl	V	-
Vespadelus baverstocki	Inland Forest Bat	V	-
White-browed Treecreeper population in the Carrathool LGA south of the Lachlan River and Griffith LGA		Endangered Population	-
Xanthomyza phrygia	Regent Honeyeater	E1	E

Of the 18 threatened flora species listed in Table 12, one (Floating Swamp Wallaby-grass) is associated with swamp margins in river red gum forest and woodland, and is threatened by changed water regimes. An additional species (yellow gum) grows within river red gum forest and woodland along the Murray. The remaining 16 species may have been recorded in river red gum types, but are generally associated with other vegetation communities. A recovery plan has been completed for one EPBC-listed flora species, sand-hill spider orchid, while plans are being prepared for three others.

Table 12 TSC and EPBC listed flora species of the Riverina

Scientific Name	Common Name	NSW Status	EPBC Status
Acacia curranii	Curly-bark Wattle	V	V
Amphibromus fluitans	Floating Swamp Wallaby-grass	V	V
Austrostipa metatoris	A spear-grass	V	V
Austrostipa wakoolica	A spear-grass	E1	E
Brachyscome muelleroides	Claypan Daisy	V	V
Brachyscome papillosa	Mossgiel Daisy	V	V
Caladenia arenaria	Sand-hill Spider Orchid	E1	E
Casuarina obesa	Swamp Sheoak	E1	-
Diuris pedunculata	Small Snake Orchid	E1	E
Diuris tricolor	Pine Donkey Orchid	V	V
Eucalyptus leucoxylon subsp. *pruinosa*	Yellow Gum	V	-
Kippistia suaedifolia	Fleshy Minuria	E1	-

Scientific Name	Common Name	NSW Status	EPBC Status
Lepidium monoplocoides	Winged Pepper Grass	-	E
Maireana cheelii	Chariot Wheels	V	V
Philotheca ericifolia		V	V
Pilularia novae-hollandiae	Austral Pillwort	E1	-
Pultenaea humilis		V	-
Swainsona murrayana	Slender Darling Pea	V	V

Figure 21 and Figure 22 show the respective distribution of threatened fauna and flora records across the region, classified into five broad groups.

The main habitat requirements of a distinctive subset of river red gum and wetland dependent species are summarised in Table 13.

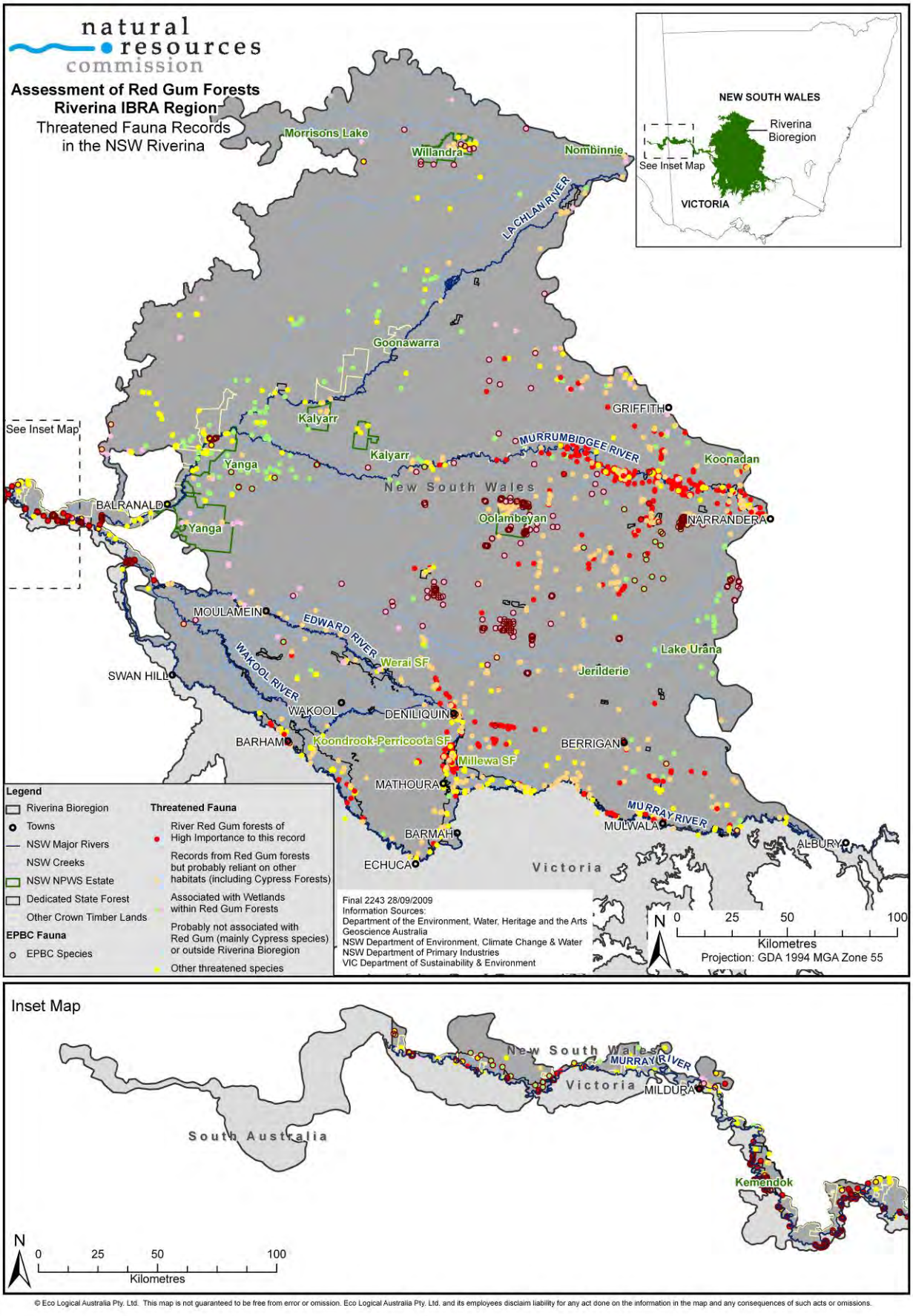


Figure 21 Threatened fauna records in the NSW Riverina

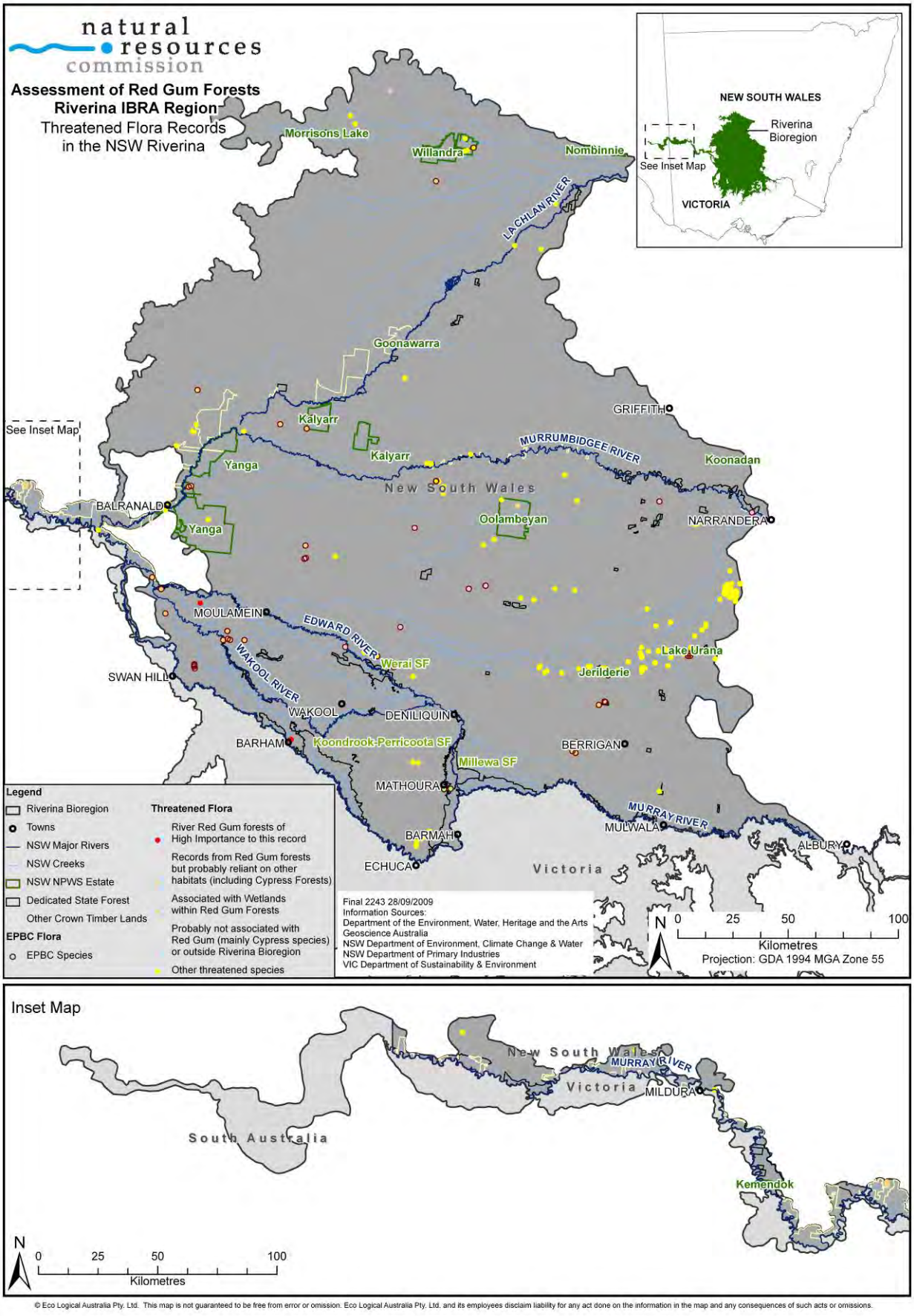


Figure 22 Threatened flora records in the NSW Riverina

Table 13 Key species recorded in the river red gum forests of the Riverina

Common Name	Scientific Name	Status	Notes on Distribution	Priority Habitat	Main habitat requirements
Australasian Bittern	*Botaurus poiciloptilus*	V (TSC Act)	Wetlands of the Barooga and Murrumbidgee groups (also found in Millewa)	Wetlands in river red gum forests	Dense reed beds are its principal habitat type, but can be found in swamps, streams and estuaries. Preys oninsects, crustaceans, frogs, fish and insects. Breeding and nesting usually take place on a platform of trampled weeds, rushes and cumbungi, usually near water level in heavy cover.
Barking Owl	*Nixos connivens*	V (TSC Act)	Barooga, Millewa, Murrumbidgee and Perricoota groups	River red gum forests	Primarily inhabits open forest and woodland, in warm lowland areas on gentle terrain (Ayers *et al*. 1996). Roosts by day in dense streamside woodlands and thickets of *Casuarina* and *Acacia*, as well as eucalypts, and forages in adjacent woodland; it is often associated with red gum species (Higgins 1999). Are assumed to be sedentary, living singly, in pairs or family groups of three to five in permanent territories containing several roost sites. Requires hollow trees for nesting. They hunt nocturnally for a variety of mammals up to the size of a rabbit, primarily native gliders (Kavanagh and Bamkin 1995). Barking Owl habitat is threatened by land clearance, logging and firewood harvesting and feral honeybees, which can take over the owls' nesting hollows. Ecology of the Barking Owl is also analysed by Kavanagh et al (1995), Kavanagh and Stanton (2009), Parker et al (2007), Webster et al (2003) and McGregor (in press)

Common Name	Scientific Name	Status	Notes on Distribution	Priority Habitat	Main habitat requirements
Blue-billed Duck	*Oxyura australis*	V (TSC Act)	Lachlan and Murrumbidgee Groups (also found in Millewa)	Wetlands in river red gum forests	Prefers habitats of permanent freshwater swamps, dams, lakes and larger rivers, usually with a cover of dense vegetation. Feeds upon a wide variety of seeds and leaves of freshwater plants as well as large numbers of midge, caddisfly and dragonfly larvae. Breeding and nesting take place in a cup-shaped nest constructed in rushes, reeds, sticks, cumbungi or lignum with a little down lining. Often a canopy of surrounding growth is pulled over it in cumbungi, rush, lignum or tea-tree, either over water or on the ground if on an island. Occasionally they will utilise the old nest of other waterfowl.
Brolga	*Grus rubicunda*	V (TSC Act)	Wetlands of the Barooga group	Wetlands in river red gum forests	Typically prefers habitats that consist of shallow swamps and their margins, floodplains, grasslands, paddocks and ploughed fields, irrigated pastures, stubble and crops. Brolgas are omnivorous with their diet consisting of grain crops, in particular sorghum and maize, as well as tubers. A variety of insects, spiders, freshwater and marine molluscs, crustaceans, small mammals and reptiles and frogs comprise the rest of their diet. Breeding and nesting usually take place in a nest constructed of grasses and plant stems, on small islands in swamps or in water. Occasionally eggs are laid on bare ground.
Freckled Duck	*Stictonetta naevosa*	V (TSC Act)	Barooga and Lachlan groups (also found in Lower Lachlan)	Wetlands in river red gum forests	Prefers heavily vegetated swamps, large open lakes and associated shores and floodwaters. Feeds by filtering and dabbling, which limits their foraging to aquatic habitats, especially shallow productive waters or soft mud at wetland edges. Breeding and nesting usually occur in a well constructed bowl shaped nest of stems and sticks in lignum or in overhanging tea-tree branch or flood debris close to water. It will at times utilise old coots nest.

Common Name	Scientific Name	Status	Notes on Distribution	Priority Habitat	Main habitat requirements
Gilbert's Whistler	*Pachycephala inornata*	V (TSC Act)	Campbell's Island and Millewa group of forests	River red gum forests	Prefers mallee, often in association with spinifex, although it also utilises shrubby mulga or taller eucalypt woodlands, Belah, riverine black box and lignum, or partly cleared country (Pizzey, 1980). Bimble Box/pine and ironbark/pine woodlands also support this species, again when in association with a shrubby understorey. They construct a bulky cup nest made of bark strips, grass, twigs and leaves, lined with grass and rootlets and loosely bound with cobwebs, wool and vine tendrils, and may be well built or rather untidy (Pizzey, 1980). Nests are located in the dense upright fork in a shrub or low tree (up to 2m high), often among a heavy growth of vine, within a mistletoe clump, or on top of a stump among coppice. Feeds on invertebrates, seeds and plant material, predominantly taken from the ground but may also be gleaned from low trees and shrubs (Barker and Vestjens, undated b).
Powerful Owl	*Ninox strenua*	V (TSC Act)	Recent record in the Barooga group	River red gum forests	Primarily distributed on the coastal side of Great Dividing Range, they inhabit tall open sclerophyll forests, dense mountain gullies, coastal forests and woodland areas. In the Riverina it has been recorded infrequently in river red gum. A sedentary species which lives singly or in pairs within permanent territories containing several roost sites. Nests are located on decayed debris in large hollow tree limbs or trunks 10-20m above the ground. Hunts nocturnally within more open forest types, their primary prey species being arboreal and semi-arboreal mammals, as well as birds, insects and terrestrial mammals. (NPWS 1996). Requires large contiguous blocks of forest/woodland

Common Name	Scientific Name	Status	Notes on Distribution	Priority Habitat	Main habitat requirements
Regent Parrot (eastern subspecies)	*Polytelis anthopeplus monarchoides*	E1 (EPBC Act) V (TSC Act)	Western group	River red gum forests	Occur in a wide range of habitats from river red gum forest, black box woodland to mallee woodland. Observed nesting in old river red gums in the Robinvale area. A typical nest tree is greater than 18 metres high, 134 to 175cm diameter at breast height (dbh) (average), a crown diameter of 19 metres and within 16 metres of permanent water. Nest trees are often surrounded by other old trees with a dbh of 125 centimetres (Beardsell, 1985; Burbidge, 1985). Regent parrots eat a wide variety of seeds and fruits, though they feed mostly in mallee. Are threatened by clearing of nesting and feeding habitat, trapping for the avicultural trade, road kills, pesticide applications on grains and accidental poisoning through consumption of baits (Webster, 1991). Requires living or dead trees with hollows larger than 5cm diameter within 1km of water courses or billabongs.
Superb Parrot	*Polytelis swainsonii*	V (TSC Act)	Barooga, Lachlan, Millewa and Murrumbidgee groups	River red gum forests	Nests in river red gum forests and forages in adjoining woodlands of river oaks (*Casuarina cunninghamiana*), yellow box (*Eucalyptus melliodora*) and other eucalypts, as well as stubble, pastures, sugar gum windbreaks and homestead gardens. Outside the breeding season birds move out of the Riverine forests into dry woodland (*Calltiris* and *Eucalyptus*). Diet consists of seeds of grasses, herbs, crops and weeds. It also feeds upon fruit and blossoms of eucalypts and acacias. Breeding and nesting usually occur in hollow eucalypt limbs. Typical nests are large, mature, healthy trees with many sprouts (though dead trees are also used), typically located close to watercourse.
Koala	*Phascolarctos cinereus*	V (TSC Act)	Recorded in the Barooga group and known to occur in the eastern parts of the Murrumbidgee and Millewa groups	River red gum forests, but reliant on other types	Has an extensive but disjunct distribution from northern Queensland to southern Victoria (Strahan, 1995). Essentially arboreal, it is an extremely agile climber and leaper. Is restricted to eucalypt forest and feeds almost exclusively on the leaves of eucalypts. In particular in the Riverina, the river red gum (*Eucalyptus camaldulensis*) and Bimble Box (*E. populnea*). Breeding occurs in trees during summer. Although it lives predominantly in trees, it may travel for some distance on the ground in search of food.

Common Name	Scientific Name	Status	Notes on Distribution	Priority Habitat	Main habitat requirements
Squirrel Glider	*Petaurus norfolcensis*	V (TSC Act)	Multiple records in the Barooga groups	River red gum forests	Inhabits a variety of wet and dry sclerophyll forests including open forests, low open forests and woodlands where it lives in family groups. Forages at night in the upper canopy feeding on nectar, invertebrates, pollen, lerps and sugary extracts from berries and fruits along with the occasional small bird and mice. Glider habitat is threatened by clearing of woodland for agriculture, logging, grazing, predation by owls, foxes and cats, and loss of genetic diversity (Ayers *et al.*, 1996).
Fishing Bat (Southern Myotis)	*Myotis macropus*	V (TSC Act)	Millewa group (also found in Lower Lachlan)	River red gum forests	Associated with creeks, rivers and depressions where there is a reliable source of water and prey items (small fish). Roosts in caves, tunnels and man-made structures including culverts and bridges.
Sloane's Froglet	*Crinia sloanei*	V (TSC Act)	Millewa and other group on Murray	River red gum forests	Occurs in the Murray-Darling Basin in grassland and woodland that are periodically inundated
Southern Bell Frog	*Litoria raniformis*	E1 (EPBC Act) V (TSC Act)	Murrumbidgee group	Wetlands in river red gum forests	Largely aquatic species found among vegetation within or at the edges of permanent water such as streams, swamps, lagoons and dams. Has taken advantage of irrigation developments in the Coleambally and Murray districts, where it has been recorded in rice crops. An opportunistic feeder of invertebrates and other frogs. Destruction of permanent wetland habitats by hydrological changes, clearing of wetland vegetation and trampling of grazing stock, along with high pesticide concentrations and salination affect the habitat of this species.
Floating Swamp Wallaby-grass	*Amphibromus fluitans*	V (EPBC Act) V (TSC Act)	All groups along the Murray, except the Western group	Wetlands in river red gum forests	Recorded on the south west slopes and plains of NSW, this threatened species occurs in permanent swamps (Harden 1993).

Common Name	Scientific Name	Status	Notes on Distribution	Priority Habitat	Main habitat requirements
Yellow Gum	*Eucalyptus leucoxylon subsp. pruinosa*	V (TSC Act)	Known from several localities along the Murray	River red gum forests	Occurs in well watered sites, often on deep soils along the Murray River.

Six Endangered Ecological Communities (EECs) listed under the TSC Act are known to occur in the NSW Riverina:

- *Acacia melvillei* Shrubland in the Riverina and Murray-Darling Depression bioregions
- *Allocasuarina luehmannii* Woodland in the Riverina and Murray-Darling Depression bioregions
- Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South bioregions;
- Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South western Slopes bioregions; and
- Sandhill Pine Woodland in the Riverina, Murray-Darling Depression and NSW South Western Slopes bioregions
- White Box-Yellow Box-Blakely's Red Gum Woodland

Of these, four are known to occur within state forests in the NSW Riverina, including inland grey box woodland, myall woodland, sandhill pine woodland and white box-yellow box- red gum woodland. The distribution of these has been mapped by Forests NSW (Figure 23). The total area of each in State Forest is 450 ha, 140 ha and 2,100 ha, respectively - a total of about 2,700 ha, representing 1% of the total area of State Forest (in contrast, river red gum and river red gum/box types cover 144,000 ha of State Forest in the NSW Riverina, or 53% of the total area).

Two aquatic EECs as listed under the *Fisheries Management Act 1994* also occur in the Riverina:

- Aquatic Ecological Community in the Natural Drainage System Of The Lower Murray River Catchment
- Aquatic Ecological Community in the natural drainage system of the lowland catchment of the Lachlan River

These EECs include all native fish and aquatic invertebrates within all natural rivers, creeks, streams and associated lagoons, billabongs, lakes, wetlands, paleochannels, floodrunners and effluent streams (those that flow away from the river) of the Lachlan, Murray, Murrumbidgee and Tumut rivers, as well as all their tributaries and branches. These EECs have not been mapped in State Forests, although they are known to occur.

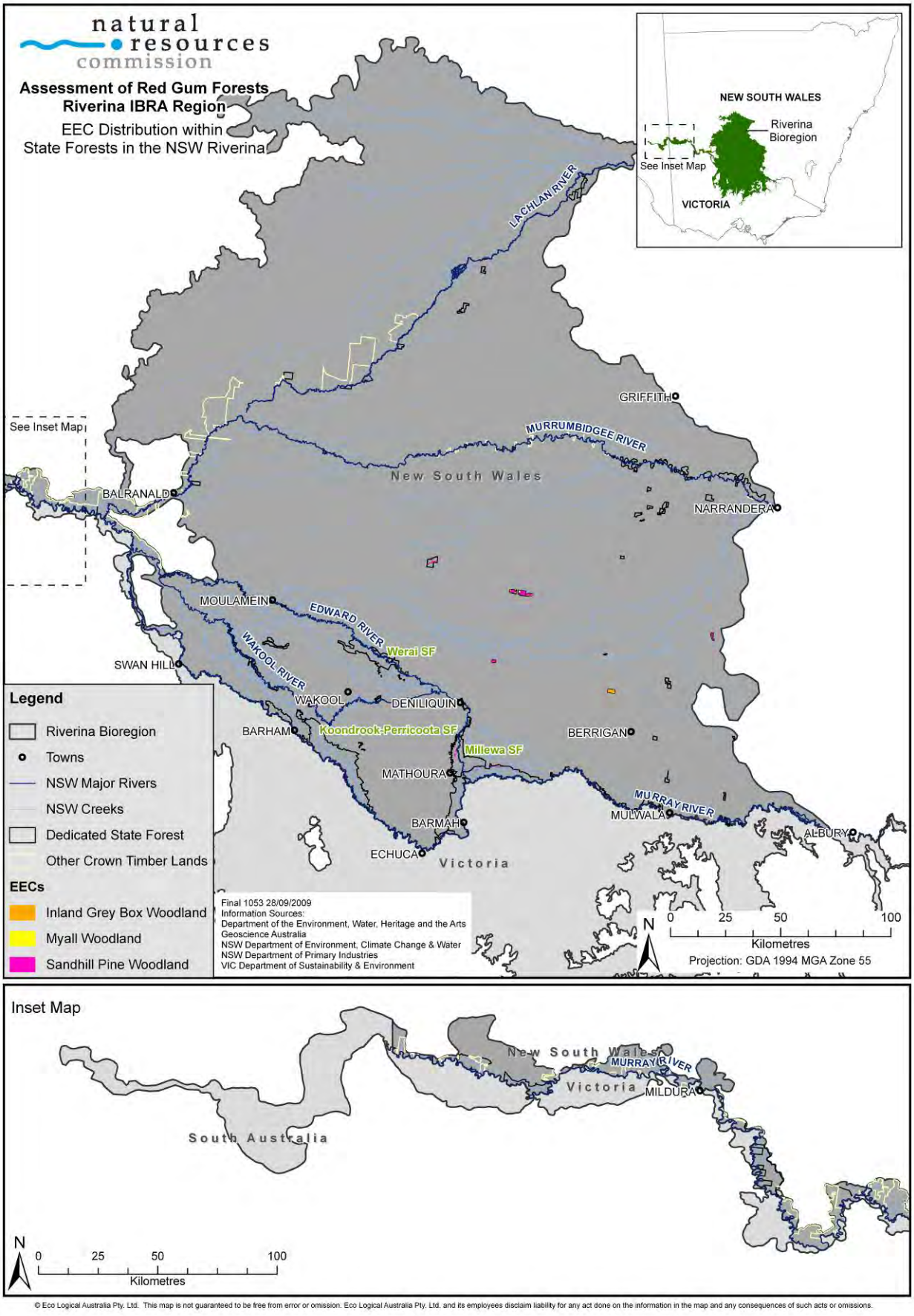


Figure 23 Potential EEC distribution within State Forests in the NSW Riverina

Conservation values associated with major forest groups (Figure 20) are summarised below. These groups have been selected as the context of reporting, as they support most of the remaining river red gum and other woodland habitat in the Riverina.

3.4.6 Millewa Forest Group

The Millewa group of forests on the Central Murray, together with the adjacent Barmah group in Victoria, constitute the largest single stand of river red gum in Australia. The Millewa Forests contain a mosaic of river red gum types, with a number of sand ridges supporting the EEC cypress type throughout. The group supports a diversity of fauna, including a population of barking owl records in region (Moira, Barmah and Deniliquin State Forests), superb parrot nesting sites (Gulpa Island and Millewa SFs), a high diversity of microbat, including fishing bat *Myotis adversus* and yellow-bellied sheathtail bat s*accolaimus flaviventris*, and brush-tailed phascogale and koala.

The Millewa group is important for threatened honeyeaters, with large number of Black-chinned Honeyeater recorded, as well as significant painted honeyeater and regent honeyeater records. It is one of the two known areas supporting Gilbert's whistler in the region. Millewa has been identified by Birds Australia as an important bird area.

The Millewa group forms part of the NSW Central Murray State Forests Ramsar site, and is listed on the Directory of Important Wetlands of Australia. The Millewa Forests are also proximal to a large Victorian reserve in the Barmah forest.

3.4.7 Koondrook Perricoota Forest Group

The Perricoota group incorporates the second largest area of river red gum forest after Millewa. It contains good condition stands in the east, although most of the western area is in poor quality, and needs relatively high flows to permit flooding. The majority of vegetation is SQ2 river red gum woodland, with black box woodlands in the eastern section. The Perricoota group forms part of the NSW Central Murray State Forests Ramsar site, and is listed on the Directory of Important Wetlands of Australia. Species listed in the *Threatened Species Conservation Act 1995* (NSW) in the area are the barking owl and yellow-bellied sheathtail bat. There are also historical records of southern bell frog.

3.4.8 Campbells Island Forest Group

The Campbells Island group of forests is a known area of Gilbert's whistler and is an important area for regionally significant woodland birds such as the white-browed babbler. Other species supported in the Campbell's Island group include black-chinned honeyeater and diamond firetail.

3.4.9 Werai Forest Group

The Werai group of forests is supported by the Edward River, which is a main overflow channel of the Murray. The river red gum forests in Werai are an important site for Inland forest bat, contains the westernmost record of brush-tailed phascogale, and is part of the NSW Central Murray State Forests Ramsar site, and a wetland of national importance on the Directory of Important Wetlands of Australia.

3.4.10 Murrumbidgee Forest Group

A number of small state forests connect a reach of the Murrumbidgee River downstream of Narrandera. These forests are dominated by red gum types, with some box woodlands on the outer floodplains. Few surveys have been undertaken in forests of the Hay area, so little data available. However, the region is known as a major breeding habitat for superb parrot, and contains records of other key avifauna including barking owl, plains wanderer (record in Wilbriggie SF), Australasian bittern and blue-billed duck. The southern bell frog has been recently recorded from this area.

3.4.11 Lachlan Forest Group

The Lachlan group of forests supports a diversity of vegetation types including river red gum, river red gum – box woodland, riverine box woodland and mallee woodland. The area has been subject to a very low level of survey, so its fauna and flora values are largely unknown. Superb and Turquoise Parrots have been recorded in these forests, along with blue-billed and freckled duck, pink cockatoo and square-tailed kite. Significant water bird breeding events are known to occur in Moon Moon State Forest.

3.4.12 Barooga Forest Group

The Barooga group of forests along the upper Murray are known to be in good condition on account of their relatively regular flooding. These forests are the most eastern in the Riverina and are comprised almost entirely of river red gum. NSW Atlas records show that the Barooga forests support a diversity of eastern and western fauna. Barooga State Forest contains the only powerful owl record in the Riverina public forests, and is known to support Australasian bittern, barking owl, brolga, koala, squirrel glider and superb parrot. It is a known locality of the squirrel glider and the brush-tailed phascogale. It contains a diversity of threatened birds including diamond firetail, freckled duck, hooded robin and magpie goose.

3.4.13 Wakool Forest Group

The Wakool Group of forests along the Wakool River are little surveyed. They comprise river red gum woodland, box – river red gum woodland and box woodland. The stand is probably very susceptible to low flow. A few threatened species such as speckled warbler, grey-crowned babbler and bush stone curlew have been recorded, while two threatened grass species recorded in the vicinity include *Austrostipa metatoris* and *A. wakoolica*.

3.4.14 Western Forest Group

The Western Group of forests are supported by lower reaches of the Murray, with some located downstream of the Darling confluence. These forests support a diversity of communities, with river red gum forests, river red gum - box woodlands, mallee woodlands and semi-arid acacia woodlands represented. The area is a known breeding habitat for regent parrot (containing known regent parrot nest sites), and supports the pink cockatoo and southern bell frog. The group contains the western blue tongue in the region, and many other threatened species are at the edge of their ranges including the chestnut quail-thrush, greater long-eared bat, inland forest bat, malleefowl and purple-gaped honeyeater.

3.4.15 Other Forests and Woodlands

A number of small and isolated state forests are located within the semi-arid rangelands of the Riverina, outside the extent of river red gum and box woodlands. These forests often contain vegetation types which have been extensively cleared in the past, including the Inland Grey Box and Myall Woodland EECs.

3.5 Heritage values

The Riverina bioregion supports cultural heritage values for both Aboriginal and non-Aboriginal people. The Barmah-Millewa Forests are listed on the Register of the National Estate, and sites along the Murray River are also listed on State Heritage lists (Pardoe and Martin 2001).

There is a rich cultural heritage associated with the Riverina region that reflects both the historical and continuing interactions between communities and forests. Aboriginal cultural heritage relates to places with traditional significance. These are often tied to the context of a site within the landscape or to stories of recent and Dreaming ancestors. European cultural heritage is related mainly to the historical connections between the river red gum and woodland forests and the development of the Riverina region. While relatively few significant sites and structures remain as testament to this history, modern day communities have long-standing connections with the river red gum forests that form part of the cultural heritage of the region.

3.5.1 Aboriginal heritage

For Aboriginal people the Riverina bioregion is a cultural landscape with archaeological sites with ongoing spiritual and cultural significance. However, the fabric of the land itself and its resources are also culturally important. For Aboriginal people, cultural, spiritual, natural, physical and economic values are interlinked. Aboriginal heritage is a subset of the overall values of importance to the Aboriginal people of the region. While the protection of archaeological sites no doubt plays a major role in the cultural heritage of Aboriginal people, this alone does not reflect the social and economic aspirations of Aboriginal people in the 21st century (Ward, 2009).

Aboriginal cultural heritage relates to places with traditional significance, places of mythology or stories, archaeological sites, post contact sites (missions, fringe camps and stations) and the plants and animals associated with traditional and cultural values. While Aboriginal cultural heritage tends to be divided between physical/conceptual, and ancient/recent, there is an inter-relationship between these different aspects and their relationship with the overall landscape.

Sometimes sites may have significance independent of the landscape, but more often the significance of a site relates to its context within the landscape. Further, landscapes may be culturally significant, relating to stories of recent ancestors or embodying the actions of Dreaming ancestors, even though there is no evidence of physical sites.

Aboriginal sites

There are comparatively few records of Aboriginal history compared with non-Aboriginal social and historical information held by the National Library database. The principal land use of the Riverina bioregion over the last 130 years has been sheep and cattle grazing. The

1880s and 1890s saw rapid land use change and large scale agricultural developments. In this context the Aboriginal heritage of the region has not been well assessed or conserved, with most of the area freehold, and cropping was not subject to regulation until recently (Pardoe and Martin, 2001).

Estimates of Aboriginal populations along the Riverina vary, but it is commonly believed that the Central Murray area may have been one of the most highly populated places in Australia, prior to European arrival (Webb 1984). The Aboriginal cultural heritage that exists in the Riverina bioregion includes oven (earth) mounds, artefact scatters, modified (scarred/carved) trees, hearths, rock art sites, shell middens, burials, PADS (potential archaeological deposits), ceremonial/dreaming sites, fish traps, stone arrangements, resource and gathering sites, and stone quarries (Navin Officer, 2009).

Canoe tree Murrumbidgee River

Recorded history of traditional tribal groups

A significant aspect of Aboriginal heritage sites in the Riverina is the high counts of registered burials. Research indicates that the Riverina has the highest density of Aboriginal burials in Australia. In the Riverina, Aboriginal mound sites are unique to the region and the highest frequency of mound sites in Australia also occurs in the Riverina (Coutts, 1981).

Aboriginal people of the Riverina most likely shaped or managed the environment in which they lived, contributing to the formation and maintenance of open woodlands rather than closed forests. Studies of traditional interactions between Aboriginal tribal groups and the environment suggest that the use of fire was significant in shaping the look of the forest. Curr observed (1883) that the Yorta Yorta people set fire to the grass and trees as frequently as every five years, both accidentally and systematically, for hunting purposes. This burning is

likely to have assisted woodland formation (as red gum is a fire sensitive species) and may have contributed to the maintenance of a forest-grassland boundary in some areas (Navin Officer, 2009).

According to Tindale (1974) it is understood that the traditional tribal groups or nations listed in Table 14 were resident in the Riverina bioregion.

Table 14 Traditional tribal groups or nations of the bioregion

Traditional tribal groups or nations of the Bioregion			
Baraparapa	Barindji	Barkindji	Dadi Dadi
Danggali	Djadjawurung	Kureinji	Latje Latje
Madi Madi	Meru	Nari Nari	Ngurraiillam
Taunguong	Wadi Wadi	Waveroo	Wamba Wamba
Wergaia and	Wiradjuri	Wongaibon	Yitha Yitha
Yorta Yorta			

Traditional tribal boundaries are largely based on linguistic evidence, as such these boundaries can be misleading because the movement of the people and their customs was fluid, not static. As per the figure below, the bioregion is bisected by a number of the traditional boundaries.

Figure 24 shows the general location of traditional Aboriginal language groups in parts of the Riverina bioregion (information and map based on Horton 1996).

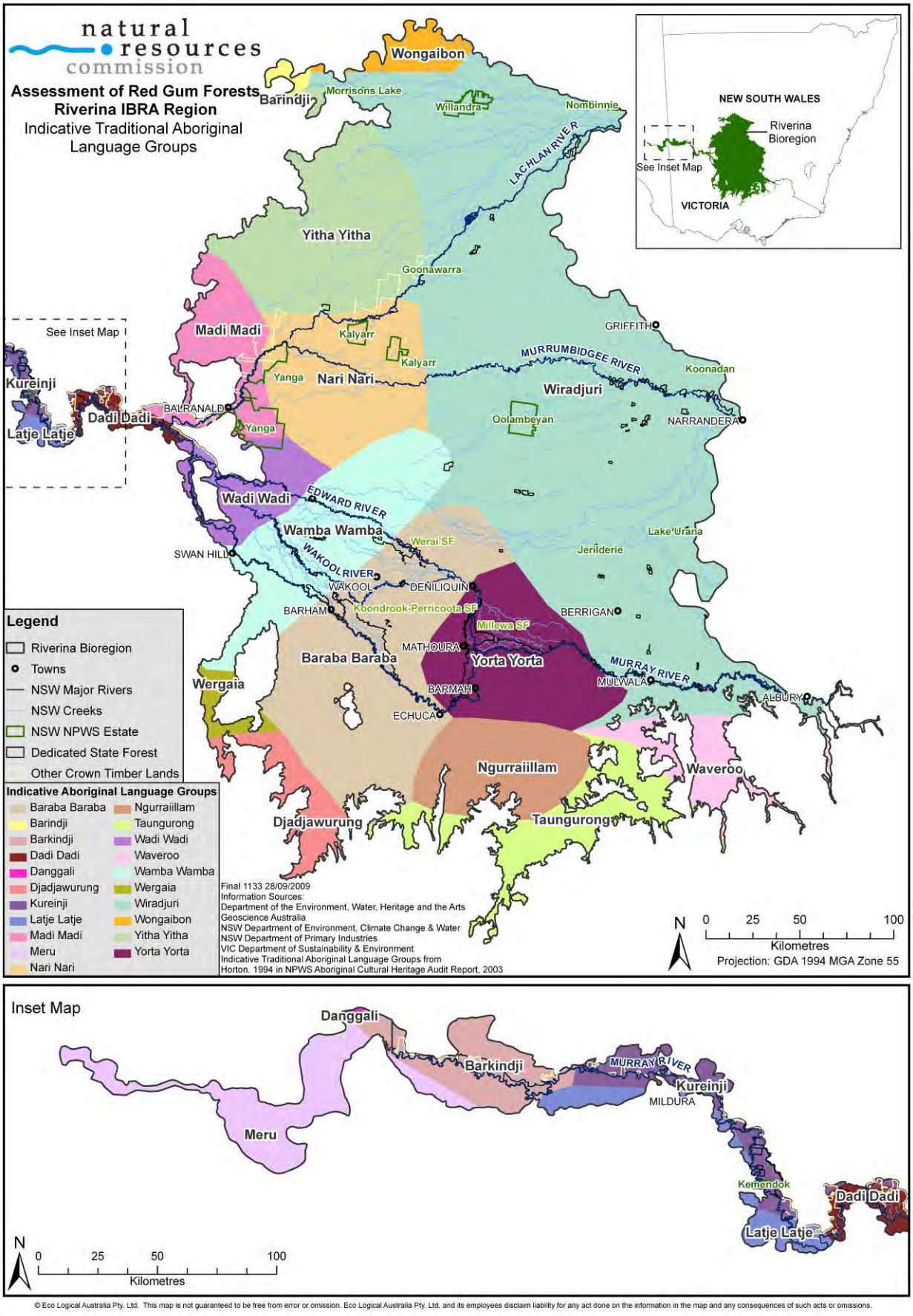


Figure 24 Indicative traditional Aboriginal language groups

NSW Forest management of Aboriginal sites

The *National Parks and Wildlife Act 1974* provides statutory protection for all Aboriginal objects and places in NSW, and Forests NSW manages significant Aboriginal sites within NSW State Forests estate in accordance with the Act (Table 15). Forests NSW also maintains a database of known Aboriginal cultural heritage sites which draws on the AHIMS (Aboriginal Heritage Information Management System) database maintained by DECCW, forest management records and from consultation with Aboriginal communities (Forests NSW, 2008). The Forests NSW EIS (Forests NSW, 2008) reports there have been 1063 site recordings and 1379 separate recording attributes in the 120,050 hectares of the south-western State Forests with greater than 25 recorded sites.

Table 15 Number of Aboriginal heritage site recordings in State Forests with greater than 25 recorded sites (Forests NSW, EIS 2008, Appendix D Table 6.2, p32)

State Forest No	State Forest Name	Area of State Forest	No. of Site Recordings
90	Banangalite	1,294	39
384	Werai	9,454	349
398	Millewa	20,938	77
558	Gulpa Island	5,478	76
576	Moira	10,578	84
615	Campbells Island	3,812	38
625	Koondrook	15,140	291
773	Lake Victoria	4,397	29
Sub total		**71,091**	**983**
Total in Riverina bioregion		**120,050**	**1063**

Representative Aboriginal organisations in the region

In NSW Local Aboriginal Land Councils and/or nations, traditional owners groups are the representative bodies for the interests, concerns and aspirations of Aboriginal people. The Murray Lower Darling Rivers Indigenous Nations (MLDRIN) is a confederation of Indigenous nations or Traditional Owners in the lower, southern part of the Murray Darling Basin. Current delegates of MLDRIN come from the Barapa Barapa, Latji Latji, Mutti Mutti, Ngarrindjeri, Taungurung, Yorta Yorta, Wamba Wamba, and Wiradjuri Nations. MLDRIN was formed in 1998 during the Yorta Yorta Native Title Case.

In 1977 the NSW Aboriginal Land Council was formed as a lobby group for Aboriginal land rights. Then in 1983, NSW enacted the formal creation of Local Aboriginal Land Councils, under the NSW Land Rights Act, as a mechanism for compensating Aboriginal people for loss of land. There are 121 Local Aboriginal Land Councils (LALCs) across the state, and according to Pardoe and Martin (2001) LALCs are the main organisations in the region responsible for cultural heritage. Table 16 shows the Local Aboriginal Land Councils that are either partially or wholly within the Riverina bioregion.

Table 16 Local Aboriginal Land Councils in the bioregion

Local Aboriginal Land Councils in the bioregion			
Albury and District	Balranald	Cummergunja	Dareton
Deniliquin	Griffith	Hay	Ivanhoe
Leeton and District	Moama	Murrin Bridge	Narrandera
Wagga Wagga	Wamba Wamba		

3.5.2 Contemporary Aboriginal values and uses

This section aims to identify Aboriginal use and heritage from existing, available or ongoing work. The NRC's assessment follows after significant work done as part of Forests NSW EIS conducted last year, and it will need to be followed up with more detailed and focussed consultations with Aboriginal people to explore future opportunities for roles in land management.

Looking forward it is important than any possible forest agreement involves extensive consultation with Aboriginal communities in order to identify possible future opportunities, aspirations and desired outcomes for Aboriginal people. This is consistent with NSW Government policy *Two Ways Together* which promotes the development of sustainable partnerships between Government and Aboriginal communities.

In undertaking its consultation with Aboriginal communities, the NRC's assessment is underpinned by the principles below:

- local Aboriginal people are the key determinants of their culture and heritage, and
- Aboriginal people maintain the right to hold their knowledge and pass on information as they see fit.

The NRC will build on the existing knowledge of cultural values and uses by further discussions with Local Aboriginal Land Councils and Traditional Owners individually in the Riverina bioregion and through organisations such as MLDRIN. So far the NRC has met or spoken with Yarkuwa Indigenous Knowledge Corporation, Cummergunja Local Aboriginal Land Council, Deniliquin Local Aboriginal Land Council, a traditional owner from Nari Nari, and representatives from Murray Lower Darling Rivers Indigenous Nations (MLDRIN). We have also received submissions from Culpra Milli Aboriginal Corporation, WIRINGIL and a traditional owner from Cummergunja. It will be important to continue to work with these groups and others to better understand the diversity of interests.

Previous work – Forests NSW EIS and 'use and occupancy mapping'

In preparation of the Forests NSW EIS (2009), there was consultation between Forests NSW and local Aboriginal communities on the impact of forest harvesting and associated road work operations on the cultural values of river red gums for cultural. During this consultation process for the EIS, Aboriginal communities identified a number of issues which they wish to address through a management mechanism. These issues included:

- cultural heritage
- protection and management programs (Forest Management Zones)
- community involvement in land use related to Forests NSW estate

- socio-economic outcomes
- enterprise development opportunities
- employment and training
- establishment of Forests Aboriginal Management Committees (FAMC's) attached to specific forests throughout the region, and
- resourcing of such Committees by Forests NSW (Forests NSW 2009).

Table 17 provides a more detailed breakdown of key issues arising from individual consultative meetings from the Forests NSW EIS (Navin Officer, 2009, p16-18 Appendix D).

Table 17 Consultation summary from the EIS (Navin Officer, 2009, p16-18 Appendix D)

Organisations	Location	General Comments Relating to Cultural Values
MLDRIN	Albury	▪ MLDRIN doesn't have a particular problem with sustainable forestry per se.
Yorta Yorta	Shepparton	▪ Yorta Yorta acknowledges the Local Aboriginal Land Councils' but believes that Traditional Owners should talk on cultural matters. ▪ Clear felling (Australian Group Selection) undermines cultural values as opposed to harvesting. It was not fully explained why this was so.
Cummergunja LALC	Cummergunja	▪ Really appreciates opportunities to go out bush and look at sites and to ensure they are protected during operations.
Yarkuwa Indigenous Knowledge Corporation	Deniliquin	▪ Access to forests for traditional purposes.
Deniliquin LALC	Deniliquin	▪ Access to forests for traditional purposes.
Balranald Community Billa Downs, Euston Culpra Station	Balranald	▪ Access to State forests for traditional purposes ▪ Protection of sites
Dareton Barkindji Elders Council Community Members	Dareton	▪ Lack of awareness that State forests are open to the public. ▪ Access to State forests for traditional purposes ▪ Employment opportunities

Use and occupancy mapping

To get around the lack of visible evidence to support contemporary cultural relationships 'use and occupancy mapping' is a useful, and recognised, social science methodology which maps an individual's relationship with the land and water. The focus is on life experience rather than archaeological or historical sites, 'Use' refers to activities such as hunting, trapping, fishing, gathering of medicine plants and 'occupancy' refers to areas Traditional

Owner groups regard as their own through place naming, traditional stories, spiritual places or burial grounds.

In recognising that the values, aspirations and contributions of Aboriginal people is integral to natural resource management The Living Murray Initiative recently employed this technique with the Yorta Yorta people in Australia (Ward, 2009).

Values and issues

The contemporary uses, values and aspirations of Aboriginal people across the Riverina is diverse. While further consultation is needed to explore and better understand the spectrum of views, at this stage it is clear that there is no unanimous view and that Aboriginal people across the region maintain different interests and concerns, reflecting their different relationships and values to the landscape.

Access to Country

Access to country is paramount for Aboriginal people across the Riverina. Access directly relates to the continuation and renewal of cultural heritage discussed earlier. Access to country is intrinsic to Aboriginal people; their stories come from the land and the ability to practise culture as they have done for thousands of years is of utmost significance, this involves gathering foods, visiting places, gathering firewood, and camping (DAA, 2009). In many cases it also involves the ability to hunt, and fish which may have implications for future tenure arrangements.

Cultural water use

The *NSW Water Management Act 2003* allows for cultural access licences. The Murrumbidgee Regulated River Water Sharing Plan contains a provision for a water allocation for cultural purposes, a sub-category of high security access licences and allows for water to be taken for Aboriginal domestic and cultural purposes (DWE, 2009). The Murrumbidgee Traditional Owners and Cultural Heritage Reference Group is developing a program to manage the licence with the Murrumbidgee CMA and in partnership with the Murrumbidgee Environmental Water Management Plan (Murrumbidgee CMA, 2009).

By watering wetlands, icon sites and places of cultural significance, environmental water supports cultural as well as environmental values. The Culpra Mill Aboriginal Corporation has been involved in the allocations of environmental water for red gums along the Tarpualin Creek Culpra Station and Malley Cliffs State Forest (Pearce, 2009)

Land title

There are limited opportunities for Aboriginal people to seek and own land for cultural and economic ventures, due to the small percentage of public land available. The Yorta Yorta Native Title Claim provides evidence that Aboriginal communities associated with the Riverina bioregion are pursuing an interest for land ownership (Purcell, 2003).

3.5.3 Non-Indigenous heritage

The river red gum and woodland forests of the Riverina bioregion have been an important resource for communities along the Murray River since the first European settlers arrived in the region in the 1820's. Due to the significant modification of landscapes across the region, cultural heritage items in the Riverina bioregion are limited to the few sites and structures that remain, and the natural heritage of the State Forests themselves. The cultural heritage of

the region is encapsulated in the enduring connections local communities and the timber industry have with the forests.

Historical connections

The history of development of the Riverina bioregion can be categorised into early exploration and development up to the late 1800's, intensification of resource use and regulation through to 1980, followed by increasing focus on balancing environmental and use values in recent decades. The river red gum and boxwood forests of the Riverina bioregion support a range of cultural heritage values which are linked to the various roles they have played during each of these historical phases.

Following the discovery of the Murray River in 1824 by Hume and Hovell, pastoralists and squatters settled on large leases that covered both open plains and forested areas. The primary use of the forests during this period was as a resource for grazing of domestic stock and for timber for bridges, huts, fence posts and firewood. By the 1840's, the area was well settled and the introduction of stock grazing on a large scale led to large areas of floodplain and woodland being cleared and converted to grasslands (Forests NSW, ESFM, 2008).

The expansion of river trade and introduction of railways from the 1850's to late 1800's led to increased cutting of river red gum timber across the region for use in transport infrastructure, to fuel paddle-steamers and as a major item of trade. Ports with associated infrastructure were established at Echuca, Swan Hill, Albury and Wahgunyah. Steamboats or paddle-steamers were introduced to the Murray in 1853 for commercial trade and operated principally between Goolwa and Echuca. The wharf at Echuca in Victoria was built entirely from red gum timber and is listed as an item of National Heritage (DEWHA, 2009).

Due to its durability, strength and resistance to air, water and insects, timber from river red gums is highly valued for use as railway sleepers. The economic use of the Red Gum forests was expanded to supply timber to the Melbourne market and to export markets of the British colonies which were heavily engaged in railway and wharf building (Forests NSW, 2008, p. 20 & VEAC, 2006, p. 105).

River paddle boats and heritage are strongly connected near Echuca wharf

Case study: Echuca wharf

Echuca Wharf was an important site on the busy Murray River in the late 1800s. It attests to the critical role that the river trade played in the pastoral boom and in the rapid economic growth and development of the colonies during this time, which ultimately led to Federation. Today the wharf is still operational with three tourist cruising paddle-steamers leaving from the wharf daily.

Echuca Wharf was constructed almost entirely of river red gum timber, which was felled and milled locally. Towering three storeys high, the wharf's height allowed for a 10 metre variation in the winter and summer levels of the Murray and enabled a year round unloading of goods. Cranes, wool press and bond stores were accommodated on the uppermost level.

Today the remaining structure is part of the central section of the original wharf. As a National Heritage listed structure, original red gum timbers are used in all maintenance and upgrades of the wharf.

Since the 1960s, the wharf and paddle-steamers have found a new life, servicing the tourist industry. Echuca is regarded as the home of the largest number of paddleboats in the world.

Source: DEWHA, 2009

From the late 1800's, intensification of the use and the recognition of their value as a resource led to increasingly formalised management of red gum forests. The introduction of irrigation schemes in the 1880's led to further clearing of forests to increase areas of cultivation. By the end of the 1800's, concern over widespread uncontrolled logging let to most of the remaining forests being reserved as forest lease or timber reserves. In the early 1900's many of these leases and reserves were dedicated as state forests under the *Forestry* Act 1916 (GHD, 2009c, p. 123). Some living trees or "ringers" remain as examples of the organised ringbarking practices carried out during this period.

From the 1980's, the remaining forests were increasingly recognised for their environmental and cultural heritage values as well as timber production values. Collaborative efforts between Forests NSW, timber industry operators, NGO and community groups as well as other Government agencies led to the development of policies and plans to promote and protect non-use values. Permanent reservation areas for Flora reserves and cultural heritage sites, retention of hollow habitat trees for fauna and the recognition of the Central Murray State Forests as wetlands of international significance stand as testaments to ecologically sustainable management practices introduced over the past 30 years (GHD, 2009c, pp. 125 – 127).

Contemporary connections

The historical relationship between the forests of the Riverina region and the communities that have relied on and managed them has led to the development of enduring connections that form part of the cultural heritage of the region. Many of the current day timber industry owners and operators are descendents of early settlers or mill operators. The adaptive process through which current forestry management practices have developed and

generated a body of institutional and local knowledge about the forests which is also a significant aspect of cultural heritage.

The strong connections between communities and the forests are evident in the role the timber industry and local community play in managing the forests under policies developed by Forests NSW for harvesting and silvicultural practices, conservation, weed and fire management, grazing and apiary.

3.6 Social and economic values

3.6.1 Social and economic context

The NRC's assessment of the river red gum and woodland forests of the Riverina Bioregion will consider the social and economic values associated with the forests at State, regional and local levels. At a regional and local level, the social resilience of communities in the Riverina bioregion will be a factor in considering the balance between use values and non-use values, as well as between current and possible future values. Resilience in a socio-economic context can be considered as the ability to absorb changes or manage changes successfully, in terms of:

- Economic viability – the versatility of an area's economy, avoiding reliance on any single crop, secondary industry or employer. In an agricultural region, the more viable economies would in theory be those with several primary products, and include primary, secondary and tertiary economic tiers. Thus, when a single primary product suffers a downturn or shock, the economy as a whole can be buffered
- Social vitality – this focuses on social bonds, reflecting people's ability to support one another and manage crises collectively.

In the first stage of the assessment (covered by this report), the focus has been on gathering the available information on the current social and economic health of the Riverina region. In the following stage of the assessment, this information and other existing research will be used to assess the potential social and economic impacts of changes in forest management regimes and tenure. The direct and indirect economic impacts of such changes will be considered by using a financial model of a typical timber industry business, and by conducting a Regional Impact Analysis to assess changes in expenditure patterns within the region. The impact on net social benefits, including non-marketed values, will be considered through a Cost Benefit Analysis.

In the time available to conduct the first stage of research, the primary focus has been on understanding the current social and economic trends, and the essential services provided within those towns within the region which may have a high reliance on the timber industry. Socio-economic profiles have been developed for towns of interest using desk based research on available statistics (see Attachment 6). A series of qualitative interviews was also conducted to develop a more in-depth understanding of the current trends of social change within communities which may have a high reliance on the timber industry.

A summary of this research, with comparison of local town trends to state and regional trends is provided below. In addition to qualitative surveys, a financial survey of the timber industry was conducted to collect primary data on the economics of the timber industry value chain, and of a typical mill. Initial insights from this research are provided in Section 3.6.2. The data collected from the financial survey will be used to develop a financial model

of a typical timber industry business and will be a key input to conducting a Regional Impact Analysis.

Overview of key findings

See Attachment 6 for a detailed discussion of the socio-economic values at a state, regional and community scale. Those towns with greater than 1 percent employment in the river red gum timber industry are identified as being towns of interest:

- Barham
- Deniliquin
- Mathoura
- Darling Point
- Balranald
- Morbein.

The profile presented in this section provides an indication of the relative economic and social health of the region against the rest of the State of NSW. It can also be used to examine if there are areas within the region that face different socio-economic contexts.

Over the last decade, the bioregion has seen a plateau in employment and population growth, suggesting a static or declining level of economic and social robustness and prosperity. Closer examination reveals that growth has lagged behind performance for NSW as a whole. Of particular note is the differing performance within the region. Local government areas within the bioregion, which are not based around a large regional service centre, have seen a decline in both population and persons employed. These LGAs include Balranald, Barham and Deniliquin.

The economy of the region is reliant on agriculture, especially irrigated cropping. Irrigated agriculture in the region, particularly in the Murray Local Government and Wakool Local Government Areas, has declined due to low general security water allocations.

Compared to state-wide figures, towns of interest in the Bioregion:

- have lower median weekly individual, household and family wages
- in the main, have a considerably lower age dependency ratio[8]
- in the main, have a higher proportion of Aboriginal people in the population.

Compared to region-wide figures, towns of interest in the bioregion:

- have a higher median individual wage
- in the main, have a considerably lower age dependency ratio[9]
- in the main, have a lower proportion of dwellings occupied.

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8 The age dependency ratio is calculated as the percentage of the estimated resident population below 14 years of age and above 65 years of age to the percentage aged between 15 and 64 years. The NSW State average is 51%

9 The age dependency ratio is calculated as the percentage of the estimated resident population below 14 years of age and above 65 years of age to the percentage aged between 15 and 64 years. The NSW State average is 51%

ABS statistics from the 2006 census indicates that 7,875 persons are employed in the forest and timber industries state wide. Employment in the region in the forest and timber industries accounts for approximately 13 percent of the total employment in these industries in NSW.

The employment profile for the region is shown in Attachment 6. In 2006, employment in the combined agriculture, fishing and forestry industries accounted for 22 percent of total employment in the region, followed by manufacturing, retail trade and health care/social assistance.

The 2006 Census indicated that a total of 1,008 persons were employed in all forestry and timber industries in the region. This is approximately 1.1 percent of total employment in the region and 4.9 percent of jobs in the combined agriculture, fishing and forestry sectors. A detailed breakdown of this figure for each relevant ANZSIC classification is provided in Attachment 6.

In the next stage of the assessment, the NRC will use two methods of socio-economic impact assessment to inform the development of its recommendations. These two techniques are:

- Regional Impact Analysis (Input-Output modelling).
- Cost Benefit Analysis.

Regional Impact Analysis is concerned with changes in economic activity associated with changes in expenditure patterns within the study area that may arise as a consequence of NRC recommendations. There are a range of techniques to assess regional economic impacts. The most commonly used, and the technique adopted for this assessment, is Input – Output modelling. The Input-Output model will be used to provide estimates of the direct and indirect impacts of alternative policy scenarios on the regional economy.

The survey of timber industry businesses is collecting primary data on the revenue, expenditure and employment of the industry. This will enable the NRC to identify the initial impact or stimulus of the recommendations, and use input-output multipliers to estimate the flow-on effects of the industry any change in forest management. The survey will also be used to develop a financial model of typical timber businesses to enable indicative analysis of direct impacts on operating profit and return on capital.

Cost Benefit Analysis involves the identification and description of all costs and benefits at a state scale that may arise as a result of any change in public land management considered by the NRC. Cost Benefit Analysis considers market values associated with industries that rely on them, as well as values that are not marketed. Non-marketed benefits (un-priced) include use values that may be related to recreation activities, Aboriginal cultural values or ecological functions such as flood regulation. Other un-priced benefits relate to non-use values such as ecosystem conservation, protection of cultural heritage and options for future uses of the forests and their resources. Non-use values represent the value that the community is prepared to pay, on average, to conserve the forests, wetlands and associated ecology for no economic gain; that is, the values that people in the community might hold for environmental assets, irrespective of whether they have direct or indirect contact with them (Bennett et al, 2007).

VEAC in their assessment used Choice Modelling to estimate dollar values for the un-priced environmental conservation values associated with the Victorian river red gum forests

(Bennett et al, 2007). Choice modelling is a *stated preference* technique, used to estimate non-market values (such as existence values or protection values). The technique involves surveying a sample of people and asking them to make choices between different management options, based on their impact on particular attributes of the forest. VEAC used the Choice Modelling as an input into their benefit cost analyses and social assessments of their recommendations.

The NRC will undertake its own costs benefit analyses and social assessments, however, it will not undertake its own Choice Modelling given the complexity and length of the research. For non-use values, the cost benefit analysis will consider the relevance of using choice modelling research conducted to support VEAC's assessment of Victorian river red gums. The VEAC Choice Modelling data may be used as an indicator of the benefit transfer of non-market values, given the comparability of the two regions ecologically, socially and economically.

The results of the VEAC Choice Modelling as reported in VEAC (2008) vary across the three sub samples for their valuation of healthy red gum forests, threatened parrots, Murray cod and other threatened native fish and recreational facilities. The sub samples for the Choice Modelling came from three areas - Melbourne, the Murray region and the Gippsland Region. The Melbourne and Gippsland Regions were prepared to pay $1.45 and $3.29 a year for 20 years to have an increase in 1,000 hectares of healthy forest, while the Murray region sample was willing to pay $0.07 a year or in other words were not willing to pay for an increase. All samples were willing to pay for an increase in the numbers of breeding pairs of threatened parrots ranging from $4 to $8.40 per 100 pairs. The implicit price for a one percent increase in the populations of Murray Cod and other threatened native fish species varied across the sub samples from about $1 to $1.40 (VEAC 2008). The stated non market values for recreation were insignificant, possibly due to conflicting perspectives on the impact environmental protection would have on recreational access to the forests.

VEAC's independent social and economic assessment, which used the results of the Choice Modelling as one input, found that VEAC's recommendations for increasing the reservation of red gum forests would result in a net increase in economic value to Victoria of $37.3 million per year for 20 years if no additional water is made available. This increased to $107 million per year if additional environmental water is provided (note that this excluded the cost of the additional water) (VEAC 2008). Most of these economic benefits result from the values people ascribe to environmental protection, some of which are dependent on the provision of adequate environmental water which is costly and uncertain.

Further, the benefits largely accrue to people who live outside of the Victorian Murray region, yet the costs are borne by those in a handful of communities within the Victorian Murray region (VEAC 2008).

3.6.2 Forestry industry

The river red gum timber industry in the NSW Riverina part of the bioregion is reliant on timber resources sourced from freehold land, Western Land Leases and State Forests. Access to resources on public land is regulated by Forests NSW under the *Forestry Act 1916.* Current quotas and allocations are based on long term yields of high quality sawlogs largely developed in the 1980's. The exception to this is the Murrumbidgee Management Area, the yields for which were reviewed more recently and which substantially decreased from their long term yields.

River red gum timbers are valued for a range of uses including furniture, joinery, railway sleepers, construction, landscape and garden products and firewood. These products are sold in key national markets, as well as some export markets.

To inform this assessment, the NRC is surveying all businesses that are licensed by Forests NSW to access resources on public land. A total of eight businesses have bee surveyed so far. It is estimated that these businesses account for 100 percent of the total quota, 83 percent of ex-quota allocation and 50 percent of the total residue base allocation on public land.

The businesses surveyed to date:

- utilise a range of resources from state forests including quota and ex-quota saw logs, residues and thinning
- produce a range of timber products including high grade furniture and veneers, railway sleepers and construction materials, landscaping materials, and firewood
- employ 163 people (157 FTE)
- have a combined reported revenue of $32,326,450
- have an average reported revenue of $4,040,806
- have reliance of 93 percent (median) of their total combined through combine put from State Forests, noting that two mills have less than 50% reliance on State Forest resources
- have an estimated asset value of $46,775,000.

Additional businesses will be surveyed in the next stage of this assessment. As such, the numbers provided above will be revised.

Approach

To inform this assessment, the NRC has reviewed information on the industry provided by Forests NSW and industry organisations, and publicly available data sources. In addition, detailed surveys are being conducted with all operations that hold licences to access timber on public land.

The criteria used by the NRC and industry representatives to select the businesses surveyed in this first stage of the assessment were those who:

- hold quota
- are considered as large ex-quota or residue operators, reliant on public forests.

In this first stage, all quota licence holders as well as two large ex-quota or residue operators that were identified as being reliant on forests on public land have been surveyed. The remainder of licences holders will be surveyed in next stage of the assessment.

Wood production

For management purposes, the Riverina State Forests are classified into three Management Areas: the Murray Management Area, Murrumbidgee/Narrandera Management Area and the Mildura Management Area.

Forestry management for wood production is primarily focused on high quality sawlogs, those with long straight boles and low levels of defect. Lower quality sawlogs and residue are produced as a by-product of high quality sawlog harvesting and thinning operations. Current quotas and allocations are generally based on long term yields of high quality sawlogs largely developed in the 1980's.

The management of wood production has changed over time as the information base on standing inventory, growth and mortality trends has developed. Initial field assessments that began in the 1940's and 1950's led to the introduction of the 1953 Murray Management Plan and long term yield constraints as a basis for timber allocations to industry (Forests NSW, 2008, p. 34).

Since this initial survey, procedures for estimating standing inventory and growth rates have improved the base of information available to allow more detailed harvest planning. Permanent 'Continuous Forest Inventory' (CFI) plots were introduced in the 1970's to measure growth rates. More recently, strategic inventory plots and permanent growth plots (PGP) have been established which provide information on standing inventory and on growth and mortality rates (Auditor General NSW, 2009, p. 21).

Management Area plans were developed in the mid 1980's which incorporated estimates of standing inventory, estimates of growth rates and allowed for some mortality. 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 High Quality sawlogs (GHD, 2009, p. 80). Volumes of other products are based on volume of High Quality sawlogs and are monitored and produced in line with customer and market demands (Forests NSW, 2008, p. 34).

Long term yields from these Management Area plans are still in use today for the Murray and Mildura Management Areas and were used up until 2005 for the Murrumbidgee and Narrandera Management Areas.

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). A peer review conducted on behalf of the NRC and findings of an Auditor General's 2009 performance audit indicate that FRAMES is robust in its operational aspects and that procedures for collecting data to calibrate the model are sound (Auditor General, 2009, p. 19). The Auditor General's report noted that yield estimates from FRAMES have not been routinely compared to actual harvest results due to significant variations in actual yields between plots (Auditor General, 2009, p. 25).

FRAMES is a useful tool for estimating long term yields under relatively stable climate conditions. However, the empirical nature of the model means that it is unable to accurately predict the impacts of step change climate scenarios on long term wood flow volumes. FRAMES utilises estimates of standing inventory from strategic inventory plots and from CFI and PGP plots to model forward the impacts of growth, mortality and harvesting on total standing volumes of timber. In doing so, it implicitly assumes that future flooding conditions will be similar to past conditions.

Forests NSW are currently updating the data used to calibrate FRAMES to include an apparent 50 percent decline in growth rates and doubling of mortality due to the drought conditions over the past decade. Insufficient data is available to predict the likely trend in

growth and mortality without flooding events to 'recharge' groundwater sources and 're-invigorate' the red gums.

The possible impact of climate change scenarios on yields is discussed further in Chapter 5.

River red gum timber allocation

Forests NSW licences mills and harvest contractors, and provides allocations to mills. Other regulatory activities undertaken by Forests NSW include enforcing harvest plans and various levels of audit to ensure that the required standards are delivered.

Timber is allocated to industry either by annual quotas or through parcel sale arrangements. Annual quotas are an allocation of sawlogs made available to saw mills. As a by-product of this management, other products such as ex quota logs and firewood vary from year to year depending on stand conditions and market demands.

Table 18 provides a summary of the resources utilised by the industry.

Table 18 Summary of forest resources utilised by the timber industry

Resource	Description
Quota	Quotas are annual allocations of high quality ("quota") sawlogs to Crown sawmills. The renewal of a quota allocation is not automatic but is based on an annual review of a mills performance. In the case of the red gum quota mills, quotas have been renewed each year without change in volume apart from minor adjustments because of small overcuts or undercuts. Transfers of quotas are subject to the approval from the Minister for Forests. Companies considering the sale of their quota must therefore make application to Forests NSW for approval to transfer. There has been only one sale of a red gum quota in the last nine years.
Ex-quota	Sawmills also use ex-quota sawlogs that do not form part of their quota allocation. This category includes logs that are of good quality but below size limits subject to further minimum limit for utilisation by the sawmiller. Ex-quota allocations are also reviewed annually and do not have the same tradability considerations as Quota Allocations.
Residue	Residue includes those parts of the log not suitable for sawn timber that are utilised for landscaping, firewood or biofuel.
Thinnings	Thinnings are logs sourced under contract arrangements from silviculture activities conducted for the purposes of improving forest health. Thinnings are generally utilised for firewood and other residue uses.

The total volume (base allocation) of each resource that is currently licensed is provided in Table 19.

Table 19 Summary of base allocation (Forests NSW, pers. comm.)

Resource	Base allocation (m^3)
Quota logs	31,010
Ex-quota logs	28,107
Residue log	101,548 (tonnes)

Note: as at August 2008/09

Table 20 shows the breakdown of annual quota volumes by management area.

Table 20 Quota volumes by management areas (Forests NSW, pers. comm.)

Resource	Quota m^3/year)	Ex-quota (m^3/year)	Residue (tonnes/year)
Murray Management Area	23,450	17,607	63,148
Mildura, Murrumbidgee and Narrandera Management Areas	7,560	10,500	38,400
Total	**31,010**	**28,107**	**101,548**

In regulating the industry's activity on public land, Forests NSW also issues four different types of licences (Table 21).

Table 21 Description of licences issued for industry activities on public land

Licence	Description
Timber Licence	Authorisation under the *Forestry Act 1916* which allows the holder to take timber (trees) as specified in the licence on Crown timber lands.
Products Licence	Authorisation under the *Forestry Act 1916* which allows the holder to take products (product of trees or shrubs) as specified in the licence on Crown timber lands.
Contractor's Licence	Authorisation under the *Forestry Regulations 2009* that allows a contractor who is employed by a holder of a timber or products licence to cut, obtain or remove timber or products.
Operator Licence	Authorisation under the *Forestry Regulations 2009* to be held by any person who is engaged or employed to cut, obtain or remove timber or products from Crown timber lands.

Industry structure

The river red gum timber industry supply chain is shown in Figure 25. The industry is concentrated among a small number of large, vertically integrated milling operations that carry out activities along the supply chain from harvesting to manufacturing. The six quota holders account for 100% of quota allocation, 78 percent of ex-quota base allocation and 37 percent of the base allocation of residue (Forests NSW, 2009, pers. comm.).

Smaller businesses operate in part of the value chain providing services to the larger integrated operations (for example by harvesting saw logs for mills) and harvesting residues for lower value products.

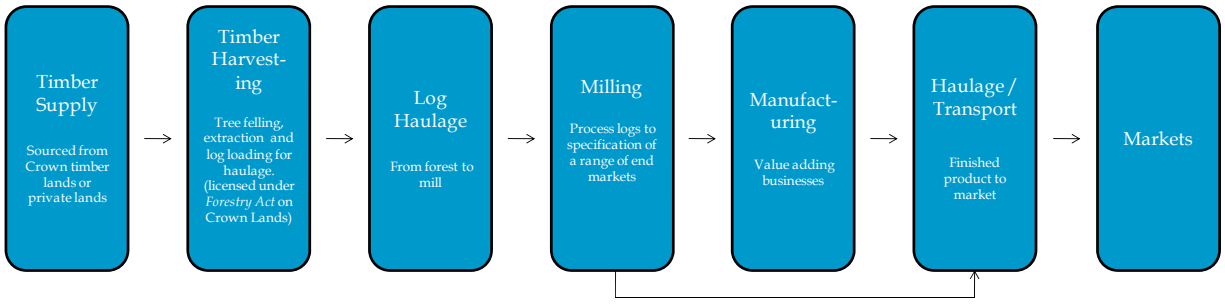

Figure 25 Timber industry value chain

Businesses involved in the industry can be categorised in a number of ways. Table 22 provides a summary of the different types of businesses in the industry.

Table 22 Summary of business types

Business type	Description
Fixed location mill (Quota)	Larger mills with quota licences that are in fixed locations, usually in or near to towns. These are generally integrated operations that conduct a significant proportion of their own harvesting operations and transport to the mill.
Mobile mill (Quota)	Mobile operations that source quota and ex quota quality logs. These operations are transported to the timber source to mill timber on site. Most of these operations also source residue material.
Mobile operations (Ex-quota)	Mobile operations that source ex-quota quality logs. Most of these operations also source residue material.
Mobile operations (Residue)	Mobile businesses that source residue materials, predominantly for firewood.

Product types

The river red gum industry has a high utilisation rate of felled log. The product mix varies as product supply contracts change (reflecting changes in demand) and with variations in the quality of the available resource.

Metropolitan and regional Victoria are the major markets for river red gum products. Adelaide and regional South Australia, Sydney and Canberra are also destinations for some products. A small amount of river red gum product is exported. Table 23 provides a description of the different river red gum products and the key markets.

Table 23 Description of river red gum products

Product	Description	Key markets
Furniture grade	Timbers for furniture and joinery	Melbourne
Veneers	Timbers for furniture and joinery	Melbourne
Weatherboards	Timbers for housing construction	Melbourne
Decking timbers	Timbers for housing construction	Melbourne
Sleepers	Replacement timbers for railways	Victoria and South Australia
Crossings timbers	Timbers for bridges and marine construction (both new and replacement)	Victoria and South Australia
Garden Timbers	Landscape sleepers	National, Victoria and South Australia
Firewood	Split firewood	Melbourne, regional Victoria, Canberra, South Australia and Local
Wood chips	Residues used for landscaping	Local markets, Victoria and South Australia
Mulch	Residues used for landscaping	Melbourne, regional Victoria, South Australia
Saw dust	Residues for feedlots	Riverina

Red gum timber prepared for furniture production

Future potential for the industry is to apply technologies to increase recovery and utilisation and increase the level value adding. Examples of this include new technologies for veneer and finger jointing short sections of timber into high value and strength products as well as kiln dried dressed products such as flooring decking and furniture.

Surveyed businesses

To inform this assessment, detailed surveys are being conducted with all operations that hold licences to access timber on public land. In this first stage, all quota licence holders as

well as two large ex-quota or residue operators that were identified as being reliant on forests on public land have been surveyed.

A total of eight businesses were surveyed. It is estimated that these businesses account for 100 percent of the total quota, 83 percent of ex-quota allocation and 50 percent of the total residue base allocation on public land. NSW Forest has identified an additional 27 businesses that are licensed to source timber from public land. A sample of these additional licence holders will be surveyed in next stage of the assessment to finalise total employment numbers and revenue directly dependent on timber from public lands.

A summary of the key indicators of the operations surveyed and their reliance on access to resources on public land is provided in Table 24.

Table 24 Summary of businesses surveyed

Summary indicators	Survey Result
Number of businesses	8
Number of fixed mills	5
Number of mobile operations	2
Average reliance on State Forest for resource	78%
Median reliance on State Forest for resources	93%
Combined reported annual revenue	$32,326,450
Average reported annual revenue	$4,040,806
Average revenue / unit throughput	$90
Median revenue / unit throughput	$102

The estimated annual volume and range of unit prices for each product for surveyed businesses is provided in Table 25.

Table 25 Estimated volume and range of unit prices (derived from surveyed businesses)

Product	Estimated of total volume	Range of unit prices ($) per m^3 unless stated
Furniture grade	10.0%	$2,000-2,500
Veneers	1.0%	$2,000-2,500
Weatherboards	1.0%	$2,000
Decking timbers (green)	2.5%	$550
Sleepers	25.0%	$600-700
Crossings timbers	2.5%	$1,500 - $1,800
Garden Timbers	12.0%	$390 - $430
Firewood	35.0%	$100 - $120 / tonne
Wood chips	7.5%	$65-100 / tonne
Mulch	1.0%	$30
Saw dust	2.5%	$35

Employment

There are a range of published estimates of employment in the timber industry in the assessment region. Each of these estimates has been developed using different methodologies, scales and data sources. A summary of these previous estimates is provided in Table 26.

Table 26 Published estimates of employment

Source	Estimate	Notes
GHD (Forests NSW, 2009a)	183	Based on assessment of ABS 2006 data and consultation with experts.
NSW Forest Products Association	537	Includes businesses reliant on resource sourced from public & private land.

Table 27 shows the breakdown of employment for each of the surveyed businesses.

Table 27 Breakdown of employment of surveyed businesses by category

Employment category	Number of positions	Full Time Equivalents
Management	17	14.5
Administration	18	15.5
Bush Operations	36	36
Milling	74	73
Other	18	18
Sub total Milling Business (surveyed)	**163**	**157**
Contractors (surveyed)		17
Forests NSW		30
Total		**204***

* This does not represent the total employed in the red gum industry on public land as our survey is incomplete. To date this survey includes 100% of the total quota 83% of ex quota allocation, and 50% of the total residue allocation on public land. These employment numbers have been verified by the business owners.

Assets

The assets of the businesses surveyed have been categorised as shown in Table 28. The valuation of assets is highly variable, as data included a mix of depreciation value, replacement value and insured value. Many businesses do not place a value on their quota so the total asset figure does not include their quota asset (which can be sold). Total assets were estimated at $46,775,000.

Table 28 Breakdown of assets by category

Asset type	Estimated value
Property	$12,135,000
Buildings	$11,090,000
Machinery and Processing Equipment	$14,203,500
Mobile Plant	$9,346,500
Total	**$46,775,000**

3.6.3 Other forest reliant primary industries

Grazing

Grazing in state forests has occurred for more than 150 years. The forests provide palatable species and water sources that are suitable for cattle production. The forests provide a feed source to fill the winter feed gap.

Grazing is licensed by Forests NSW and guided by Forests NSW Grazing Strategy. Graziers are issued either short term grazing permits, or annual occupational permits. Occupational permits describe the area which is able to be grazed, the time of the year when grazing is permitted, and management activities to be conducted such as weed and pest animal control. Forests NSW estimate that the current occupation permits for grazing cover some 115,000 ha. This supports an estimated 7000 head of cattle (Forests NSW, 2008).

Grazing also impacts upon the ecological value of the red gum forests. For instance see Jansen and Robertson (2001a), Jansen and Robertson (2001b) and Jansen and Healey (2003) for impacts of grazing upon riparian habitats, riparian bird and frog communities.

Apiary

State forests are a valued resource for the Apiary industry. The forests contain species that are sought after for honey production. In addition they provide rehabilitation areas for hives – to enable apiarists to rebuild the strength and health of hives. Due to the availability of water, the forests are useful drought reserves for the apiary industry.

There are an estimated 600 sites in state forests in the Riverina region that are suited for bee keeping. Forests NSW issues permits that allow an apiarist to set down hives in a defined area. The permit area is generally a 1.5 x 1.5 kilometre square. In 2005/06 Forests NSW issued 461 Occupation Permits.

3.6.4 Recreation and tourism

The State Forests of the Riverina region have a long history of use by surrounding communities and visitors to the region. Recreational values are connected to the river, beaches, trails and natural surroundings of the region. The most popular sites are the white sandy beaches found at the bends of the Murray River. Many generations of families have spent time experiencing and enjoying visits to these areas and participating in the activities they support.

The Murray, Murrumbidgee, Edward and Lachlan rivers provide a focus point for many outdoor activities, while the adjoining State Forests provide access and complementary

facilities. Good access, a favourable climate and close proximity to urban areas have ensured the region's continued popularity for recreational and tourism activities associated with the iconic red gums, rivers and wetlands.

Recreation contributes greatly to individuals' quality of life, happiness, health and overall well being. For many people a short visit or a camping trip in to the red gum forests is a planned activity to relax, unwind, get back in touch with nature and escape the demands of the modern world. During the NRC's tours of the area, it was evident that visitors to the region embrace the feeling of freedom that comes with getting away.

This section provides an overview of the importance of all tourism in the region and each town of interest. It also describes the activities that are routinely undertaken in the state forests of the Riverina region. Many of these activities contribute positively to regional and local economies.

Importance of tourism in the region

Tourism data is collated on a regional basis. Collectively, the Murray[10], Riverina[11] and Outback[12] tourism regions cover the area of this assessment. The total annual tourism expenditure for these three regions in the year ending March 2009 was $1.197 billion (Tourism NSW, 2009, Regional Tourism Statistics).

Holidays or leisure were the most common reason given for domestic overnight visits to the regions; namely 50 percent for the Murray, 49 percent for the Outback and 31.5 percent for the Riverina. In the Murray and the Outback, the most popular accommodation option was "Caravan or camping near road or on private property". This reflects the holiday or leisure purpose of the visits.

Domestic overnight visitor numbers in the regions have been on a trend downwards across all three regions since 2005. The Murray has seen a 31 percent decline in domestic overnight visitor numbers and the Riverina 28.5 percent, while the Outback experienced only a 3 percent decline.

Table 29 provides an overview of the value of total tourism in the Murray, Riverina and Outback regions for the year ending March 2009. The three regions combined account for approximately 5 percent of the total value of tourism to NSW.

10 The Murray region comprises the local government areas of Albury; Berrigan; Corowa Shire; Greater Hume Shire; Jerilderie; Murray; Urana; and Wakool.

11 The Riverina tourism region covers the local government areas of Bland; Carrathool; Conargo; Coolamon; Cootamundra; Deniliquin; Griffith; Gundagai; Hay; Junee; Leeton; Lockhart; Murrumbidgee; Narrandera Temora; and Wagga Wagga.

12 The Outback Region covers the local government areas of Balranald; Bogan; Bourke; Brewarrina; Broken Hill; Central Darling; Cobar; Unincorporated Far West; Walgett; and Wentworth.

Table 29 Overview of total tourism in the region (Tourism Research Australia, 2009)

Region	Expenditure $	'000 total visitors	'000 visitor nights	% of visitors to regional NSW
Murray	418	1,555	2,365	4.2%
Riverina	523	2,019	2,014	5.1%
Outback	256	702	1,660	2.8%

Notes: Includes major regional centres such as Albury and Wagga Wagga. Expenditure values exclude airfares and long distance transport costs.

Table 30 provides an overview of the source of visitors for each region. Anecdotal evidence from the NRC's tours of the region, indicated that the areas in the assessment that are in the Riverina and Outback regions also rely upon a majority of Victorian visitors.

Table 30 Overview of the visitor source for each region (Tourism Research Australia, 2009)

Region	Riverina Region	Murray Region	Outback
Visitors from Victoria	25%	62%	22%
Visitors from regional NSW	42%	19%	39%
Visitors from Sydney	20%	8%	13%

Unfortunately, tourism data specific to the NSW river red gum forests in either State Forests or National Parks is very limited. However, Forests NSW estimate that the river red gum forests receive an estimated 500,000 visitor days per year (Forests NSW, ESFM, 2008), bringing expenditure into local and regional areas (Table 31).

Table 31 Summary of other key tourism statistics in each region (Tourism NSW, 2009a,b,c)

Key statistics	Riverina Region	Murray Region	Outback
% total regional NSW tourism visitors	4.8%	4.3%	2.6%
% total regional NSW tourism visitor nights	3.5%	4.3%	2.6%
% domestic overnight visitors staying in a 'caravan park or commercial camping ground'	8.3%	14.0%	25.3%
% domestic overnight visitors staying in a caravan or camping near road or private property	4.9%	26.2%	14.5%
Expenditure domestic overnight travel	$295 million	$265 million	$229 million
Average spend on domestic overnight travel per night	$147	$112	$138
Number of domestic day trip visitors	1.162 million	852,000	223,000
Expenditure by of domestic day trips	$210 million	$145 million	$21 million
Average spend on domestic day trip	$181	$171	$94

Visitors to State Forests engage in a wide range of activities including organised events and tours and individual activities. Entry to the State Forests is free for most individual visitors while groups are required to take out special purposes permits to undertake organised activities (Forests NSW 2005).

Tourism and recreation activities on public land

Camping

Campfires and barbecues are some of the most traditional aspects of recreation in the Riverina State Forests. The popularity of camping is ensured by the facts that it is: free in State Forests; people are not restricted to designated spots; they can camp in large groups; they can have campfires in some locations (outside of fire ban periods); and they are not required to notify anyone or use booking systems. Anecdotal evidence from the NRC's tours of the region, indicate that campers enjoy the freedom of dispersed camping in State Forests. Dispersed camping is defined as camping along the river frontage accessible by vehicle, at a site of one's choosing, and where there are generally no facilities i.e. toilets, drinking water or fireplaces.

Another appeal of camping in state forests is that holidaymakers are permitted to bring their dogs (although restrictions may apply in some areas). This is an important value as many pet owners make decisions about where they holiday based on whether their dogs are permitted. People living in the region also enjoy walking their dogs in the area, taking the opportunity to enjoy the scenery while they do so.

A number of camp sites are provided in the region with facilities such as bush toilets, tables, water supply and fireplaces. Forests NSW maintain these sites and in particular trim trees where there are overhanging branches. The open and flat terrain of the Riverina Region also encourages a high degree of dispersed camping.

The region also offers something for those seeking a more remote camping experience, where camp sites are located away from tracks, requiring users to arrive on foot or by boat. People participate in numerous activities whilst camping such as swimming, picnics, day walks, drinking, touring and travelling local towns.

While camping in state forests is popular, campfires do pose environmental risks. In popular camping areas, firewood collection (both licensed and illegal) can put pressure on the woody debris resource, which provides habitat for flora and fauna (Forests NSW, 2009). Unattended and abandoned campfires and cigarettes can also pose a significant bushfire danger (VEAC 2006, Forests NSW, 2009).

The volume of litter left behind by campers can be significant, both at designated garbage collection points and dispersed throughout the camp sites.

Water based activities

Boating, water-skiing and wake-boarding are common recreational activities in the Riverina Region and are supported by a small number of boat ramps (largely confined to the Murray Irrigation Area).

Canoeing and kayaking are popular ways to access shallow areas and provides good transport for bird-watching without polluting the rivers. Houseboats are another popular

way to relax and explore the region and can be hired out of most major centres along the Murray River.

Each of these activities can have cumulative impacts on the environment. Engine based activities create noise pollution, disturbing local fauna, as well as other visitors in the area. Water based activities can also impact on the health of the river, for example by disturbing sediment in the rivers, damaging river bank vegetation and contributing to bank erosion (Forest NSW, 2009).

Recreational fishing is an increasingly popular activity, appealing to individuals and families alike. The rivers in the region are home to popular native species such as freshwater crayfish, golden perch and Murray cod and introduced species such as redfin, trout and European carp. Recreational fishers may access the river by 4WD, boat or from the river bank.

A NSW Fishing licence is required to fish in the Murray River. In addition, there are closed seasons and size and bag limits for many species, including the Murray cod. There are many fishing clubs who organise social fishing competitions and some clubs actively stock the rivers with native fish, in addition to fish stocking programs run by the Department of Industry and Investment.

Fishing is a popular recreational activity
Photo: Gekko Images

Vehicle based activities

The extensive network of roads and trails in the State Forests allow for active forms of recreation and tourism. Car touring, cycling, mountain biking, horse riding and hiking are all popular pursuits. There are a number of designated forest drives in the river red gum forests for use by four wheel drives and trail bikes (Forests NSW 2004). These trails are also shared by walkers and horse riders.

Four wheel driving is a popular activity that gives participants access to remote areas of the State Forests of the Riverina bioregion. The extensive network of roads and fire trails in the area provides diverse opportunities both for short trips and extended touring. Four wheel driving is often associated with other outdoor pursuits such as fishing and dispersed vehicle-based camping. As with many pursuits, the negligence of some can impact on the

natural environment as their four wheel driving contributes to soil erosion and compaction, dust generation, and vegetation degradation (Forests NSW, 2009).

Many people enjoy motor bike and trail riding as it gives them a way to see areas that many other people do not get to see. Motorbike riding can lead to environmental damage such as noise pollution, weed transmission, disturbance of Aboriginal heritage sites and vegetation degradation (VEAC, 2006; Forests NSW, 2009). Mountain bike riding also fits in well with other activities such as camping.

Hunting

Recreational hunting of feral pigs and goats, foxes, rabbits and hares, wild deer and wild dogs is permitted in the Riverina State Forests under the *Game and Feral Animal Control Act 2002*. Hunting for game species such as some species of deer, ducks and quail is also permitted but during open seasons only.

People generally hunt feral animals to be in the outdoors, to socialise, to help reduce feral animal species, for food in some cases or in pursuit of trophies such as skins. Hunters will generally shoot opportunistically at whichever feral species is found, rather than setting out to hunt a particular species (Game Council of NSW 2009).

People wishing to hunt feral animals in State forests must hold a current Restricted NSW Game Hunting Licence (R-Licence) issued by the Game Council NSW. The R-Licence is only available to hunters who have completed the mandatory training and accreditation program as members of Game Council approved hunting organisations. They must also have written permission from the Game Council of NSW, obtained through a tightly controlled booking system (Game Council of NSW 2009). Hunting is not permitted in national parks.

Walking activities

Bushwalking is a popular activity in the state forests in the Riverina region, with both day walks and extended and overnight trips available. Many of the walking tracks, board walks and bird-viewing hides are within easy access to main towns.

Walking trails wind their way along the creeks and rivers and are one of the many recreational facilities provided within the Riverina bioregion. Forests NSW also maintains map boards, signposting and interpretative signage providing walkers with an opportunity to learn about the birdlife, wetlands and red gum forests. (Forests, 2008) Walkers in the Riverina State Forests have access to designated walker-only tracks and camps, although they are also permitted to use vehicle tracks and to camp at sites that are accessible by car.

There are a number of Aboriginal walking trails and educational walks in the region. In addition, Forests NSW regional staff members conduct a variety of interpretive tours for local and visiting industry, naturalist and academic groups (Forests, 2008).

Nature based activities

The State Forests of the Riverina provide for a number of passive recreational activities such as picnicking, painting, photography and bird-watching.

The Riverina State Forests offer a number of habitats for birds giving visitors the opportunity to observe many different bird species. There are also a number of purpose-built bird hides in the region. Cockatoos, robins, parrots and kingfishers are some of the

birds commonly found in the forests. The lakes and lagoons in the wetland areas also support populations of waterbirds including swans, pelicans, ibis, cormorants, spoonbills and many types of duck.

There are a number of Tourist Information centres to provide groups and individuals with the opportunity to learn more about the surrounding area including heritage and ecology of the region.

Bird hide at Millewa State Forest
Photo: Industry & Investment NSW

Organised Events

Major tourism events and organised activities are held in the State Forests every year, attracting tens of thousands of visitors. These events are authorised by special purpose permits.

Events range from car rallies, festivals, fishing tournaments, boat races and athletic events through to more unusual pursuits such as sled dog racing, rogaining and carriage driving.

The Peaches & Cream Festival is held biennially around the second or third weekend in January. It is Australia's oldest running festival, with a town parade and music festival located at Thompson's Beach, the largest inland beach on the Murray River.

The "Southern 80" is an annual high-speed 80km ski race held on the Murray River in the border towns of Echuca (Vic) and Moama (NSW) in February of each year. The Southern 80 Ski Race has been going for over 40 years and attracts over 400 competitors and over 40,000 spectators (Moama Water Sports Club website), many of whom camp along the river.

Tourism in National Parks

Yanga National Park

The park's natural features and terrain provide opportunities for many different recreation activities including walking, cycling, drive tours, wildlife observation and canoeing.

The park has 13 caravan sites and 26 camping sites. Significant investment has been channelled in to developing quality tourist interpretation centres at the Yanga homestead and woolshed. These centres depict the park's natural and cultural values.

Visitation to Yanga National Park is projected to reach 50,000 visits per annum (DECCW 2009 *Tourism Potential of National Parks in NSW Riverina Red Gum Forests*). During the NRC's tour the local community and industry queried the size of this projection. The reasons for their disagreement centred on the remoteness of the region, the number of national parks closer to major population centres and the perception that the regional tourist market is already well serviced.

Yanga Homestead Interpretation Centre

3.7 Carbon sequestration values

The significance of forests for carbon sequestration, and the adverse consequences of deforestation, are now recognised internationally (IPCC 2007) and in the Australian context (Garnaut 2008). However, the implications for management of standing forests remain a matter of research and debate, particularly where objectives other than simply carbon sequestration are sought (Keith et al 2009, Garnaut 2008, Miles and Kapos 2008). Notwithstanding some preliminary studies, knowledge of the implications of alternative forest management regimes, and of the life cycle analysis of carbon in forest products, are generally lacking. This is also the case for river red gum forests, although Forests NSW (pers comm.) has conducted a preliminary analysis of an overall carbon budget, and there have been analyses of specific products such as sleepers (Energy Strategies 2007).

A comprehensive assessment of the carbon sequestration values of the red gum forests would require analysis of the:

- carbon stocks and fluxes of forests at different stages of development, and under the environmental conditions anticipated for the future

- impacts of different management regimes on these stocks and fluxes, and
- life cycle of wood products originating from the forests.

The monetary value associated with this carbon sequestration will also depend on the role accorded native forests in any Australian carbon pollution reduction scheme and in any post-2012 international climate regime.

Given the lack of available data and the limited time available for this NRC forest assessment, the NRC will not be in a position to fully assess the carbon sequestration values of the river red gum forests or the wood products originating from them. However, the NRC will seek to assemble as relevant a set of data as possible about the carbon sequestration values of the river red gum forests to inform its assessment.

4 Trajectory of climate change

4.1 Long term climate change

In 2007 the Intergovernmental Panel on Climate Change (IPCC) released their fourth assessment report (IPCC, 2007), concluding that:

- warming of the climate system is unequivocal
- humans are very likely to be causing most of the warming that has been experienced since 1950
- it is very likely that changes in the global climate system will continue well into the future, and that they will be larger than those seen in the recent past.

These changes have the potential to have a major impact on human and natural systems throughout the world including Australia (www.climatechangeinaustralia.gov.au).

The South Eastern Australian Climate Initiative (SEACI) is a three year, $7 million research program investigating the causes and impacts of climate change and climate variability across south eastern Australia. Launched in 2006, SEACI is a partnership involving government and industry, and is managed by the Murray-Darling Basin Authority. CSIRO and the Bureau of Meteorology are research partners.

The SEACI has stated that there is growing evidence that lower rainfall and reduced runoff in the south-east of Australia is linked to global warming (SEACI, Media release, 1 May 2008). Predictions are for warmer temperatures and reduced rainfall and runoff. Figure 26 shows the forecast temperature change across NSW, including the Riverina bioregion, and Figure 27 shows forecast changes in rainfall.

DECCW and the University of NSW have prepared a regional assessment of the global climate modelling for NSW. This work has identified drying in the Riverina and loss of snowpack in the Australian Alps as some of the significant regional changes for NSW. This drying is likely to be outside historical experience in this region. In particular, the work identified significant disruption to regular winter rains and snowfalls in the region, reduced soil moisture and changes in catchment hydrology likely to lead to significant changes in flows.

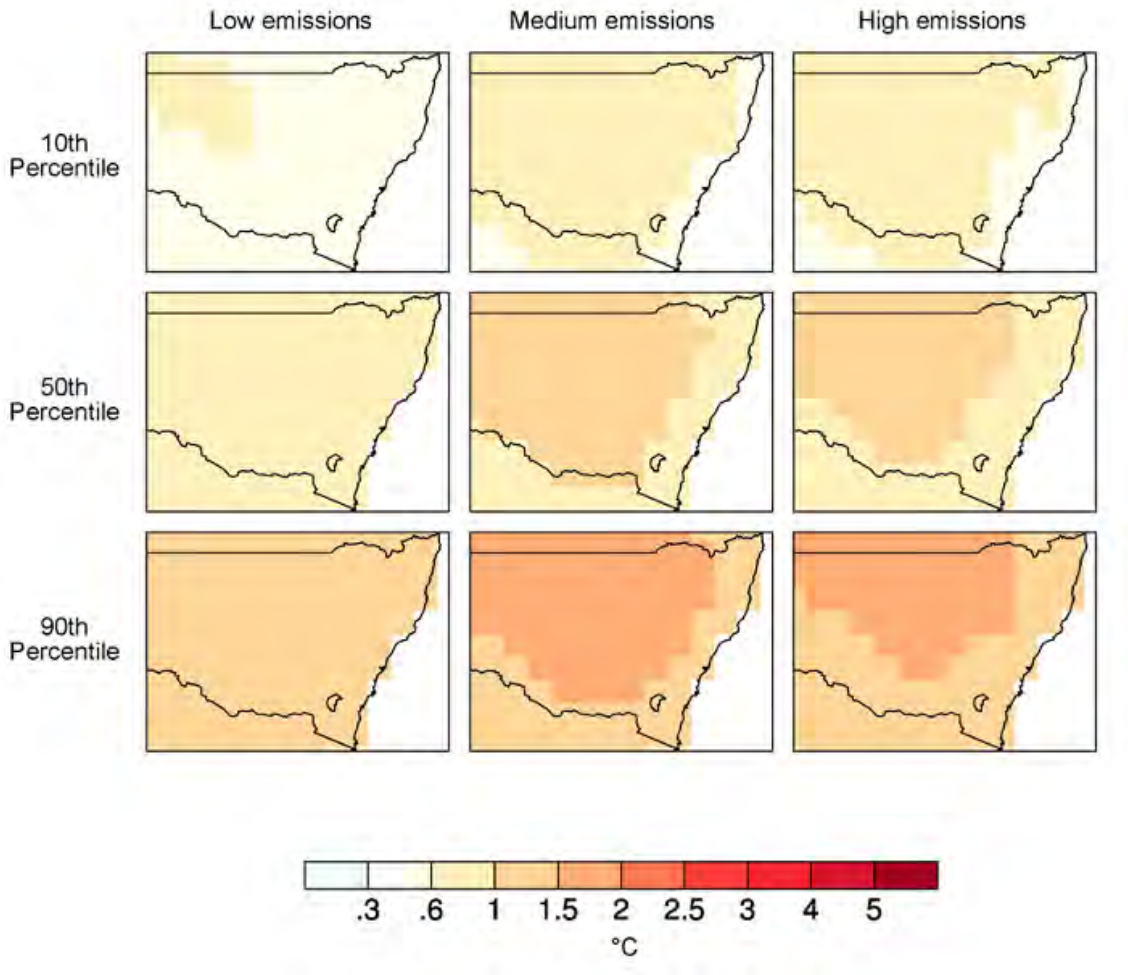

Figure 26 Forecast NSW/ACT temperature change 2030 summer. ***Emissions scenarios are from IPCC Special Report on Emission Scenarios*** (www.climatechangeinaustralia.gov.au)

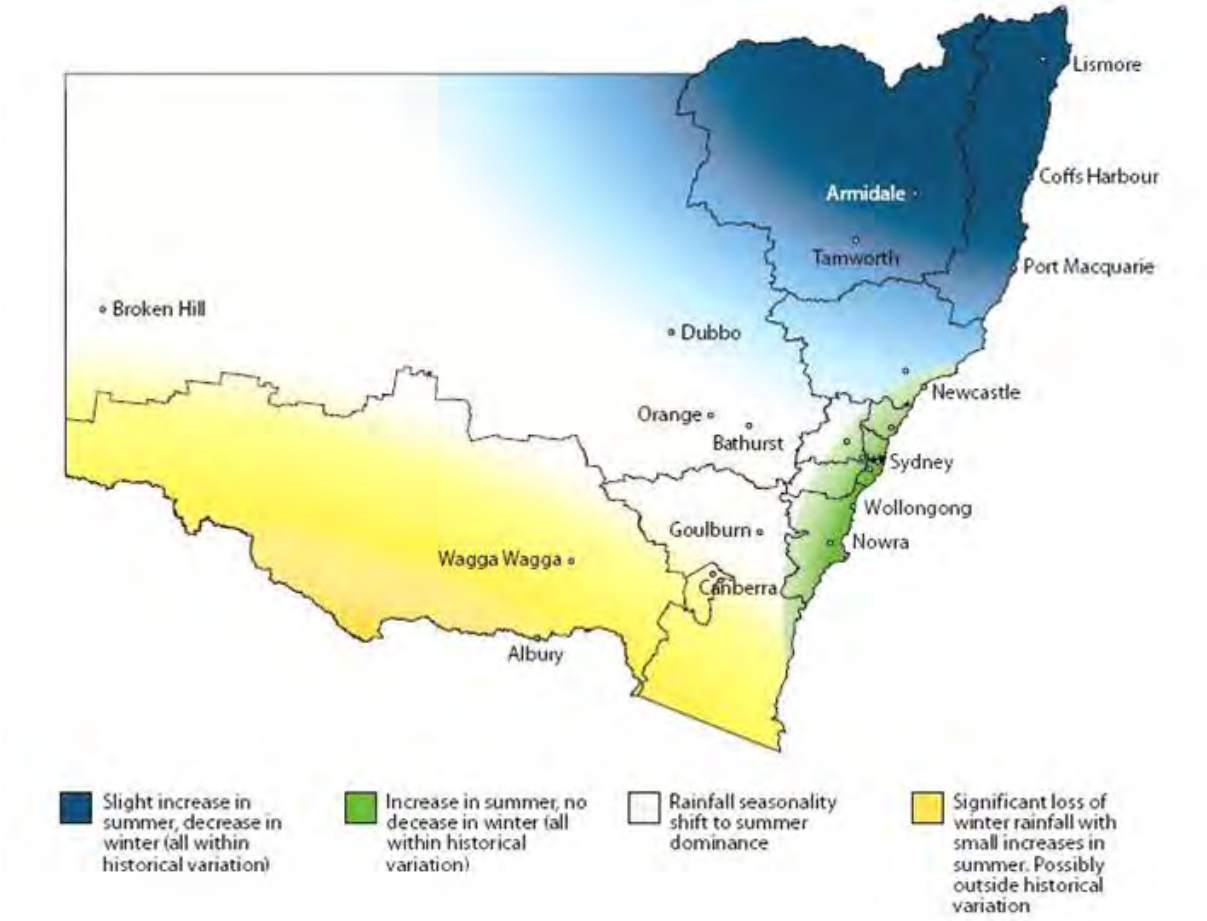

Figure 27 Forecast rainfall changes (DECCW, 2009)

The IPCC has developed a range of emission scenarios to project future climate change. However, it is difficult to make plans based on such a large variation in the projections (for instance, temperature in south-eastern Australia is projected to rise by 1.1 – 6.4°C by 2100 (IPCC 2007).

The rate of global emissions growth since 2000 has been greater than for the most fossil-fuel intensive of the IPCC's emission scenarios. The Garnaut Climate Change Review concluded that all of the IPCC's emissions scenarios may underestimate the future growth in emissions in the early 21st century (Garnaut, 2008). Analysis of global mean surface temperatures also shows that the rate of warming is in the upper range of the IPCC's climate projections.

The NRC used the high emission scenarios in the climate change considerations in this report as the most accurate projections of the future. DECCW and the University of NSW Climate Centre have prepared climate change information for the A2 scenario, which is towards the upper range of available scenarios and was based on current global emissions growth trends and the latest climate observations. Other high-range scenarios were used for projections of run-off and stream-flow (A1B), as these projections had already been undertaken for other studies.

4.2 Recent rainfall and river inflow variability

As can be seen in Figure 28, rainfall over the past eight years throughout the Riverina region is either 'very much below average' or the 'lowest on record' (www.bom.gov.au).

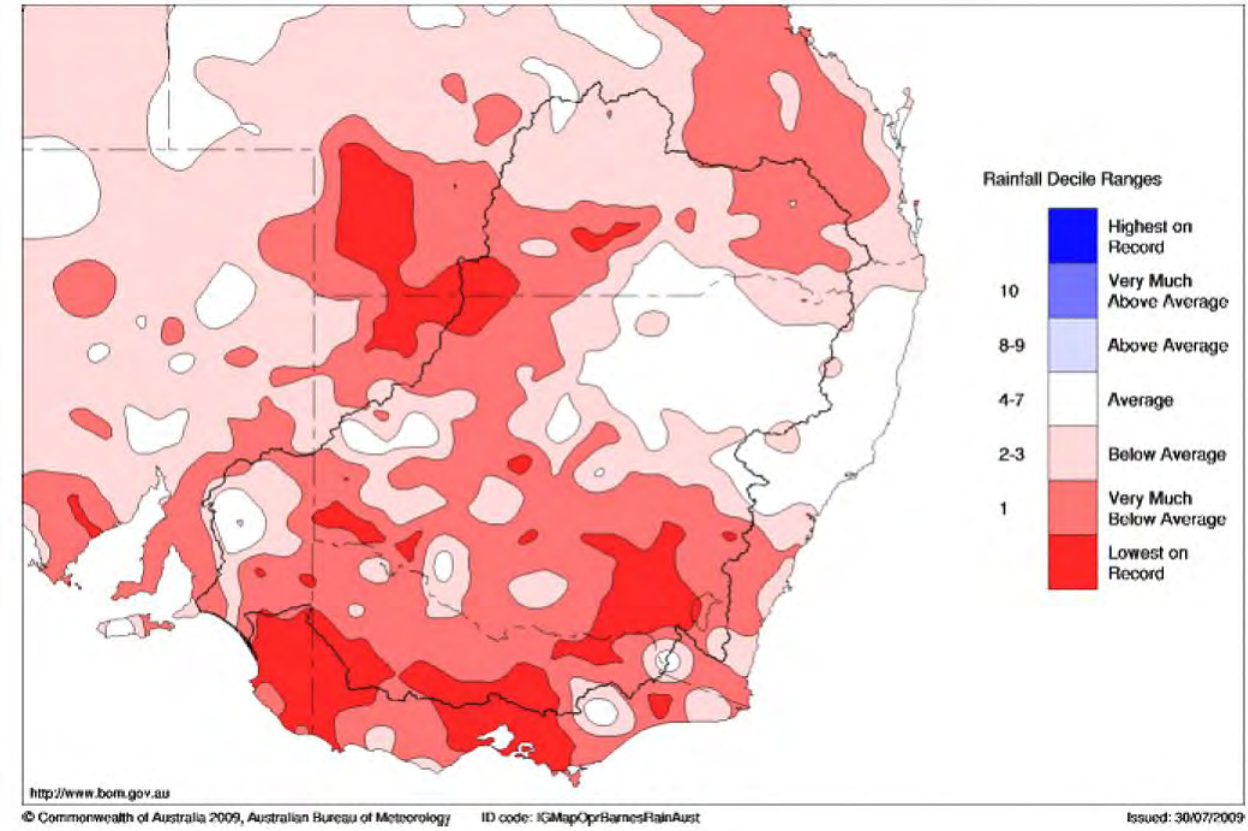

Figure 28 Rainfall deciles for the Murray Darling Basin, for 8 years from 1/07/01 to 30/06/09 (www.bom.gov.au)

This extended low rainfall has had significant impacts on catchment runoff and consequently river inflows. Many government agencies are have been working to identify whether the rainfall and runoff patterns being observed are part of an extended drought or a shift to a lower average pattern, also known as a 'step change'.

4.3 Natural climate variability

4.3.1 Inter-decadal shifts

NSW has a very variable climate. Even if the influence of climate change were completely discounted, the NSW climate can make inter-decadal shifts in both temperature and rainfall that may last 40 or 50 years. As can be seen from Figure 29, average rainfall measurements last century indicate that the period from 1890-1950 was considerably drier than the period 1950-1980.

Between 1951 and 2000 high rainfall resulted in average surface water availability in the Murray Darling of 16,500 GL per annum for the Murray Darling Basin. By comparison, the 50 year period between Federation and 1950 water availability was only 13,500 GL per annum. In the past decade we have seen the weather patterns shift, with a dramatic decline

in runoff. The average annual inflow between 1998 and 2005 of 10,500GL is similar to the 10,300GL experienced in the Federation drought of 1897–1904, and 10,550GL in the devastating droughts of 1938–1945.

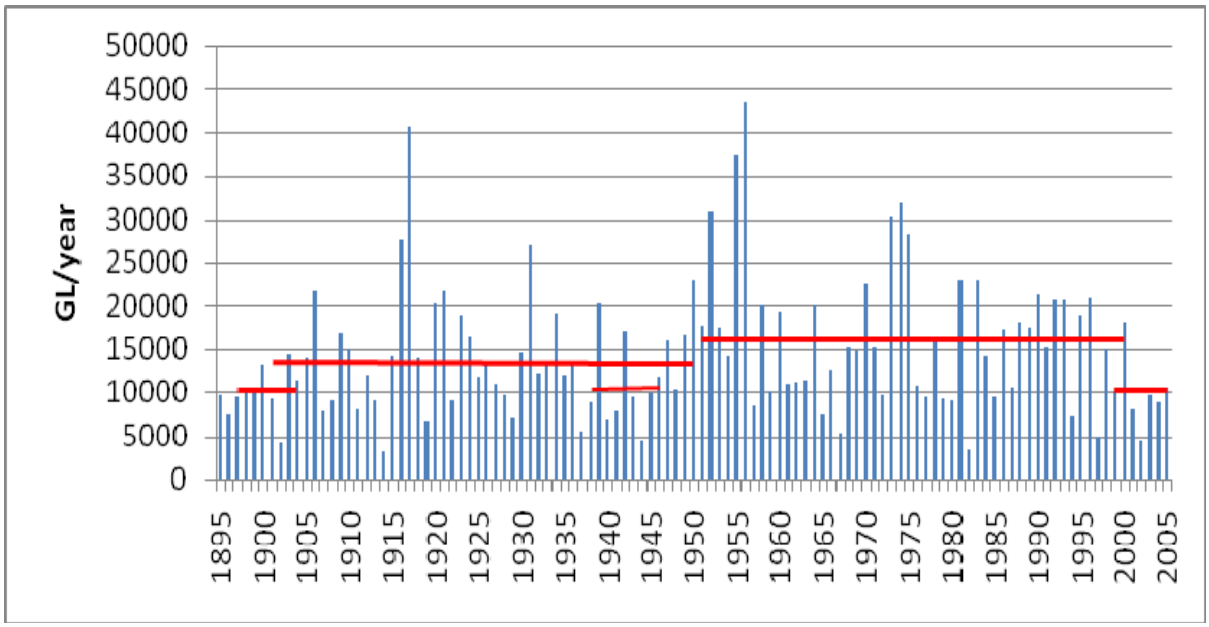

Figure 29 Murray River inflows 1895 – 2005 (Wentworth Group of Concerned Scientists, 2008)[13]

When examining historical changes to the NSW climate, a cool or even exceptionally hot month or year is less important than a multi-decadal trend. Current climate trends indicate an accelerating increase in average annual temperature in NSW. During the 1950s to 1980s, the annual average temperature rise was around 0.1°C per decade; since 1990 it has been about 0.5°C per decade. For NSW as a whole, 2007 was the warmest year on record for mean temperatures (average of maximum and minimum) and 2005 the third warmest. All years from 1997 to 2007 were warmer than average, an unprecedented sequence in the historical records. Since the turn of this century, all years have recorded an annual average mean temperature of more than 0.5°C warmer than the climatological average, with 2007 a record 1.1°C above average.

4.3.2 The ENSO Cycle

The term El Niño refers to the extensive warming of the central and eastern tropical Pacific Ocean which leads to a major shift in weather patterns across the Pacific. This occurs every three to eight years and is associated with drier conditions in eastern Australia. El Niño Southern Oscillation (ENSO) is the term used to describe the oscillation between the El Niño and La Niña (or opposite) phases.

In the eastern Pacific, the northward flowing Humboldt current brings cooler water from the Southern Ocean to the tropics. Furthermore, along the equator, strong east to south-easterly trade winds cause the ocean currents in the eastern Pacific to draw water from the deeper

[13] Data was estimated by the modelling of historic climate and current development for the period 1895 to 2005.

ocean towards the surface, helping to keep the surface cool. Driven by the trade winds the cold water then flows westward along the equator and is heated by the tropical sun. This means that under 'normal' conditions the western tropical Pacific is 8 – 10°C warmer than the eastern tropical Pacific. The warmth of the western Pacific drives convection and is associated with cloudiness and rainfall.

However, during El Niño years, the trade winds weaken and the central and eastern tropical Pacific warm. This change in ocean temperature sees a shift in cloudiness and rainfall from the western to the central tropical Pacific Ocean, away from the Australian landmass. This westward shift of the area of active convection usually results in below average rainfall across eastern Australia. Conversely, during La Niña phases, the trade winds are enhanced, transporting additional moisture to the western Pacific region. Eastern Australia usually receives above average rainfall during these events.

Climate change needs to be seen in the context of climate variability and may contribute to both a change in average conditions and an increase in variability. These changes in turn can affect catchment hydrology more significantly than the projected changes in average conditions might indicate.

The MDBA issues a monthly 'Drought Update'. Issue 20, August 2009 (www.mdba.gov.au) of the drought update stated the following:

> *The two month total for June – July is tracking as the 11th driest in 118 years of records. Initial 2009-10 allocations announced by the States for Murray River irrigators are zero or very low. The prospect for improved allocations this season remains highly dependent on future rainfall and system inflows. For south-eastern Australia, the latest rainfall outlook from the Bureau of Meteorology shows a moderate shift towards drier conditions across the western half of the Murray-Darling Basin. An El Niño event looks to be developing across the Pacific, and current predictions indicate that it will reach peak intensity late in the year. El Niño events are usually (but not always) associated with below average rainfall in the second half of the year across large parts of southern and inland eastern Australia.* ***Overall; despite the small improvement in July system inflows, the current outlook for the 2009-10 water year remains poor, and is similar to the previous two years.***

Figure 30 shows the dramatic decrease in average inflows to the Murray system in recent years compared with the long term average.

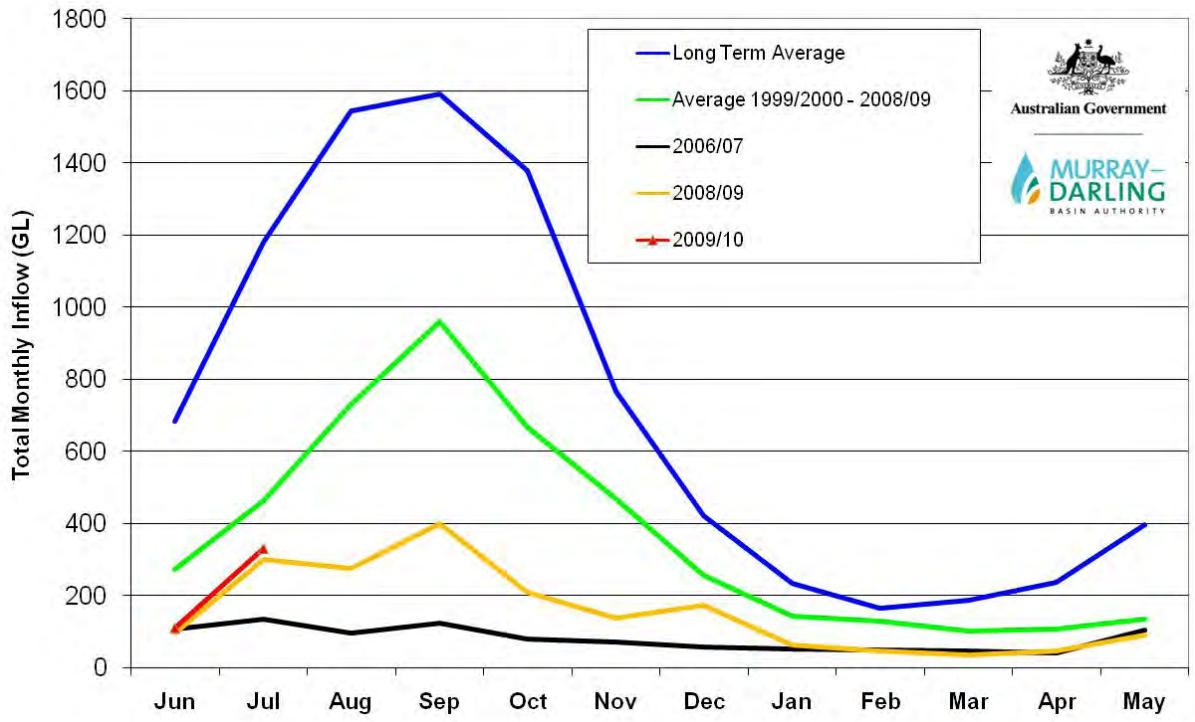

Figure 30 **Murray system inflows, excluding Snowy and Menindee inflows (www.mdba.gov.au)**

4.4 Future water availability

4.4.1 CSIRO Murray Darling Basin Sustainable Yields Project

A considerable amount of work has been completed in recent years assessing likely water availability under future climate scenarios. The most recent and comprehensive of these assessments is the CSIRO's Murray Darling Basin Sustainable Yields Project completed in November 2008. The Sustainable Yields Project (CSIRO, 2008) is the world's largest basin-scale investigation of the impacts on water resources of:

- catchment development
- changing groundwater extraction
- climate variability
- climate change.

The findings of the Sustainable Yield Project (CSIRO, 2008) are presented as 18 regions within the basin (Figure 31). The following are some of the key findings from the Sustainable Yields Project relevant to future water availability in the Riverina region:

- A very substantial decline in surface water availability is possible in the south of the Murray Darling Basin.
- In volumetric terms, the majority of the impact of climate change would be borne by the environment rather than by consumptive water users.

The Murray, Murrumbidgee and Lachlan regions are also of relevance to the Riverina region. The findings for the Murray region are discussed briefly below.

For the Murray region, average surface water availability is 11,162 GL/year. If the recent (1997 to 2006) climate were to persist (that is, a step change), average surface water availability for the Murray region would fall by 30percent, average diversions in the Murray region would fall by 13percent and end-of-system flows would fall by 50percent. The best estimate (median) of climate change by 2030 is less severe than the recent past. Under this 2030 climate, average surface water availability for the Murray region would fall by 14 percent, average diversions in the Murray region would fall by 4 percent and end-of-system flows would fall by 24 percent.

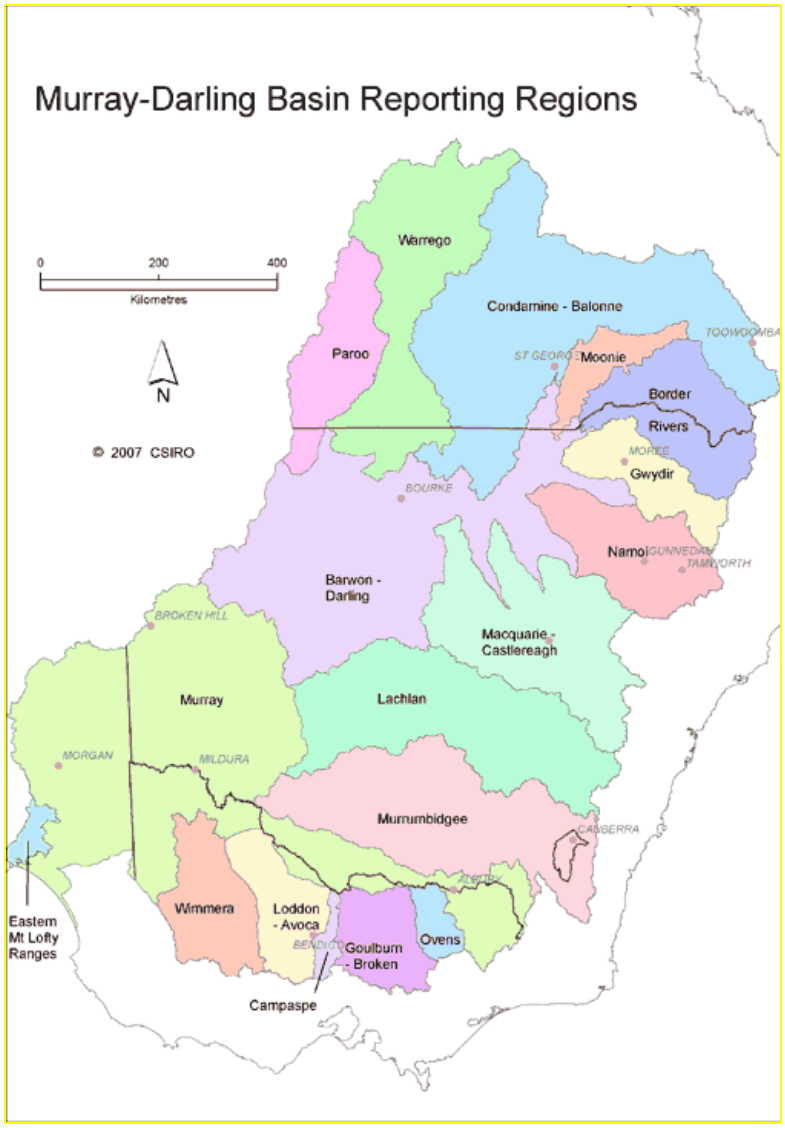

Figure 31 Assessment and reporting regions within the Murray Darling Basin (CSIRO, 2008)

A range of other factors were also assessed as part of the CSIRO work including groundwater extractions, the expansion of commercial forestry plantations and increases in the total capacity of farm dams. The assessment found:

- Current groundwater use is unsustainable in seven of the twenty high-use groundwater areas in the basin and will lead to major drawdowns in groundwater levels in the absence of management intervention. It should be noted that parts of the Lower Lachlan, the Upper Lachlan, the Mid-Murrumbidgee and the Upper Murray are all listed as unsustainable.

- 'Best estimate' projections of commercial forestry plantations and farm dams indicate only very minor impacts on the total runoff reaching rivers across the basin.

4.4.2 Groundwater – surface water interaction

There is limited detailed understanding of the complex interactions between surface water and groundwater in the Riverina bioregion. This is an important parameter in determining vegetation responses to a range of watering regimes, however methods for predicting responses may be limited (MDBA, pers comm). This is currently being investigated and assessed as part of the development of the Basin Plan by the MDBA.

A conceptual understanding of groundwater behaviour in the Koondrook-Perricoota Forest was developed by Salient Solutions in 2007/08. These studies found that:

- The hydrogeology of the Forest is poorly known primarily as a result of the lack of data. It is a complex area, and is undergoing dynamic changes as a result of the surrounding irrigation development, the changes in flow frequency in the streams and rivers, and impacts from groundwater extraction to the east and south (Salient Solutions, 2007).
- The water balance of the Koondrook-Perricoota Forest is likely dominated by recharge from overbank river flows (Salient Solutions, 2008).
- There does not appear to be any groundwater discharge directly to the Murray River (Salient Solutions, 2008).

It is expected that this situation would be similar at the Millewa Forest and other sites (MDBA, pers comm). The Sustainable Yields study for the Murray noted that "of the future developments considered, the increases in groundwater extraction would have noticeable impacts on the hydrology of some of the Icon Sites" (CSIRO 2008). This report concluded that the groundwater levels under Barmah-Millewa and Gunbower-Koondrook-Perricoota forests would be expected to fall by up to one metre in addition to the reduction in groundwater level under current levels of groundwater extraction.

4.4.3 The Basin Plan

The MDBA is currently in the process of developing a Basin Plan. The Basin Plan is a strategic plan for the integrated management of the water resources (surface water and groundwater) in the Murray-Darling Basin in a way that promotes the objectives of the *Water Act 2007*, in particular by:

The MDBA released a conceptual framework for the Basin Plan in June 2009 (MDBA, 2009). This proposed the following key elements to the Basin Plan:

- sustainable diversion limits
- environmental watering plan
- water quality and salinity management plan
- water trading rules
- social and economic analysis and implications
- monitoring and evaluation plan.

Sustainable diversion limits will limit the quantity of surface water and groundwater that may be taken from the Basin water resources as a whole, from individual water resource plan areas and particular parts of water resource plan areas within the Basin. These areas will be defined in the Basin Plan and will draw upon current state water resource plan areas.

Sustainable diversion limits will be set by the MDBA using the best available science, and will define the level at which water in the Basin can be taken from a water resource without compromising key environmental assets, key ecosystem functions, key environmental outcomes or the productive base of the water resource. This will vary in different years and will take into account the effects of climate change and variability.

The **environmental watering plan** will "safeguard existing environmental water, plan the recovery of additional water, and coordinate the use of environmental water across the Basin" (MDBA 2009). It is expected that the environmental watering plan will contain, in relation to the Basin:

- environmental objectives for water-dependent ecosystems
- targets to measure progress against these objectives
- a management framework for environmental water
- the methods used to identify key environmental assets requiring water
- the principles and methods which will set the priorities for applying environmental water
- the principles to be applied in environmental watering.

The proposed Basin Plan will be produced by mid-2010, and following statutory consultation and refinement, the first Basin Plan will be released in 2011. Water Resource Plans will be developed for individual water resource plan areas within the Basin once the Basin Plan is in place and as the current state water resource plans expire. This will occur from 2014 to 2024 for NSW, and between 2019 and 2029 in Victoria.

In the interim, future water availability and implications for water-dependent ecosystems across the NSW Riverina are being collated from the best available information/knowledge.

4.4.4 Analysis of impacts to high flow events under climate change

Using the Sustainable Yields Project data (CSIRO, 2008) for Murray River flows at Yarrawonga, a simple statistical analysis was completed for a range of flood flows using the River Analysis Package (eWater CRC, 2007). The River Analysis Package (RAP) assists river and water resource managers to undertake condition assessments, environmental flow planning and river restoration design.

Four flow scenarios were used in the analysis. The scenarios used all mirror the Sustainable Yields Project scenarios:

- Historic (pre 1997) climate without current water resource development extractions
- Historic (pre 1997) climate with current water resource development extractions
- Step change climate with current water resource development extractions
- 2030 climate change with current water resource development extractions.

A range of flood flows at Yarrawonga from 18,300 ML/day to 100,000 ML/day were assessed. In addition the duration of flood events was tested from long (60 day events) to brief (1 day) flood pulses. The results of the analysis are presented in Table 32.

Some important observations from this analysis are:

- The smaller, long duration (20,000 ML/day, 60 days) occurred naturally (pre development) about every one to two years. Under 2030 climate change these events will only occur once every 5 years and only once every 10 years under a step-change future.
- The very large 'landscape restoration' floods (100,000 ML/day, 10 days) occurred naturally (pre development) about once every 11 years. Under 2030 climate change and step change these events do not appear in the flow forecast modelling. That is to say they are unlikely to occur. The consequences of this are discussed briefly in Section 4.5.

Table 32 Analysis of flood flows at Yarrawonga for four climate and water resource development scenarios (data courtesy of CSIRO)

			Scenario P (historic climate, pre-development)			Scenario A (historic climate, current development)			Scenario B (step-change climate, current development)			Scenario Cmid (2030 climate change, current development)		
Flood Magnitude	Season	Duration	Frequency	Avg period between floods	Max period between floods	Frequency	Avg period between floods	Max period between floods	Frequency	Avg period between floods	Max period between floods	Frequency	Avg period between floods	Max period between floods
ML/D			no. occurences	years	years	no. occurences	years	years	no. occurences	years	years	no. occurences	years	years
18,300	Aug - Dec	60+ days	74	1.1	3.8	36	2.6	10.9	11	8.2	34	26	3.5	13.6
25,300	Aug - Dec	60+ days	45	1.9	5.7	25	3.2	12.7	6	14.2	37.7	16	5.4	17.6
35,000	Aug - Dec	60+ days	21	4.4	10.6	9	9.1	24.0	2	38.6	38.6	5	14.2	37.8
35,000	Aug - Dec	30+ days	54	1.7	6.0	25	3.7	12.8	4	19.1	24.8	10	8.6	17.7
45,000	Aug - Dec	30+ days	30	3.0	12.7	11	7.4	24.0	1	N/A	N/A	6	12.6	37.9
45,000	Aug - Dec	60+ days	7	12.2	37.8	3	28.1	38.5	1	N/A	N/A	2	17.9	17.9
60,000	Aug - Dec	1+ days	141	0.8	9.8	77	1.2	13.3	19	4.5	38.7	43	2.1	17.0
60,000	Aug - Dec	10+ days	68	1.3	6.8	23	3.5	24.1	2	0.0	0.0	11	5.8	37.8
60,000	Aug - Dec	30+ days	11	7.8	24.1	4	18.8	37.8	0	N/A	N/A	1	N/A	N/A
80,000	Aug - Dec	1+ days	72	1.3	6.8	39	2.4	17.9	9	9.5	38.7	20	4.3	37.8
80,000	Aug - Dec	10+ days	24	3.4	15.9	8	8.2	37.8	0	N/A	N/A	1	N/A	N/A
80,000	Aug - Dec	30+ days	2	63.8	63.8	1	N/A	N/A	0	N/A	N/A	0	N/A	N/A
100,000	Aug - Dec	1+ days	53	1.8	13.6	23	3.7	20.8	3	29.0	56.6	7	12.7	37.9
100,000	Aug - Dec	10+ days	8	11.2	25.0	2	38.7	38.7	0	N/A	N/A	0	N/A	N/A
100,000	Aug - Dec	30+ days	0	N/A	N/A	0	N/A	N/A	0	N/A	N/A	0	N/A	N/A

4.5 Landscape implications

There is considerable evidence that due to the ongoing drought, and what is likely to be a step change in rainfall and runoff patterns, that the river red gum forests of the Riverina bioregion are under severe stress. The Draft Ecological Character Description for the NSW Central Murray State Forests (GHD, 2009) included the following condition summary across the three forests that constitute the Ramsar site (Table 33).

Table 33 Condition of river red gum forests (GHD, 2009)

Site	Condition/Trend
Millewa Forests	**Poor** Despite the 2005-06 EWA managed flood only 20% of the river red gums in the Forest remain in a healthy condition. **Declining** 75% of the Forest now in a State of decline and a further 5% considered to be in poor health (MDBC, 2007$_c$).
Koondrook Forests	**Very Poor** In 2005 71% of trees sampled in the Koondrook Forest were in a highly stressed, near dead or dead condition and forest understorey was also classed as poor and unsatisfactory (Jurskis *et al.*, 2006). In 2007-08 87% classed as 'unhealthy' (Turner and Kathuria, 2008). **Declining** The forests have not been extensively flooded since 2001 and so health is continuing to deteriorate (MDBC, 2007$_b$)
Werai Forests	**Poor** majority unhealthy, including 92% of SQ2 sampled 'Highly stressed, near dead and dead' (Jurskis, 2006)/ **Trend** unknown, probably declining.

In 2009, the NSW DECCW held expert panel assessments of the likely changes in biodiversity as a result of projected climate changes in the Riverina. That expert panel identified a number of potential impacts to ecosystem function (Table 34).

Table 34 DECCW expert panel assessments of likely changes in biodiversity (DECCW, 2009)

Impact	Comment
The structure, composition and function of ecosystems are likely to change	All ecosystems in NSW, even the most hardy and resilient, are expected to alter in response to climate change. The structure of ecosystems will be influenced by changes in fire regimes and hydrological flows. Changes in species' distributions and abundances will alter the composition of ecosystems.
Distributions of individual species are likely to change	The distribution of individual species is likely to shift in latitude and altitude in response to increased temperatures. Drier conditions over much of the west of NSW, as well as a shift in seasonal patterns of rainfall in the south-west are likely to cause range contraction in a number of species.
Changes in fire frequency and intensity are likely to have widespread impacts	Larger and more intense fires are likely to extend in the future into infrequently burnt wet forests and refuges such as canyons that are protected by their topography, changing forest structure and composition. Species that are highly sensitive to fire are likely to disappear, while those that depend on old or dead hollow-bearing trees and woody debris are likely to have less habitat. Small patches of fire-sensitive ecosystems in a matrix of extensive drier vegetation are most at risk. More extensive fire combined with drought stress is likely to decrease the flowering of plants such as banksias and eucalypts in

Impact	Comment
	dry forests and heaths, impacting on nectar-feeding animals.
Changes in invertebrate populations are difficult to predict but likely to be substantial	Invertebrates have many functions in ecosystems – for example as pollinators, predators, herbivores, detritus feeders, disease vectors, biological controllers of pests and food for other organisms. Invertebrate ecology and population dynamics are likely to change greatly, with consequences that are likely to be substantial but are generally hard to predict from current knowledge. Changes are already apparent in some of the better known and more significant invertebrates, such as the plague locust Chortoicetes terminifera. Breeding adults of this species were observed as early as July in 2008, and it is expected to benefit from warmer and wetter summers and warmer night-time temperatures.
Rainfall decline and reversed seasonality are likely to cause major changes in the Murray Valley	The Riverina and Murray Valley are very likely to suffer major ecological changes as a result of reduced annual rainfall, a shift in rainfall seasonality from winter to summer dominance, declining overall river flows and a loss of spring snow-melt. Species adapted to 'Mediterranean' conditions (wet winters and hot, dry summers) are likely to be displaced or lost. Floodplain and wetland species that have already declined dramatically over the past decade are likely to decrease further. Many ecosystems are likely to collapse.
Species and ecosystems that are stressed by other factors are less likely to resist climate change	Many Australian ecosystems and species have evolved in highly variable climates, and consequently are likely to have some capacity to resist expected climate changes. However, many ecological communities and species in NSW have declined severely because of land clearing, water extraction, habitat fragmentation, grazing and introduced pests. Species and ecosystems that are stressed by non-climatic factors are less likely to be resilient to climate change impacts

4.5.1 Moving to a new equilibrium

The forest landscapes within the Riverina region have evolved over long, 'landscape evolution' time periods. For forests to survive over time it is necessary for young saplings to be recruited to the population of mature trees (eucalypts live 200-500 years) which over time naturally thin to mature forests of greater intra tree spacing (Sutherland et al, 2004). If, as demonstrated by the Sustainable Yields Project (CSIRO, 2008), we are likely to observe a markedly different hydrological regime over the coming decades, then it is reasonable, and prudent, to plan for a new ecological equilibrium.

The revision of sustainable diversion limits within the Basin Plan (MDBA, in preparation) is a tangible example that agencies are already taking steps to manage resources under a 'new norm' or equilibrium.

The Victorian Government's Draft Northern Region Sustainable Water Strategy (DSE, 2008), a peak long term (50 year) water resource planning document, had this to say about management in an uncertain water future:

> *The Draft Strategy examines two scenarios in detail – a continuation of recent low inflows (1997/98 – 2006/07) (Scenario D) and medium climate change projections (Scenario B) and compares these to the base case. Focusing on Scenario D (step change) allows us to plan for the 'worst case' which is less risky than assuming inflows will soon return to average*

conditions. However, the worst case may not eventuate and therefore it is also important to examine the impacts of medium climate change. Comparing Scenario D and Scenario B against the long-term average ensures that the community is aware of the range of possible water futures.

As can be seen, the Victorian Government is not considering a return to historical average inflows as part of their long term water resource planning (DSE, 2008).

5 Implications of climate variability and climate change

5.1 Summary

This section outlines the current understanding of site characteristics, current water availability and future flooding regimes for each of the Water Management Units (WMUs) and associated forest stands as defined in Chapter 2 and 3. The understanding of climate variability and future climate change implications for the river red gum communities supported by these WMUs is then discussed in terms of environmental, social and economic implications for the Riverina bioregion.

The approach to this assessment has involved collating as much available information as possible within the given time constraints. No new modelling or data analysis was included in the scope of this assessment. Therefore the conclusions drawn are based on an understanding of existing information, both documented information and that gained through discussions with relevant experts.

5.1.1 Uncertainty in future environmental watering

The extent of information available on each WMU varies, with the greatest information for the Central Murray sites. The description of the sites and the information presented reflects this variation, and the NRC welcomes new information on the less well described sites if this is available. There is considerable uncertainty about possible changes to water allocations and river regulation under a future Murray Darling Basin Plan. Clearly, if such a plan responds to the apparent need for greater environmental watering, we can expect some greater watering of the forests.

In assessing the likelihood of provision of environmental water to the forests under the Living Murray initiative (TLM), there is uncertainty about the actual water available to the Icon Site with respect to water recovery; and availability under the current mix of entitlements. Considering future water availability predictions with climate change (refer to Chapter 4), the total quantum of water in the Murray Darling Basin is significantly reduced. It is not possible to comment on who will get water when or if it will become available in the future. However, in a future with limited water availability, it seems likely that environmental watering of some forests might 'compete' with consumptive water needs within the system (for example, those of Adelaide).

However, for this assessment the NRC has used the current level of development when modelling the likely impact of climate variability and change as this is the best information currently available.

The Living Murray Environmental Water Recovery Progress Report for June 2009 (MDBA, 2009a) reports that there is currently 342.5 GL from an overall target of 500 GL of water listed on the Environmental Water Register. Projects to recover a further 163.2 GL are being implemented. However the report notes that some of these projects may not recover as much water as expected due to factors including changes in project budget, changes in the market price of water or changes in water market rules.

KPMG completed an independent review of the Living Murray Initiative First Step in April 2009. The review assessed how much water is available in the river system for use at the Icon Sites in 2009-10 (MDBA 2009b). The portfolio of recovered water is a mixture of high,

medium, low and opportunistic (unregulated and supplementary) securities. Due to the nature of the various entitlements, the volumes available for use at icon sites at any particular time will vary depending on river flows, allocations and water management rules. The estimated amount of TLM water that may be available for environmental watering in spring 2009 was 3.55 GL at the time of publication of the review. This is based on the current mix of entitlements associated with the 212.88 GL (Long Term Cap Equivalent, LTCE) recovered water listed on the Environmental Water Register as at 31 March 2009 and assuming allocation levels will be the same on 1 September 2009 as they were 12 months ago.

The review notes that in a wetter year, TLM portfolio could realise a significantly larger quantity of water for environmental watering, including opportunistic entitlements.

5.1.2 Flooding

The Riverine forests of the bioregion are already adjusting to the long term impacts of river regulation since the 1950s. This period saw a substantial reduction in the frequency, duration and magnitude of floods, as well as a shift from winter/spring to predominantly summer flooding. The current drought and future climate variability and change look set to further reduce water availability for the majority of red gum stands across the bioregion.

CSIRO modelled scenarios indicate that a further substantial reduction in the magnitude and duration of floods (particularly large floods) can be expected for the majority of forest stands, particularly the larger forest groups of Millewa, Koondrook-Perricoota and Werai. The delivery of environmental water to the Millewa Forests and intervention works at Koondrook-Perricoota will assist in maintaining some of the moderate sized floods, however the loss of larger floods under climate change will still greatly reduce the extent of forest inundated into the future.

A further reduction in flood extent, duration and frequency is also expected for river red gum forest stands associated with the Murrumbidgee and Lachlan Rivers, and riparian zones along the Edward, Wakool and Murray Rivers downstream of Koondrook-Perricoota Forests. One exception is the river red gum stands along the Upper Murray River, for instance the Barooga State Forest, that are unlikely to be detrimentally affected by climate change due to the relatively frequent flooding associated with the delivery of irrigation water along this section of the Murray channel.

5.1.3 Environmental values

Further reductions in flood magnitude and extent for major river red gum stands across the bioregion have a range of environmental implications. In many of the forests, it is likely that proportions of high quality river red gum will continue to transition to a structure and vigour of lower quality stands. In the absence of regular flooding, parts of the river red gum communities at higher elevations will likely decline to a point where the forest will no longer be able to produce seed and propagate, resulting in parts of the stand assuming the structure of a derived grassland or chenopod community.

Millewa is likely to provide the best long-term security for ecological communities and individual species associated with river red gum in the NSW Riverina. The forest is large and heterogeneous, providing opportunities for species to move and adapt, and requires relatively low flows (compared with downstream forests) to achieve reasonable levels of inundation. However there will be a decline in river red gum wetland extent.

Koondrook-Perricoota is the second largest river red gum wetlands after Millewa, and will also continue to provide some security for ecological communities. However modification to the vegetation community in Koondrook-Perricoota is likely to be significant, with much of the high productivity river red gum transitioning to lower productivity stands.

The Werai forest is likely to be the worst off of the Ramsar site forests (Millewa, Koondrook-Perricoota, Werai), where it is estimated that over 40 percent of the Red Gum stand and associated wetlands could be lost within 50 years if current conditions persist, or deteriorate under climate change.

Continued loss of forest extent is also expected for forest stands associated with the Murrumbidgee, Lachlan and other riparian zones, with associated reduction in fauna reliant on these ecosystems.

5.1.4 Social and economic values

In a future of increasing variability in climate, and reduced water allocations, the towns of interest in the bioregion will face increasing pressures. This is due to the primary dependence of these towns on agriculture, which will face adjustment.

There are a range of possible responses for timber industry businesses. It is likely that responses will be different for each business, as each has a different approach to maximise their returns. The current status of plant and equipment, business focus, current supply volumes, log quality and the associated ability to adjust is variable. The ability to adapt is not dependent on variables such as location or mill throughput, as may be hypothesised.

5.2 Millewa Forests

The assessment for Millewa Forests includes:

- site characteristics and water requirements
- future water availability and flooding regimes
- the likely impacts of future water availability for the associated forests.

The interim ecological objective stated within the Icon Site Management Plan for Barmah-Millewa Forest is to "*ensure healthy vegetation in at least 55percent of the area of the forest (including virtually all of the Giant Rush, Moira Grass, river red gum forest, and some river red gum woodland)*" (MDBC, 2006a).

Initial work in the Icon Site Management Plan indicates that flows of 18,300 ML/d (at Yarrawonga, with appropriate duration and season) are likely to be appropriate for achieving the required inundation extent associated with meeting the objective. However, the most recent hydrological modelling for the Barmah-Millewa Forest has indicated that flows in the order of 35,000 ML/d are required to achieve the desired inundation extents to meet the objective (Water Tech, 2009).

Analysis of modelled streamflow data produced by the CSIRO (CSIRO, 2008a) predicts that naturally occurring floods > 25,000 ML/d will significantly reduce in frequency under climate change. Current easement constraints of 25,000 ML/d between Yarrawonga and Barmah-Millewa also limit the ability to manipulate the delivery of floods larger than

25,000 ML/d. Therefore it is unlikely that inundation extents beyond the 25,000 ML/d will be delivered at the appropriate frequency and duration to sustain vegetation communities into the future. Considering this, the ecological objectives for Barmah-Millewa forest are unlikely to be met.

At 25,000 ML/d, the extent of inundation in Millewa Forest (NSW floodplain only) includes 52 percent of river red gum Site Quality 1 (plus 36 percent of Site Quality 2, and 22 percent of Site Quality 3). Therefore it is likely that less than 50 percent of the existing river red gum Site Quality 1 in Millewa Forest will receive its required flooding regime into the future.

5.2.1 Site characteristics

The Barmah-Millewa Forest and associated wetlands are maintained by the large volumes of water (regular flooding) temporarily banked up behind the Barmah Choke. The Barmah Choke is a section of the Murray River with limited capacity to carry flows (a landscape feature associated with the historical uplift of the Cadell Tilt Block and subsequent adjustment of the Murray River course) (MDBC, 2006a). The channel capacity of the Barmah Choke is approximately 10,400 ML/d (at Yarrawonga Weir).

The hydrology of the forests involves an intricate arrangement of inflow sources and drainage routes. The regularity, extent, duration and season of flooding is governed by flow in the Murray River. Relatively small changes in topography influence the distribution and depth of flooding. Water passes over the floor of the forests as sheet flow in large floods, and through the forests predominantly as creek flow during small flood events. Underground water sources only influence localised areas, and are considered to be of secondary importance to overland flooding (MDBC, 2006a).

Over 50 water management structures are currently present through the Barmah-Millewa Forest. Primary structures are regulators with a discharge capacity generally greater than 100 ML/day and occur in anabranch streams near their exit point from the Murray River, Edward River and Gulpa Creek. The purposes of these structures are to maintain regulated flows within stream, and to permit river freshes and floods to pass into the forest (MDBC, 2006a). Secondary and tertiary regulating structures (with discharge capacity < 100 ML/day, for example, pipes, culverts, earthen banks and small regulators) are mostly situated in drainage features within the interior portions of the forest.

The main purpose of these structures is to manipulate water distribution and depth within localised areas, and to provide vehicle access (MDBC, 2006a). Once flows at Yarrawonga Weir exceed 10,400 ML/day (Barmah Choke capacity), the regulators are progressively opened to allow water to enter the forest. The majority of flood flow entering the Millewa Forests leaves the Murray River and flows past Deniliquin in the Edward River. Flood flow then enters the Edward-Wakool system, passing through the Werai Forests system, before finally returning to the Murray River some 200 km to the west at Wakool junction (GHD 2009).

Since regulation of the Murray River, the natural hydrologic regime has been considerably altered. For example, under natural conditions, 70 percent of the forest would be flooded for an average of 2.9 months in 78 percent of years. Since regulation, this level of flooding is only experienced for an average of 1.3 months in 37 percent of years. Overall the flood return frequency and inundation duration to the major vegetation communities has been significantly reduced.

Small localised flooding, covering less than 10 percent of the forest, occurs approximately eight times more frequently since regulation began, and tends to occur between December and April (MDBC, 2006a). This unseasonal flooding generally occurs because of the rejection of pre-ordered irrigation supplies due to rainfall events having occurred. This typically causes the Murray River flows to increase from near forest channel capacity of about 10,400 ML/day to a flow of 12,000 to 15,000 ML/d or more for a period of up to about 5 to 7 days. Unseasonal flooding may also arise in part from increased tributary flows. Agreement between Forests NSW and the Victorian DSE has allowed an arrangement of 'annual alternating' acceptance of any excess river flows during the unseasonal flooding period (December – April). This co-operative arrangement allows the wetlands in each state a better chance of drying every second year akin with a more natural regime (MDBC, 2006a).

The Living Murray interim ecological objective for Barmah-Millewa Icon Site is to enhance forest, fish and wildlife values ensuring:

- successful breeding of thousands of colonial waterbirds in at least three years in ten, and
- healthy vegetation in at least 55 percent of the area of the forest (including virtually all of the Giant Rush, Moira Grass, river red gum forest, and some river red gum woodland) (MDBC, 2006a).

Water requirements of the Millewa Forests can generally be described as the flooding regime that occurred under natural (pre-regulation) conditions (MDBC, 2006a). For river red gum forests, inundation for up to 5 months in winter-spring, in approximately 40 – 92 percent of years would be ideal (Table 35).

Table 35 Flood frequencies of the major Barmah-Millewa Forest vegetation communities before river regulation (MDBC 2006a, p. 23)

Vegetation community	Flood frequency (% of years with inundation)	Duration	Season
Giant Rush	75% - 100%	7 – 10 months	Winter – mid-Summer
Moira Grass	65% - 100%	5 – 9 months (no more than 10 months; min depth 0.5 m)	Winter – mid-Summer; 2 – 3months dry in late-Summer – early-Autumn
River Red Gum forest	40% - 92%	5 months	Winter - Spring
River Red Gum woodland	33% - 46%	1 – 2 months	Spring
River Red Gum/Black Box woodland	14% - 33%	1 – 4 months	Winter - Spring

Critical limits of acceptable change for river red gum forest and woodland across the NSW Central Murray State Forests were provided in the Draft Ecological Character Description (ECD) (GHD, 2009) and are shown in Table 36.

These are initial values proposed for future refinement, and indicate that a minimum flood frequency of 50 percent of years (for the appropriate duration and season) is required to maintain higher quality Red Gum forest (Site Quality 1). This 50 percent minimum flood frequency correlates well with the 40 percent lower threshold stipulated in the Icon Site Management Plan (MDBC, 2006a).

Table 36 Critical limits of acceptable change for Red Gum in NSW Central Murray State Forests (extracted from GHD 2009, Table 29, p.153)

Sub-component / process	Adaptive management action	Optimum frequency (% of years)	Minimum frequency (% of years)	Optimum operating conditions	Environmental outcomes
River Red Gum Forest (SQ1)	Exceed channel capacity, flood lower parts of floodplain	70 – 90%	50%	Flood pulse in Aug-Dec. Inundation less than 24 months.	Watering of river red gums and other native plant species Magnitude (i.e. extent of flood) will determine extent of SQ1 and SQ2 type forest inundated
River Red Gum Woodland	Exceed channel capacity, achieve broad scale flooding	30 – 70%	20%	Flood pulse in Sep-Nov. Inundation less than 24 months.	Watering of river red gums and other native plant species.

Approximate flow levels required for inundation of various forest extents of the combined Barmah-Millewa complex are provided in Table 37.

Based on these estimates the magnitude of a beneficial summer-spring flood required to achieve the interim environmental objectives (55 percent extent inundation) is considered to be in the order of 18,300 ML/day according to the Icon Site Management Plan (MDBC, 2006a).

Table 37 Desired flow magnitude and flooding extent for Barmah-Millewa Forest (MDBC 2006a)

Flow at Yarrawonga Weir	Inundation extent
< 10,600 ML/day	In channel flows
10,600 – 18,300 ML/day	Inundates up to 55% of Barmah-Millewa Forest (this includes virtually all Giant Rush, Moira Grass, river red gum forest and some river red gum woodland)
18,300 – 25,300 ML/day	Inundates 55 - 66% of Barmah-Millewa Forest
> 25,300 ML/d	Inundates > 66% of Barmah-Millewa Forest

However the most recent assessments by the MDBA indicate that environmental flows required to achieve the Barmah-Millewa objectives (healthy vegetation in 55 percent of the forest) are likely to be much higher than the 18,300 ML/d (I. Burns, MDBA, pers. comm. 14 Sep 2009).

These assessments set out in Table 38 are part of the preliminary data analysis which has been undertaken for the development of the Murray Darling Basin Plan. The analysis was

based on the recent hydrological modelling by Water Technology (Water Tech, 2009) conducted for the Barmah-Millewa Forest.

Table 38 Requirements to meet Barmah-Millewa ecological objectives in relation to Red Gum forests based on preliminary MDBA analysis

Objective	Area of inundation	Flow to achieve inundation	Duration	Frequency	Timing	Max time between events
Healthy vegetation in at least 55% of the area of the forest	36,300 ha	Flow peaking at 45,000 ML/d with extended periods above 35,000 ML/d achieves approximately 64% total forest flooded.				
... including virtually all of the River Red Gum forest (SQ1, SQ2)	Approx. 42,700 ha (with other veg types total 62,000 ha)	Flows 25,000 – 35,000 ML/d with peak of 45,000 ML/d. Achieves 71% inundation River Red Gum SQ1, SQ2 forest (64% total forest)	3 months total	1 in 3 years	Winter, Spring	3 years
... including some River Red Gum woodland (SQ3)	Approx. 13,700 ha (with other veg types total 62, 000 ha)	Flow above 35,000 ML/d peaking above 45,000 ML/d. Achieves 50% inundation of River Red Gum SQ3 woodland (64% total forest)	1 month	1 in 3 years	Spring	4 years

Based on the MDBA analysis (MDBA, pers. comm.), water requirements to achieve the interim ecological objective for the combined Barmah-Millewa forest relate to inundation extents associated with flows of around 35,000 ML/d or greater (see Table 38) which is effectively double the original estimate of 18,300 ML/d proposed in the Icon Site Management Plan.

Water Management Areas (WMAs) delineate areas of the forest where points of inflow and outflow best segregate one section of the forest from another (Leslie and Harris, 1996). The concept of WMAs allows different management requirements and opportunities within each area to be recognised on a localised basis, and then integrated within the overall sphere of forest management (Leslie and Harris 1996). Eight WMAs have been identified within the Millewa forests, and overlying these are four more general WMAs identified by Forest NSW (Figure 32). For flows over 17,000 ML/d, the Millewa forests are typically treated as one unit, however lower flows can be managed in a more detailed way across the four inundation areas (Rodda, Forests NSW, pers. comm. 11 Sep 2009).

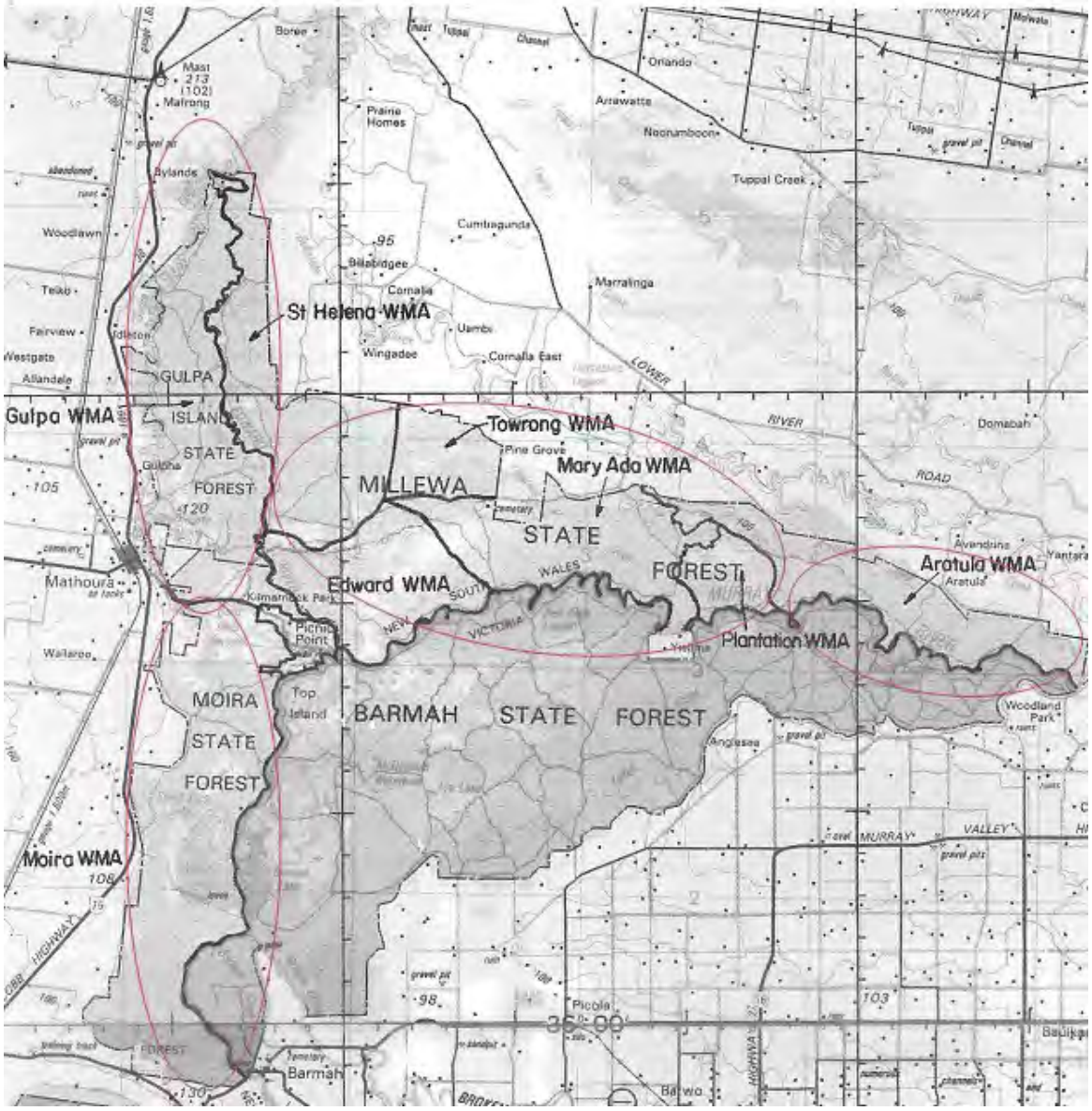

Figure 32 Millewa forests eight WMAs (Leslie and Harris 1996, Figure 1, p. 8) plus four general management areas (red outlines)

5.2.2 Future water availability

In 2008 the CSIRO completed an assessment of sustainable water yields in the Murray Darling Basin. Climate and hydrological modelling was conducted for a range of scenarios including:

- A – historical climate, with current development
- B – recent climate (based on last 10 years, step-change), with current development
- C – future climate to 2030, with current development.

Implications on flooding for Barmah-Millewa Forest were assessed for the beneficial spring-summer flood, defined as the 18,300 ML/day (for a period of 60 days in August – December) at Yarrawonga Weir (Table 39). This is the volume that was initially understood to

correspond with achieving the 55 percent inundation of the forest required to achieve the interim ecological objective, based on the Icon Site Management Plan (CSIRO, 2008).

Table 39 Barmah-Millewa beneficial flow event definition (CSIRO, 2008, p166)

Flow event description	Flow event definition	Indicators reported
Beneficial spring-summer flood (MDBA 2006)	Flows exceeding 18,300 GL/d for 60 days Aug-Dec at Yarrawonga Weir.*	Avg period between floods Max period between floods Avg flood volume per year Avg flood volume per event

*(this is the 55 percent inundation flood)

Results on the flood frequency under each of the scenarios are shown in Table 40.

Comparison across the scenarios shows that under scenarios B and C (step-climate change and 2030 climate change) floods exceeding 18,300 ML/day are likely to occur less frequently, with a greater period between floods, and with a lower average flood volume per year and per event. The reduction in flood frequency is considerably more extreme under step-climate change (B) than modelled 2030 climate change (C) as would be expected as step-climate change assumes a continuation of conditions from the last 10 years.

Table 40 Environmental indicator values under scenarios A, B and C, plus % change (from Scenario A) in indicator values for scenario C (CSIRO 2009, p167)

Barmah-Millewa Forest	A	B	Cmid	B	Cmid
Floods exceeding 18,300 ML/d		years		% change from Scenario A	
Average period between floods	3.5	4.55	3.96	30	13
Max period between floods	10.9	33.90	21.26	211	95
		GL		% change from Scenario A	
Average flood volume per year	291	55	148	-81	-49
Average flood volume per event	905	226	516	-75	-43

Modelled scenarios include environmental water allocations for Barmah-Millewa Forest. This includes a 100 GL/yr environmental water entitlement, plus a lower security allocation of 50 GL to be provided in years where the irrigation water allocation in Victoria exceeds 130 percent. The 100 GL/yr of high security water, and additional 50 GL (when triggered), is to be drawn equally from NSW and Victoria, and can be accrued in storage as an environmental water allocation kitty up to a maximum of 700 GL (MDBC, 2006a).

Additional environmental water which is not included in the modelled future water availability is the 500 GL/year to be recovered and applied to the six Icon Sites under The First Step decision of The Living Murray initiative. The Living Murray program has recently undertaken modelling which examined the degree to which environmental water requirements of the Icon Sites can be met with the 500 GL under historical climate conditions, and the potential impact of climate change (2030) (TLM, 2008). This modelling also considered the feasibility and benefits of structural works proposals for the relevant Icon Sites.

As Barmah-Millewa does not have a defined structural proposal, it was not modelled specifically. Rather the focus was on other Icon Sites, with Barmah-Millewa being treated in a relatively passive context (including current operating rules and entitlements). However, overall it was felt that the Barmah-Millewa Forest would benefit from the additional water recovery and the operation of other structures (TLM, 2008).

5.2.3 Future flooding regime

A floodplain inundation model for Barmah-Millewa forests has recently been completed (Water Tech, 2009). The model outputs include flooding extents for a range of inundation levels based on flow volume at Yarrawonga Weir (Table 41). Analysis of this data also provides an indication of the extent of river red gum vegetation communities in the Millewa Forests inundated at various flows in the Murray River channel (Water Tech, 2009). A comparison of these design flows with the predicted inundation extents for the combined Barmah-Millewa forest can also be made (Table 41).

Table 41 Inundation extent of Red Gums on NSW floodplain (Millewa forests) at various design flows (based on flow at Yarrawonga) that have been mapped (Water Tech 2009). A comparison of approximate inundation extent for the combined Barmah-Millewa Forest (MDBC 2006a) is also shown.

	Inundation extent on NSW active floodplain (Water Tech 2009)			Inundation extent for combined Barmah-Millewa forest
Design flows with mapped inundation extent (Water Tech 2009)	River Red Gum, Site Quality 1	River Red Gum, Site Quality 2	River Red Gum, Site Quality 3	Based on MDBA preliminary analysis (except 60,000 ML/d – CSIRO analysis)
ML/d	%	%	%	
10,400				
13,000	23	8	2	
15,000	34	13	3	18,300 ML/d was the initial estimate to achieve 55% inundation extent of combined forest based on the Icon Site Management Plan.
25,000	52	36	22	Achieves 71% inundation of river red gum forest (corresponding with the 'virtually all Red Gum Forest' objective in the Icon Site Management Plan.
35,000	62	49	35	Achieves 50% inundation of river red gum woodland
45,000	74	63	48	Flows peaking at 45,000 ML/d with extended periods above 35,000 ML/d achieves approx. 64% of total forest flooded.
60,000	88	81	74	Flow required for 55% inundation extent based on CSIRO RiM-FIM modelling (Overton et al. 2006)

For the Millewa Forest, based on the results shown in Table 41.

- At 15,000 ML/d (closest design flow to 18,300 ML/d), only 34 percent of river red gum Site Quality 1 is inundated, plus 8 percent of Site Quality 2 and 2 percent of Site Quality 3.
- At 25,000 ML/d, approximately 52 percent of river red gum Site Quality 1 is inundated, plus 36 percent of Site Quality 2, and 22 percent of Site Quality 3.
- With flows up to 35,000 ML/d, approximately 62 percent of Site Quality 1 is inundated, plus 49 percent of Site Quality 2, and 35 percent of Site Quality 3.
- Larger flows of 45,000 ML/d will inundate up to 74 percent of Site Quality 1, plus 63 percent of Site Quality 2, and 48 percent of Site Quality 3.

To examine the future flood frequency of larger floods (> 18,300 ML/d) under climate change (step-change and 2030 climate change), daily modelled streamflow data (1895 – 2006 at Yarrawonga Weir) were obtained for the CSIRO climate scenarios (A, B, Cmid).

The differences in flood frequency for larger floods, in addition to the 18,300 ML/d, were compared across the different scenarios, to examine the likely impacts on inundation extents. This analysis was conducted using the River Analysis Package (RAP) to determine the number of events in the flow series data. A two-day flood independence criterion was used in the RAP analysis, and events were defined as noted in Table 42.

Table 42 Flood frequency assessment under climate change scenarios

Flood magnitude ML/d	Season	Duration	A	B	C (mid)
18,300	Aug - Dec	60 days +			
Avg period between floods (years)			2.6	8.2	3.5
Max period between floods (years)			10.9	34.0	13.6
25,300	Aug – Dec	60 days +			
Avg period between floods (years)			3.2	14.2	5.4
Max period between floods (years)			12.7	37.7	17.6
45,000	Aug - Dec	60 days +			
Avg period between floods (years)			28.3	N/A*	17.9
Max period between floods (years)			38.7	N/A	17.9*
60,000	Aug - Dec	30 days +			
Avg period between floods (years)			19.3	N/A	N/A
Max period between floods (years)			37.8	N/A	N/A

*same as avg. because only two events were recorded

Slight differences in data reported for the 18,300 ML/d between this analysis and the CSIRO analysis (Table 40) are likely to be attributed to subtleties in the data analysis process (e.g. flood independence). However the trends are the same, with floods becoming significantly less frequent under climate change. This is particularly the case for the larger floods, with no

floods of 60,000 ML/d (for 30 days) occurring under 2030 climate change (or step-climate change) (Table 42). There is a significant reduction in the frequency of naturally occurring floods between 25,000 – 45,000 ML/d under climate change. The approximate extents of flood magnitudes in Table 42 are shown in Figure 33, Figure 34, Figure 35, Figure 36, and Figure 37. Additional flood magnitudes for which inundation extents are not available were assessed previously in Chapter 4.

An additional constraint on future flooding in Barmah-Millewa is the current easement constraint on water delivery to the forest. Existing easements along the Murray River between Yarrawonga Weir and Barmah-Millewa only allow for a maximum of 25,000 ML/day to be delivered to the forest (L. Brokeman [Forests NSW] pers. comm. 8 Sep 2009). Any floods greater than 25,000 ML/day have to occur naturally. However flow regulation is often put in place to reduce the magnitude of any naturally occurring large floods. When a natural large flood is expected, lake and river levels are often allowed to drop in order to mitigate the effect of flooding on adjacent private land (beyond the easements). Therefore flow regulation also reduces the magnitude of naturally occurring large floods, and limits the potential for delivery of large floods into the future.

The current easement limitation means that the extent of floodplain vegetation communities inundated at the 25,000 ML/d flow (Figure 35) is the limit of what can feasibly be protected into the future through flow manipulation. It is understood that an expansion of easements up to a capacity of 40,000 ML/day is currently being investigated (L. Brokeman [Forests NSW] pers. comm. 8 Sep 2009, I. Burns [MDBA] pers. comm. 15 Sep 2009). If easements are increased to allow increased flooding at 40,000 ML/day, a greater extent of vegetation can be protected, in the order of that mapped for the 45,000 ML/d design flow (Table 42).

5.2.4 Flooding conclusions

Based on the recent hydrological modelling for the Barmah-Millewa Forest (Water Tech 2009) and preliminary assessments conducted by the MDBA (I. Burns [MDBA] pers. comm. 15 Sep 2009), flood inundation extents associated with flows in the order of 35,000 ML/d are likely to be required to achieve the interim ecological objectives for the combined forest (55 percent healthy vegetation, including virtually all river red gum forest and some Woodland). These are significantly higher flows (effectively double) than the original 18,300 ML/d desirable flow event defined in the Icon Site Management Plan.

The frequency of natural floods with a magnitude > 25,000 ML/d are expected to significantly decrease into the future under climate change. Analysis conducted for this assessment has indicated that under climate change the frequency of floods > 25,000 ML/d may reduce from occurring every 3.2 year to 5.4 years, with the maximum period between floods increasing from 12.7 to 17.6 years. Given the current easement constraints of 25,000 ML/d between Yarrawonga and Barmah-Millewa, there is also limited potential to artificially deliver larger floods to the forest. Therefore inundation extents beyond 25,000 ML/d are unlikely to be achievable at the frequency required for sustaining river red gum vegetation.

While there is confidence that 18,300 ML/d can be delivered to the Barmah-Millewa Forest into the future, based on the information gathered from this assessment this flow is unlikely to achieve the ecological objectives for the combined forest. Only 34 percent of river red gum Site Quality 1 (plus 13 percent of Site Quality 2, and 3 percent of Site Quality 3) is inundated in Millewa at 18,300 ML/d.

At 25,000 ML/d, the extent of inundation in Millewa Forest includes 52 percent of river red gum Site Quality 1 (plus 36 percent of Site Quality 2, and 22 percent of Site Quality 3). If easements are extended into the future to the order of 40,000 ML/d, then there will be potential to sustain up to 74 percent of river red gum Site Quality 1 (plus 63 percent of Site Quality 2, and 48 percent of Site Quality 3), which represents a significant enhancement of area inundated compared to the 25,000 ML/d extents. Therefore it is likely that less than 50 percent of the existing river red gum Site Quality 1 in Millewa Forest will receive its required flooding regime into the future.

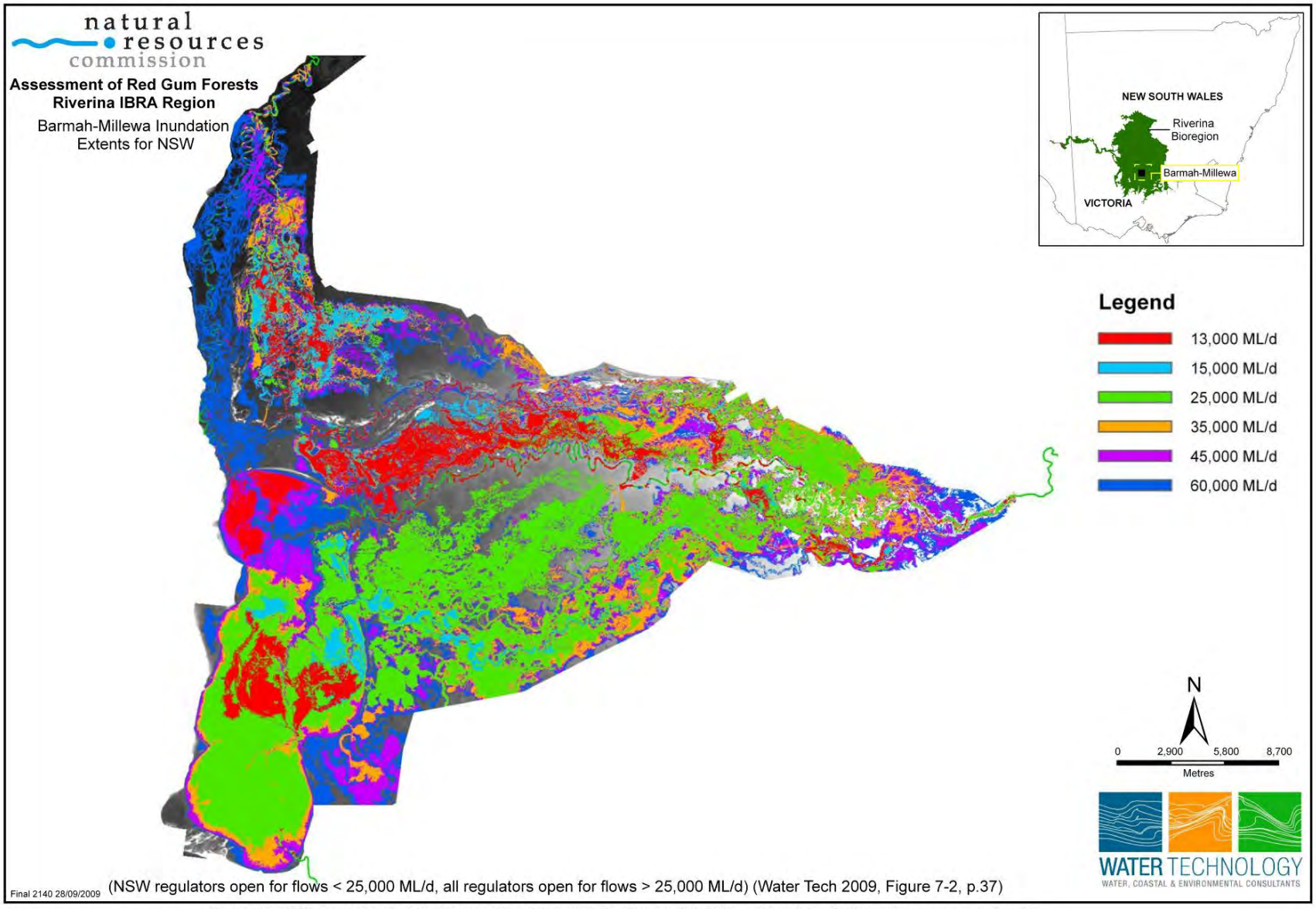

Figure 33 Barmah-Millewa inundation extents for NSW (NSW regulators open for flows < 25,000 ML/d, all regulators open for flows > 25,000 ML/d) (Water Tech 2009, Figure 7-2, p.37)

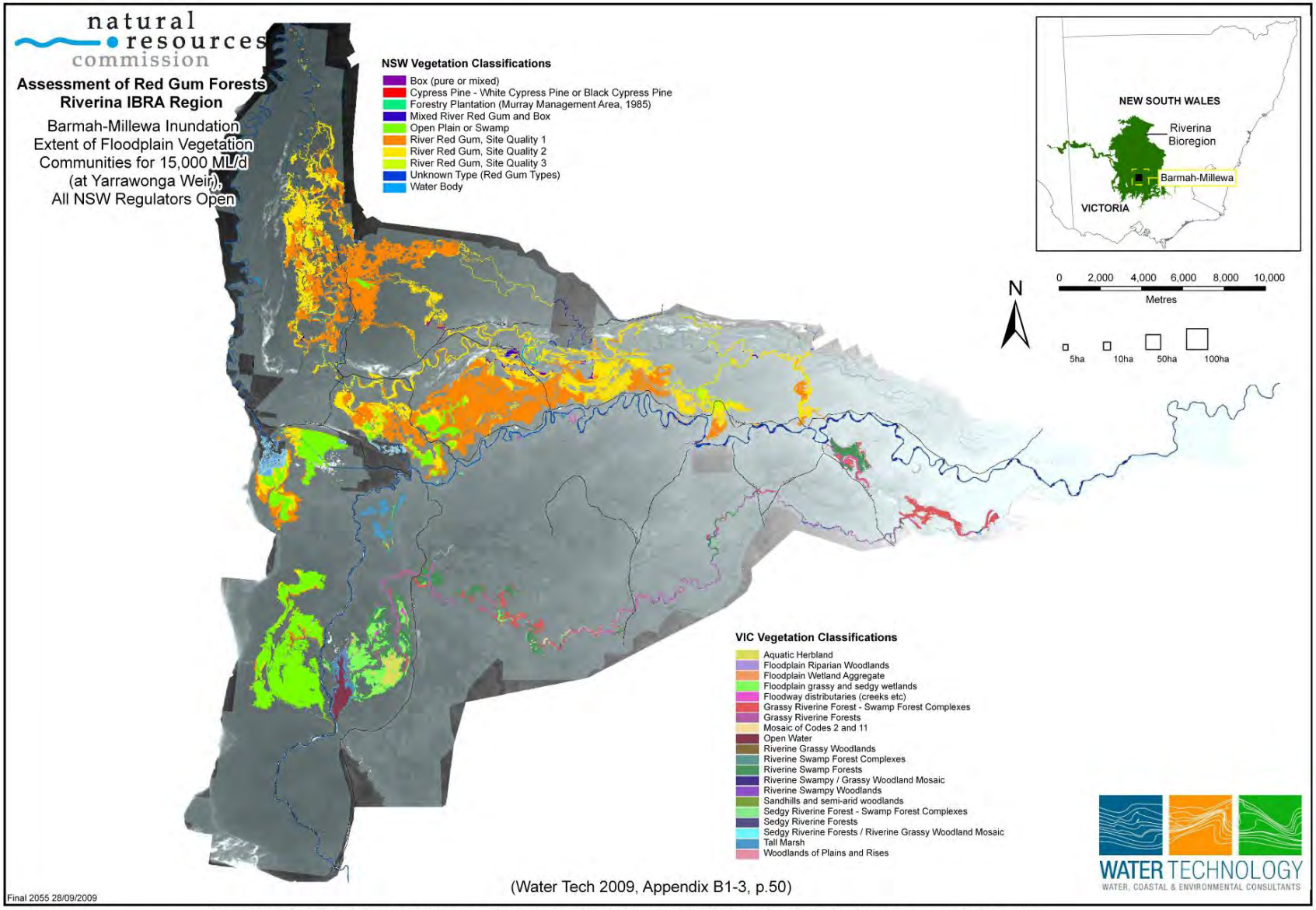

Figure 34 Barmah-Millewa inundation extent of floodplain vegetation communities for 15,000 ML/d (at Yarrawonga Weir), all NSW regulators open (Water Tech 2009, Appendix B1-3, p50)

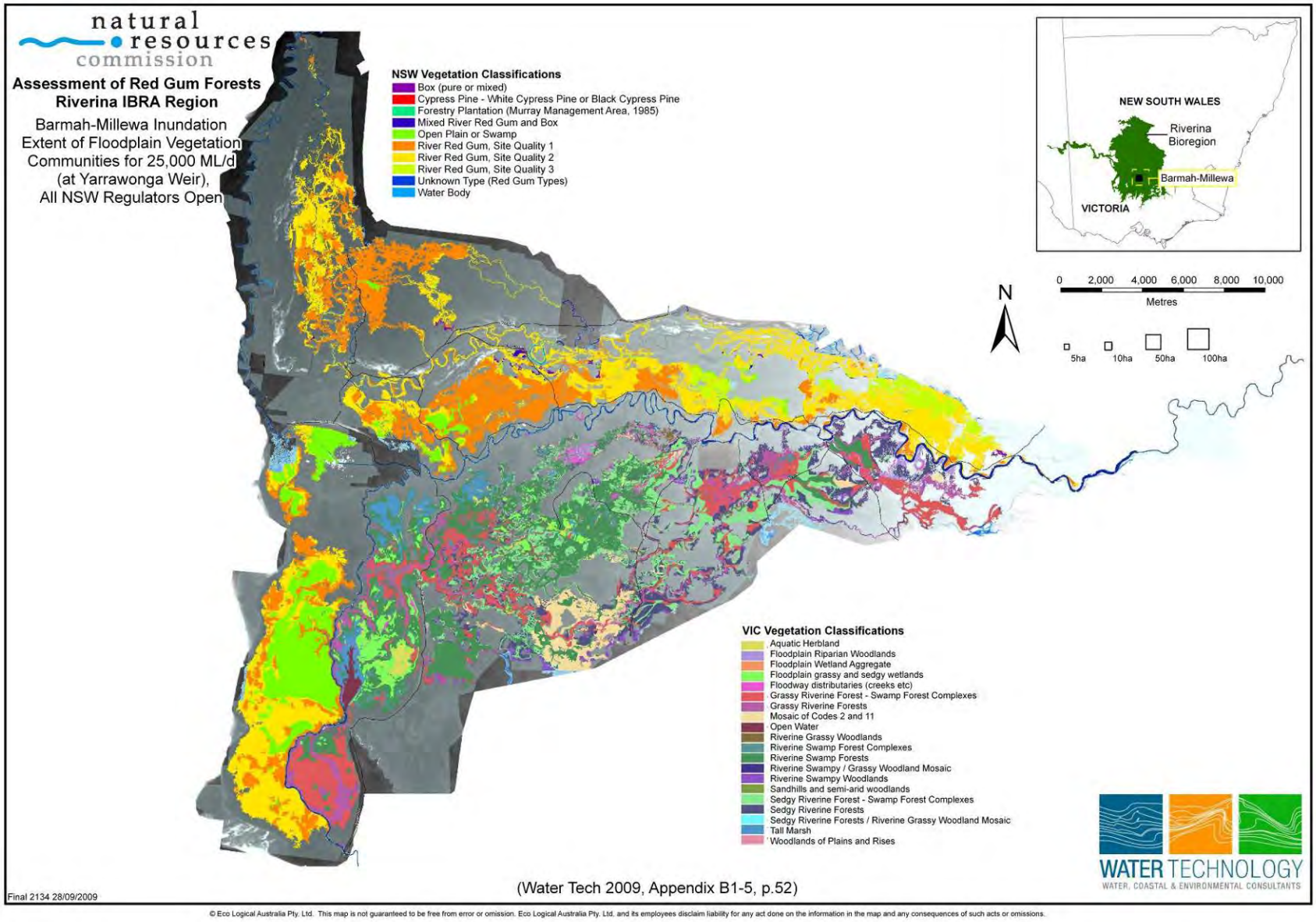

Figure 35 Barmah-Millewa inundation extent of floodplain vegetation communities for 25,000 ML/d (at Yarrawonga Weir), all regulators open (Water Tech 2009, Appendix B1-5, p.52)

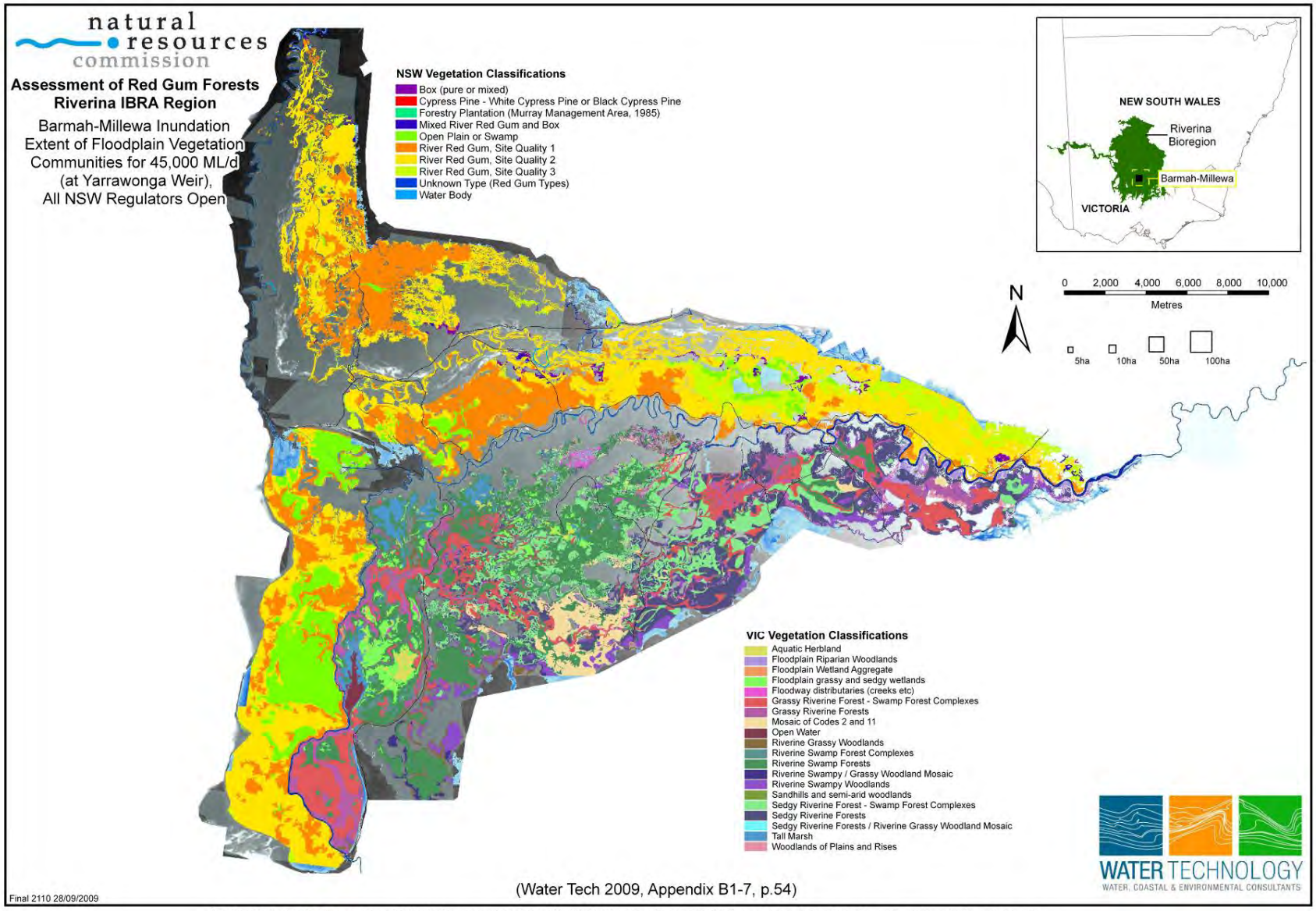

Figure 36 Barmah-Millewa inundation extent of floodplain vegetation communities for 45,000 ML/d (at Yarrawonga Weir), all regulators open (Water Tech 2009, Appendix B1-7, p.54)

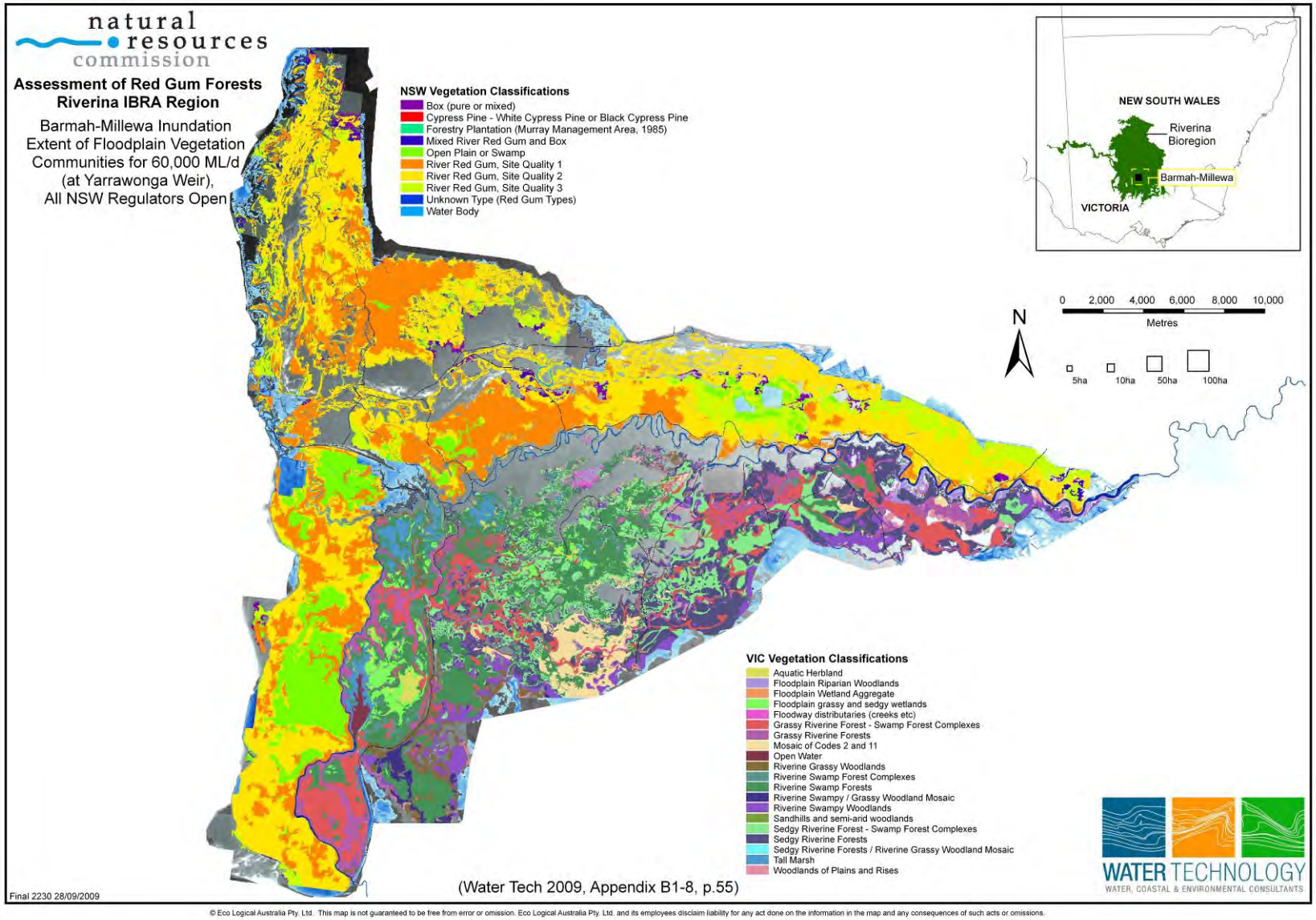

Figure 37 Barmah-Millewa inundation extent of floodplain vegetation communities for 60,000 ML/d (at Yarrawonga Weir), all regulators open (Water Tech 2009, Appendix B1-8, p.55)

5.3 Koondrook-Perricoota and Campbells Island

5.3.1 Summary

The assessment for Koondrook-Perricoota and Campbells Island includes:

- site characteristics and water requirements
- future water availability and flooding regimes
- the likely impacts of future water availability for the associated forests.

The majority of the river red gum sites (87 percent) in Koondrook-Perricoota Forests are unhealthy or stressed (Turner and Kathuria, 2008) and the proposed Flood Enhancement Works will need to be undertaken for any significant improvement to the health of the Koondrook-Perricoota Forest to be achieved under both historic and projected climate change conditions.

The Living Murray modelling undertaken as part the Environmental Works and Measures Program indicates that watering requirements of Koondrook-Perricoota Forest necessary to support the feasibility of the Flood Enhancement Works can be fully met.

Based on flood extent modelling undertaken by DHI, the peak flood event for the flood enhancement works (6000 ML/d) would inundate 52 percent of the Koondrook-Perricoota Forest. This comprises inundation of 55 percent river red gum Tall Open Forest (SQ2) and 56 percent of river red gum – box woodland. The minimum flood event (2000 ML/d) would inundate 34 percent of the Koondrook-Perricoota Forests. This comprises inundation of 38 percent river red gum Tall Open Forest (SQ2) and 33 percent of river red gum – box woodland.

The Flood Enhancement Works will provide the flexibility to operate within a range of flows to sustain a range of ecological processes. The exact ecological outcomes arising from operation of the proposed structures will be unknown until they have been operated in real time, under a range of antecedent conditions. Operation of the structures will be altered in line with adaptive management principles in order to react to the ecological response observed. The Flood Enhancement Works are currently in the planning period and so there is still a lengthy time period for construction, testing, and operation adjustment for significant improvement to the health of the Koondrook-Perricoota Forest to be achieved.

5.3.2 Site characteristics

The Gunbower- Koondrook-Perricoota Icon Site, composed of the Gunbower Forest in Victoria and the Koondrook and Perricoota Forests in New South Wales covers approximately 50,000 ha of Murray River floodplain (MDBC 2006b).

The Koondrook-Perricoota Forest is state forest, covering approximately 32,000 ha. This area is managed by Forests NSW and is included in the NSW Central Murray State Forests Ramsar site. To the north-west of the Koondrook Perricoota Forest is Campbells Island State Forest. The Perricoota forest group incorporates the second largest area of river red gum forest after Millewa, and the Campbells Island forest group is almost entirely composed of lesser quality river red gum (Site Quality 2).

The Perricoota Forest has been significantly altered by river regulation (MDBC, 2006b). High banks on the river channel inhibit flooding by low flows of short duration from entering the forest. The decline in forest quality was noted as early as 1948 in some areas (MDBC, 2006b).

Water enters the Koondrook Forest via two inflow effluents at Swan Lagoon when the Murray River flow exceeds 16,000 ML/d (GHD 2009). This flow starts to pass water through the first 15km of the system, through the Burrumbarry Creeks. This flow does not inundate a significant portion of the forest, with broad area flows observed when the flows exceed channel capacity in the Murray (>30,000ML/d) (GHD 2009). Inundations at flow rates for the Murray River are shown in Table 43.

Table 43 Inundation of Koondrook river red gum forests (MDBC 2008 cited in GHD 2009)

River flow (ML/d)	Inflow to forest (ML/d)	Inundated area in hectares / % of total					
		River Red Gum forest (SQ1, SQ2)		River Red Gum woodland (SQ3, Box-gum)		Total River Red Gum forest	
15,000	0	-	-	-	-	-	-
20,000[a]	300	500	2%	-	-	500	2%
25,000	1,500	1,030	54%	2,060	12%	3,520	11%
30,000[b]	3,800	1,330	70%	7,400	43%	10,300	33%
35,000	6,500	1,885	99%	16,245	95%	25,000	80%

a – inflows to forest via Burrumbarry Creek start at 16,000 ML/d
b – channel capacity of Murray River is 30,000 ML/d, beyond which overtopping and broad area flows commence

Water requirements of Koondrook-Perricoota are targeted to achieving a closer representation of conditions that occurred under natural (pre-regulation) conditions (MDBC 2006b). This comprises a cycle of regular periodic surface flooding in winter and spring, combined with annual summer/autumn drying (Table 44). Regulation and consumptive demands of the river has resulted in a decrease of the frequency of flooding to once every 10-12 years (DECC 2008).

Table 44 Natural (pre-regulation) flood frequencies of the Koondrook-Perricoota Forest vegetation communities (MDBC 2006b)

Water regime class	Frequency	Duration	Timing
River Red Gum with flood dependent understorey	7-9 years in 10	4 months	winter / spring

The Living Murray specifies that environmental water will be used to achieve the following environmental value objectives for Koondrook-Perricoota:

- Successful breeding of thousands of colonial waterbirds in at least three years in ten, and
- 30 percent of the river red gum forest in healthy condition (MDBC 2006b).

The water requirements to achieve these objectives are listed in Table 45.

Table 45 Target water requirements for meeting Flood Enhancement Project objectives

Indicator	Measure	Target	
		Minimum	Preferred
Extent	Proportion of River Red Gum forest (with water dependent understorey) inundated	30 percent	> 70 percent

Indicator	Measure	Target	
		Minimum	Preferred
Timing and duration	Between August and December for at least three consecutive months	Sep, Oct and Nov	Aug – Sep, Oct, Nov-Dec
Frequency	Number of inundations	50 percent of natural	Natural precedent
	Maximum period between inundations	4 years	Natural precedent

There are three scales of surface water delivery and management for the Koondrook-Perricoota Forests (MDBC, 2006b):

1. releases from headwater storages
2. water control structures on river banks (regulators)
3. installation and operation of internal water control structures.

For releases from headwater storages on the Murray to inundate the Koondrook Perricoota forests, water needs to be matched from water from the Goulburn. Releases from Hume Dam equate to a flow of 17,000 ML/d at Torrumbarry, well below the 30,000 ML/d effective flood level (MDBC 2006b). At this flow rate, much of the Murray River flow passes through the Edward River, bypassing the Koondrook-Perricoota area.

The Torrumbarry weir holds water which can be used to flood the Gunbower forest through regulators and channels. Under current management arrangements it is not possible to pass water into Koondrook-Perricoota from this regulator. Forests NSW are currently undertaking a project to adjust and install new water management infrastructure to Koondrook-Perricoota Forest from the Torrumbarry weir.

The Koondrook-Perricoota Forest Flood Enhancement Works aims to (Forests NSW, 2009b):

- maximise the effectiveness of more frequent 'lower' flood peaks
- deliver water to 30-52 percent of the forest extent
- connect the river with thousands of hectares of potential fish breeding habitat
- maintain waterbird breeding colonies
- maintain the essential process that sustains the forest
- restore and maintain foraging and breeding habitat across the forest for a range of species.

The structural works will allow up to 6,000ML/d flow to be passed through the Torrumbarry Weir. Forests NSW have outlined the main structural components of the proposal as (Forests NSW, 2009b);

- an excavated channel to connect Bullock Head Creek and the Burrumburry Creek System to the Torrumbarry Weir pool to enable the flow of water into the forest
- upstream structures to allow diversion of water into the forest from Torrumbarry Weir and escape regulators at Swan Lagoon to prevent flows re-entering the Murray River

- downstream structures to prevent water leaving the forest and to maximise return flows back to the Murray River. This will include a return channel to allow return flow back to the Murray River and a floodway to increase water returns to the Murray River
- downstream stoplog regulators will be implemented to control the flow of the water out of the forest
- a levee around the downstream perimeter of the forest is required to protect adjoining properties from flooding.

The design of the scheme provides the flexibility to operate within a range of flows (Forests NSW, 2009a). This ensures that it can deliver effective and measurable environmental outcomes across a broad range of available water. The proposed structures have been designed to create a major flood event; however they can also manage smaller flows that can be used to maintain core wetland areas, or medium flows of variable volume and duration that can be manipulated to either provide a quick fresh across the forest or be drawn out to ensure successful recruitment of wetland species (Forests NSW, 2009a).

Forests NSW completed the Preliminary Environmental Assessment for this project in April 2009 and plan on completing construction by mid 2011.

5.3.3 Future water availability

In 2008 the CSIRO completed an assessment of sustainable water yields in the Murray Darling Basin. Climate and hydrological modelling was conducted for a range of scenarios including:

- A – historical climate, with current development
- B – recent climate (based on last 10 years, step-change), with current development
- C – future climate to 2030, with current development

Implications on flooding for Koondrook-Perricoota Forest were assessed for the beneficial spring-summer flood, defined as the 30,000 ML/day (for a period of 30 days in Aug – Jan). Results on the beneficial flood frequency under each of the scenarios are shown in Table 46. Comparison across the scenarios shows that under scenarios B and C (step-climate change and 2030 climate change) floods exceeding 30,000 ML/day are likely to occur less frequently, and with a lower average flood volume per year and per event. Note that this modelling was undertaken for the current Koondrook-Perricoota Forest without the proposed flood enhancement works.

Table 46 Environmental indicator values under scenarios A, B and C, plus percent change (from Scenario A) in indicator values for scenario C (CSIRO 2009, p167)

Gunbower-Koondrook-Perricoota Forest	A	B	C mid	B	C mid
		Years		percent change from Scenario A	
Average period between floods	3.8	5	4	30	15
Max period between floods	11.8	38	21	219	77
		GL		percent change from Scenario A	

Gunbower-Koondrook-Perricoota Forest	A	B	C mid	B	C mid
Average flood volume per years	118	12	57	-90	-52
Average flood volume per event	401	52	221	-87	-45

Note: this data does not include proposed flood enhancement works discussed

Future water availability for Koondrook-Perricoota Forest under the CSIRO sustainable yields assessment does not include:

- Additional environmental water from the 500 GL/year to be recovered and applied to the six Icon Sites under The First Step decision of The Living Murray initiative; or
- Operation of the Koondrook-Perricoota Forest Flood Enhancement Works.

The Living Murray program has recently undertaken modelling (TLM, 2008) which:

- examined the degree to which environmental water requirements of the Icon Sites can be met with the 500 GL under historical climate conditions, and the potential impact of climate change (2030); and
- indicates the feasibility and benefits of structural works proposals for the relevant Icon Sites to inform investment decision making under the Environmental Works and Measures Program (EWMP) (TLM 2008).

Investigation of icon site-specific infrastructure under the EWMP has occurred to identify how the Icon Sites can be "efficiently" watered as floods from the river are no longer frequent enough to sustain the health of the system. The operation of the Koondrook-Perricoota Forests Flood Enhancement Works is modelled in this investigation.

Two levels of operation, a preferred operation and a minimum operation have been modelled for each of the works and water proposals, so that a broad sensitivity analysis could be undertaken for the investment decision. The preferred operating strategies reflect the operation of the water and work proposals and are used to test the feasibility of the proposals under the current climate. The minimum operating strategies represent the minimum water use/requirement needed to deliver the environmental outcomes that would support investment and have been modelled using the 2030 medium climate change scenario to conduct a sensitivity analysis to test the viability of structures in low water years.

The two operating strategies tested for the Koondrook Perricoota Forest flood enhancement works are listed in Table 47.

Table 47 Koondrook-Perricoota operating strategies assessed in TLM modelling (TLM 2008)

Operating strategy	*Preferred*	*Minimum*
Flood frequency	1 in 3 years	1 in 3 years
Intervention watering duration	105 days	100 days
Diversion rate	6,000 ML/d for 50 days, then 3,400 for 55 days	2,000 ML/d
Threshold / criteria to start operation	>6,000 ML/d available flow at Torumbarry	>2,000 ML/d available flow at Torumbarry

Operating strategy	*Preferred*	*Minimum*
Threshold / criteria to stop operation	>34,000 ML/d at Torumbarry for 3 months	>26,000 ML/d at Torumbarry for 3 months
Area inundated	~ 14,000 ha	~ 4,000 ha
Maximum time between events	4 years	7 years

This modelling forms part of a staged approach to inform operations so that environmental outcomes are maximized over the longer time period.

The objective of the study was to prove the feasibility of the works and it was considered that if the tested flood events could be delivered then the works were worth building. The modelling does not represent how the works would operate in reality, nor be conclusive as to the limit on what could be delivered. The results of the study should thus be interpreted accordingly.

The modelling found that the water requirements of Koondrook-Perricoota Forest (as per the operating strategies in Table 47) can be fully met by the 500 GL recovered by the First Step decision plus the 70 GL of Murray River Increased Flows – component of the water recovered under the Snowy Water Inquiry Outcomes Implementation Deed if the proposed flood enhancement works are undertaken. The sites' overall demand is lower than the volume of water recovered both under the preferred operation with the current climate scenario and also for the minimum operating regime under a 2030 climate change scenario.

The operation of the Koondrook-Perricoota Flood Enhancement Works is detailed in the Preliminary Works Operation Plan (NSW Department of Commerce, 2009). As stated in the plan, the Flood Enhancement Works has been designed to provide the flexibility to operate within a range of flows to sustain a range of ecological processes, for example,

- Frequent, low flows to maintain the wetland habitats occurring in lagoons, depressions and flood runners;
- Less frequent floods of medium magnitude to maintain the extent of the Red Gum communities, with larger floods maintaining the extremities, and smaller floods supporting the core areas with flood dependent understorey communities;
- Flood events of long duration to cue and facilitate bird breeding; and
- Very large, infrequent flood events to provide an occasional boost to the fringing Black Box communities.

The proposed scheme is capable of achieving inundation of up to 52 percent of the forest (with the 6000 ML/d event), but cannot maintain this extent. Maximum maintainable extent is 41 percent, with this reducing quickly during the flood recession. The decision to water will be based on the water requirement of the ecological system and the availability of water and it will be guided by the series of Watering Principles, and tempered by risk management strategies (NSW Department of Commerce, 2009). Unregulated water will be used when beneficial, and overbank flows will be favoured as a cue for initiating watering.

The Plan comments that the exact ecological outcomes arising from operation of the proposed structures will be unknown until they have been operated in real time, under a range of antecedent conditions, and that the exact nature of both unregulated and regulated river flows, and the quantum of environmental water available, is unknown. Consequently, operation of

the structures will be altered in line with adaptive management principles in order to react to the ecological response observed.

5.3.4 Future flooding regime

A floodplain inundation model for Koondrook-Perricoota Forest was developed in 2008 for the NSW Department of Commerce (DHI Water & Environmentn 2008). The model outputs include flooding extents for a range of inundation levels based on structural and operational options aimed at improving inundation of the forest.

The inundation extent was modelled for four flow options: 2,000; 3,000; 4,000 and 6,000 ML/d. Table 48 summarises the results of this model run. Maximum flood extents for the 2,000 ML/d and 6,000 ML/d flows relate to 34 percent and 52 percent inundation respectively.

Table 48 Flow component for steady state runs (DHI Water & Environment 2008)

Inflows	Final water surface level (m AHD)	Time to reach final pool level (days)	percent inundation of Koondrook-Perricoota forest
6000 ML/d	78.5	45	52
4000 ML/d	78.45	75	47
3000 ML/d	78.3	80	42
2000 ML/d	78.1	80	34

The spatial data for maximum flood extents at 2,000 and 6,000 ML/d was provided and overlaid on vegetation types mapped for this project (Figure 38, Figure 39). Table 49 summarises the results of this assessment.

Table 49 Vegetation groups inundated under 2,000 ML/d and 6,000 ML/d

Vegetation Group	Koondrook & Perricoota SF (Ha)	6,000ML/d (Ha)	percent	2,000ML/d (Ha)	percent
River Red Gum Very Tall Forest (SQ1)	82	0		0	
River Red Gum Tall Open Forest (SQ2)	25,979	14,263	55	9,754	38
River Red Gum Woodland (SQ3)	0	0		0	
River Red Gum - Box Woodland	4,010	2,258	56	1,319	33

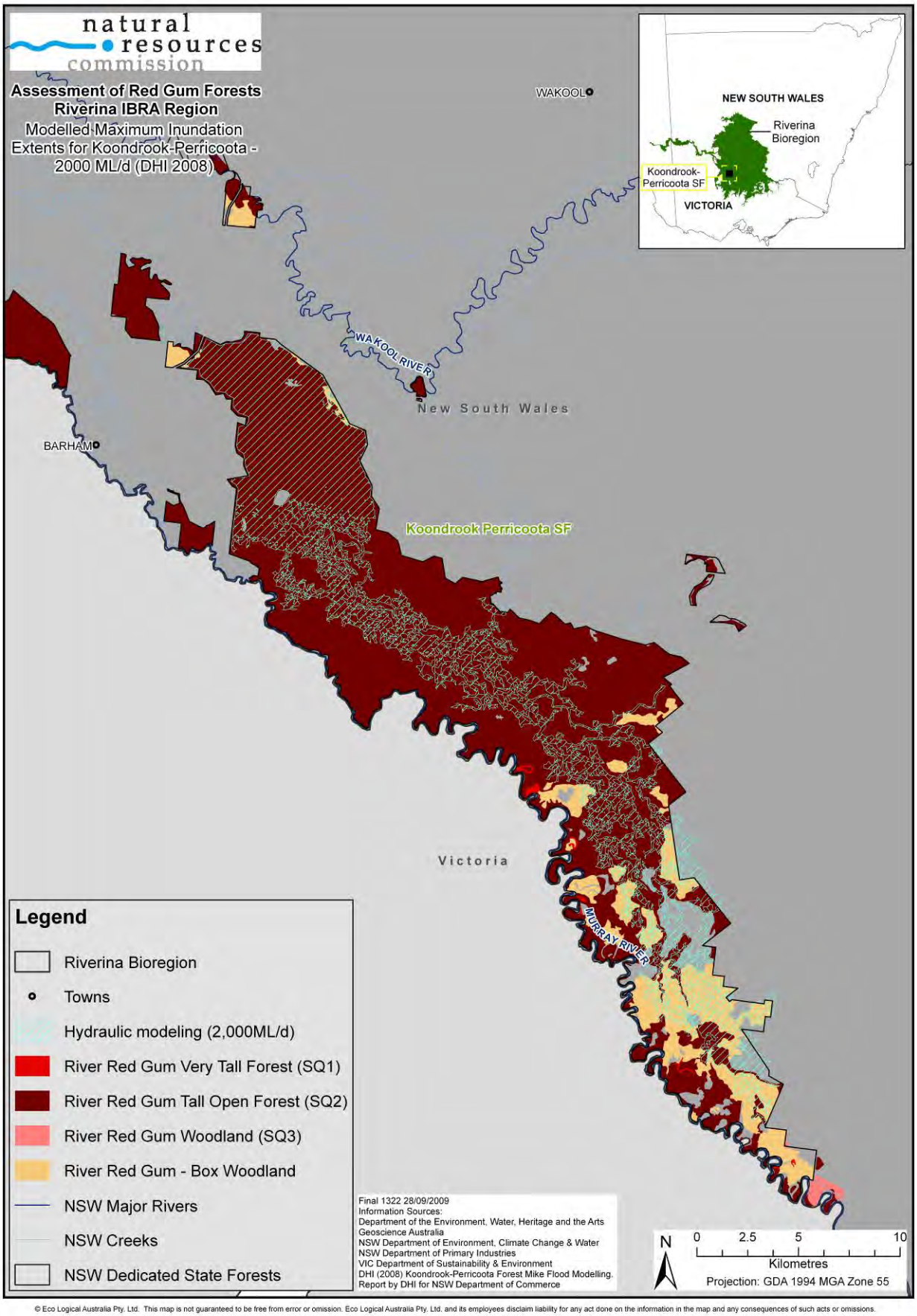

Figure 38 Modelled maximum inundation extents for Koondrook-Perricoota – 2000 ML/d (DHI 2008)

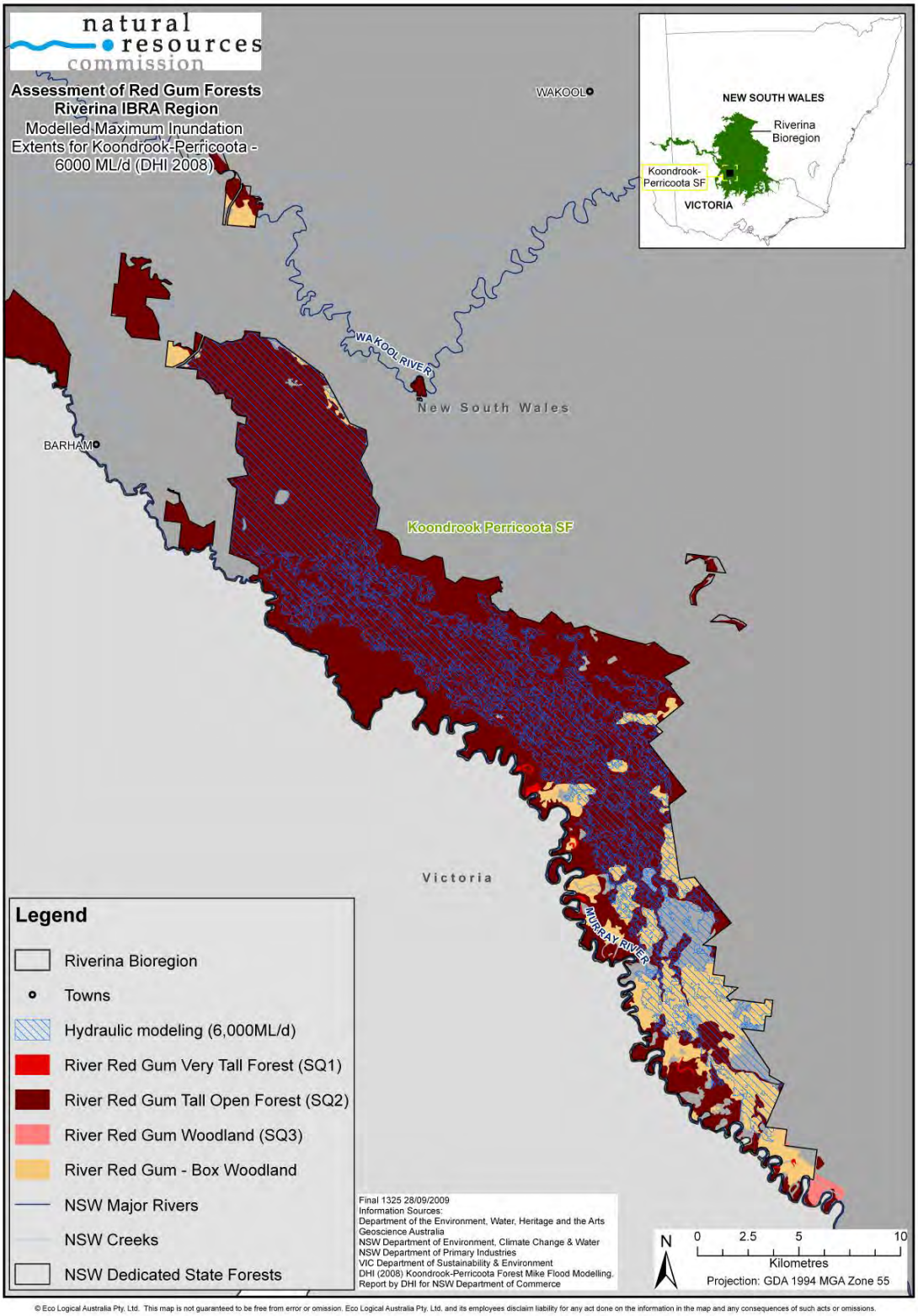

Figure 39 Modelled maximum inundation extents for Koondrook-Perricoota – 6000 ML/d (DHI 2008)

5.3.5 Flooding conclusions

Overall, the majority of the river red gum sites (87 percent) in Koondrook-Perricoota Forests are unhealthy or stressed (Turner and Kathuria, 2008). Without the proposed flood enhancement works, floods of the necessary frequency, volume or duration to provide for the water

requirements of significant areas of the forest will not occur. The Flood Enhancement Works will need to be undertaken for any significant improvement to the health of the Koondrook-Perricoota Forest to be achieved under historic climate conditions and projected climate change conditions.

The Living Murray modelling undertaken as part the Environmental Works and Measures Program indicates that water requirements of Koondrook-Perricoota Forest necessary to support the feasibility of the Flood Enhancement Works can be fully met by the 500 GL recovered by the First Step decision plus the 70 GL of Murray River Increased Flows – component. The frequency of flood events to be delivered and met in the modeling was approximately 1 in 3 years.

Based on flood extent modelling undertaken by DHI, the peak flood event for the flood enhancement works (6000 ML/d) would inundate 52 percent of the Koondrook-Perricoota Forest. This comprises inundation of 55 percent river red gum Tall Open Forest (SQ2) and 56 percent of river red gum – box woodland. The minimum flood event (2000 ML/d) would inundate 34 percent of the Koondrook-Perricoota Forests. This comprises inundation of 38 percent river red gum Tall Open Forest (SQ2) and 33 percent of river red gum – box woodland.

The Flood Enhancement Works will provide the flexibility to operate within a range of flows to sustain a range of ecological processes. The exact ecological outcomes arising from operation of the proposed structures will be unknown until they have been operated in real time, under a range of antecedent conditions and operation of the structures will be altered in line with adaptive management principles in order to react to the ecological response observed.

The Flood Enhancement Works are currently in the planning period. Construction (estimated to be complete by 2010), testing, monitoring and adapting operation will follow and so there is a lengthy time period between now and effective operation of the works for significant improvement to the health of the Koondrook-Perricoota Forest to be achieved.

5.4 Werai Forests

The assessment for the Werai Forests includes (where information is available):

- site characteristics and water requirements
- future water availability and flooding regimes
- the likely impacts of future water availability for the associated forests.

The Werai is hydrologically linked to flooding in the Millewa Forest via the Edward River. When flows exceed 10,400 ML/d in the Murray River (Barmah Choke capacity, measured at Yarrawonga Weir) water is diverted into the Edward River and flows on to the Werai Forests. Flooding commences in the forest when the flow at downstream Stevensons Weir is 2,900 ML/d. The predicted reduction in flood events in the Millewa Forest under climate change is likely to reduce the flooding extent in the Werai Forests. As the Werai is yet to have hydrological modelling conducted, the exact nature of this impact, and associated flooding extents cannot yet be determined.

5.4.1 Site characteristics

The Werai Forests consist of the northern portion of the NSW Central Murray State Forests and occupy an area of 11,403 ha, including the Werai State Forest and Barratta Creek State Forest (GHD 2009). The Forests are situated approximately 46 km northwest of Deniliquin, on the floodplain of the Edward and Niemur Rivers between Yadabal Lagoon and Morago (GHD 2009). This site is not an Icon site, however has Ramsar listed wetlands of international significance, including extents of river red gum forest.

The Werai Forests unit is hydrologically linked to the Millewa Forests via the Edward River (Figure 40). When flow exceeds the Barmah Choke capacity (> 10,400 ML/day at Yarrawonga Weir) substantial volumes of water are diverted down the Edward River and ultimately to the Werai Forests (GHD 2009). The Bullatale Creek also brings water from central Millewa to the Edward River near Deniliquin during periods of high flow (GHD, 2009).

The Werai Forests can be considered as having two WMUs (two commence to flow points), where low flow flooding can be managed differently to higher flow flooding.

Floodwater enters the forest via three effluents (Tumudgery Creek, Neimer Creek and Reed Beds Creek), all of which have regulator structures, as well as overbank flow. Generally, overbank flooding in the lower portions of the forest is initiated at flows of about 2,900 ML/day at downstream Stevens Weir (downstream of Deniliquin) (GHD, 2009). Flows up to 13,000 ML/d constitute broad area flooding (floodplain forests) (GHD, 2009). On average, the Werai Forests are flooded 3 to 4 days after the Millewa Forests are flooded.

5.4.2 Future water availability

As the Werai is hydrologically linked to Millewa forests, future water availability in the Werai will be impacted by water availability in the Murray River and Millewa Forests. The reduction in flood frequency of larger floods to Millewa Forest, particularly those > 25,000 ML/d will result in a subsequent reduction in flooding of the Werai. A more specific relationship between flooding in Millewa and flooding in the Werai is unknown at this time.

5.4.3 Future flooding regime

Hydrological modelling has not been undertaken for the Werai at the time of this investigation, therefore an assessment of specific flooding regimes and extents has not been possible.

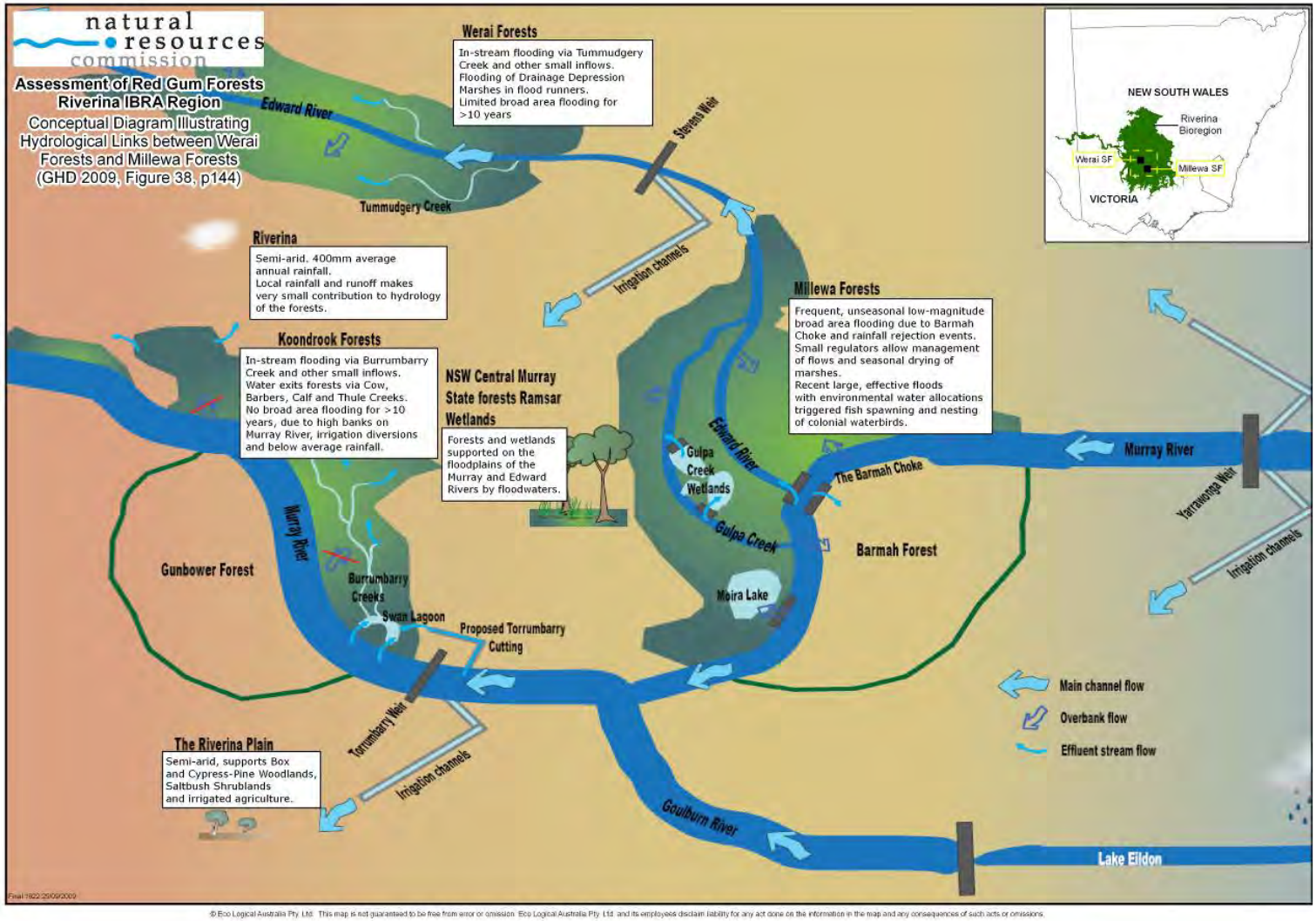

Figure 40 Conceptual diagram illustrating hydrological links between Werai Forests and Millewa Forests (GHD 2009, Figure 38, p144)

5.5 Murrumbidgee River

The assessment for the Murrumbidgee region includes:

- site characteristics and water requirements
- future water availability and flooding regimes
- the likely impacts of future water availability for the associated forests.

The Murrumbidgee River has two WMUs of interest:

- the Mid Murrumbidgee Wetlands (downstream of Narrandera)
- the Lowbidgee/Yanga region.

Future flooding to these zones is expected to decrease in frequency and magnitude under climate change, which will likely result in a reduction of inundation extent of river red gum stands along the Murrumbidgee River. A floodplain inundation model is not currently available for the Murrumbidgee region, therefore detailed information on the extent of river red gums inundated at various flow levels is not feasible at this time.

5.5.1 Site characteristics

The Murrumbidgee region is located within southern NSW and covers 87,348 km^2 or 8.2 percent of the MDB. The region is bounded to the east by the Great Dividing Range, to the north by the Lachlan region, and to the south and west by the Murray region. The Murrumbidgee River rises in the Snowy Mountains to the east, and flows 1,600 km westward across widening alluvial flats and onto broad plains towards its junction with the Lachlan and Murray Rivers. The Lachlan confluence is in the Great Cumbung Swamp 50 kilometres north-east of Balranald. The Murray junction is about 200 kilometres further west, and this area constitutes the Lowbidgee.

The Murrumbidgee region contains a total of 33 sites listed as wetlands of national significance, and two of these sites are Ramsar listed as wetlands of international importance. The two Ramsar sites consist of several wetlands including two large lowland complexes, the Mid Murrumbidgee Wetlands and the Lowbidgee Floodplain Wetlands (Figure 41).

Red gum forests adjacent to Murrumbidgee River

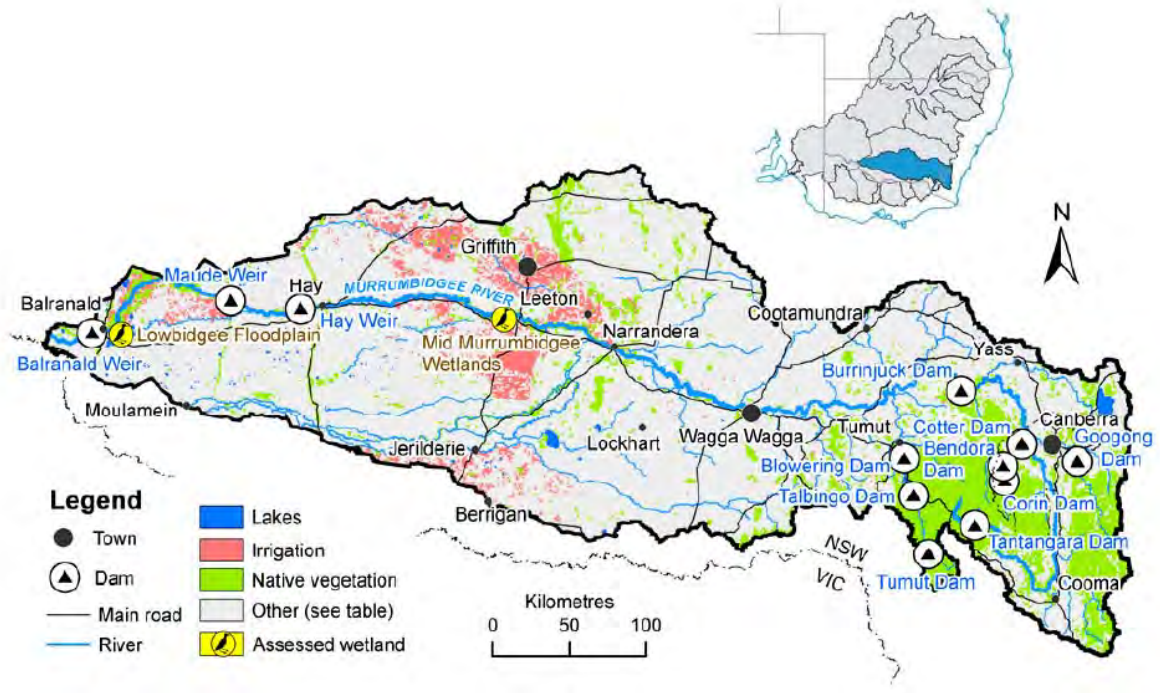

Figure 41 Landuse and key environmental assets in the Murrumbidgee region (CSIRO 2008b, Figure 2-2, p. 16)

Mid-Murrumbidgee Wetlands (downstream of Narrandera)

The Mid Murrumbidgee Wetlands are an assemblage of lagoons and billabongs along the Murrumbidgee River from Narrandera to Carrathool, with an estimated total area of 2,500 ha. Wetlands are on the floodplain and receive flows from the river mostly during winter and spring floods. River red gum forest and woodlands dominate the vegetation of the area with Black Box woodland being more marginal on the floodplain (CSIRO 2008b, Environment Victoria 2001).

Land tenure is a mixture of state forest, nature reserves, crown reserves and freehold. Commence-to-flow thresholds for billabongs and lagoons at several locations on the middle section of the Murrumbidgee Rivers are between 12 and 29 GL/day, and the Narrandera State Forest (a substantial wetland area) floods at 26.8 GL/day at the Narrandera gauge (CSIRO 2008b, Hardwick et al. 2001).

Lowbidgee/Yanga region

The Lowbidgee Floodplain is around the lower Murrumbidgee River downstream of Maude and covers some 200,000 ha. The broader Lowbidgee is sub-divided into the Nimmie-Pollen-Caira system near Maude Weir, and the Redbank-Yanga system further downstream. The floodplain receives floods overbank or via controlled diversions from Maude and Redbank weirs, which occurs most often during winter and spring (CSIRO 2008b, Kingsford and Thomas 2001).

Vegetation of the Nimmie-Pollen-Caira system is predominantly extensive areas of Lignum, however the Redbank-Yanga system is covered by river red gum forest and woodlands, with Black Box on the floodplain margins (CSIRO 2008b, Environment Victoria 2001). Land tenure is mostly freehold, although recently the NSW Government purchased much of the Redbank-Yanga portion (over 31,000 ha) and made it a national park in 2001 (CSIRO 2008b, DECC 2007).

The Murrumbidgee River decreases in channel capacity in a downstream direction from a channel capacity of 35 GL/day at Hay, 20 GL/day at Maude Weir and 11 GL/day at Redbank Weir (CSIRO 2008b, Kingsford and Thomas 2001). Overbank flows onto the Lowbidgee Floodplain occurs at 20 GL/day (at Maude), although controlled diversions from both Maude and Redbank weirs can occur at much lower flow levels (CSIRO 2008b).

The rivers of the region are greatly affected by the dams of the Snowy Mountains Hydro-electric Scheme, plus diversions for irrigation and water supply, with a total of 14 dams and 8 large weirs (Murrumbidgee CMA 2008). The current level of surface water extraction in the Murrumbidgee River is relatively high, with 53 percent of average available water being diverted for use (CSIRO 2008b). Since development and flow regulation/extraction commenced in the Murrumbidgee region, the average period between big floods that inundate the Mid Murrumbidgee Wetlands has nearly doubled, and the maximum period between events has more than tripled (CSIRO 2008b). For the Lowbidgee Floodplain, the average period between high flow events has more than tripled and the maximum period between events has more than doubled (CSIRO 2008b).

5.5.2 Future water availability

In 2008 the CSIRO completed an assessment of sustainable water yields in the Murray Darling Basin. Climate and hydrological modelling was conducted for a range of scenarios including:

- A – historical climate, with current development
- B – recent climate (based on last 10 years, step-change), with current development
- C – future climate to 2030, with current development.

Implications for flooding along the Murrumbidgee River, particularly for the Mid Murrumbidgee Wetlands and Lowbidgee Floodplain Wetlands, were assessed based on flood frequencies exceeding 26.8 GL/d at Narrandera gauge and 20 GL/day at Maude Weir, which represent the commence to flow volumes for inundation of the wetlands (Table 50).

Table 50 Definition of environmental indicators (wetland commence to flood flows) assessed by CSIRO (CSIRO 2008b, Table 7-1, p. 122)

Name	Description
Mid Murrumbidgee Wetlands	
Average period between high flow events	Average period (years) between flows exceeding 26.8 GL/d at Narrandera gauge
Maximum period between high flow events	Maximum period (years) between flows exceeding 26.8 GL/d at Narrandera gauge
Average flooding volume per year	Average annual volume above 26.8 GL/d at Narrandera gauge
Average flooding volume per event	Average event volume above 26.8 GL/d at Narrandera gauge
Lowbidgee Floodplain	
Average period between high flow events	Average period (years) between flows exceeding 20 GL/d at Maude Weir
Maximum period between high flow events	Maximum period (years) between flows exceeding 20 GL/d at Maude Weir
Average flooding volume per year	Average annual volume above 20 GL/d at Maude Weir
Average flooding volume per event	Average event volume above 20 GL/d at Maude Weir

Comparison of results across the modelled scenarios shows that high flow flooding sufficient to commence wetland inundation (as listed in Table 51) is, in general, likely to occur less frequently and be of lesser volumes (per year and per event) under climate change (step-change and 2030) (Table 51).

Table 51 Environmental indicator values under A, B and C, and percentage change (from Scenario A) in indicator values under scenarios B and Cmid (CSIRO 2008b, Table 7-2, p. 123)

	A	B	C mid	B	C mid
Mid Murrumbidgee Wetlands	years			percent change from A	
Average period between high flow events	0.8	2.0	1.0	150	29
Maximum period between high flow	9.7	10.9	9.7	12	0

events					
	GL			percent change from A	
Average flooding volume per year	652	202.1	443.4	-69	-32
Average flooding volume per event	525	383.3	451.5	-27	-14
Lowbidgee Floodplain	years			percent change from A	
Average period between high flow events	1.5	3.5	1.7	133	16
Maximum period between high flow events	10.5	16.2	10.5	54	0
	GL			percent change from A	
Average flooding volume per year	509	132.3	341.0	-74	-33
Average flooding volume per event	785	486.7	604.5	-38	-23

For the Mid Murrumbidgee Wetlands, under scenario B (step-climate change) the average period between high flows would more than double to be nearly 2 years, and the maximum period between events would increase slightly to nearly 11 years (CSIRO 2008b). Average flooding volumes per event and per year are also substantially reduced . Under scenario Cmid (2030 climate change) the average period between high flows would increase but the maximum period between events would not be effected (CSIRO 2008b). The average flooding volume per year and per event would also be reduced, and so further degradation to these wetlands is likely.

For the Lowbidgee Floodplain, under scenario B (step-climate change) the average period between high flows would more than double to be 3.5 years and the maximum period between these events would increase by over 50 percent to be more than 16 years (CSIRO 2008b). Average flooding volumes per event and per year are also substantially reduced. Under scenario Cmid the average period between high flows would increase but the maximum period between events would not be affected (CSIRO 2008b). The average flooding volume per year and per events would also be reduced, and so further degradation to these wetlands is also likely.

5.5.3 Future flooding regime

As indicated by the CSIRO modelling, future flooding is expected to decrease in frequency and magnitude (extent) which will likely result in a reduction of inundation extent of river red gum stands along the Murrumbidgee River. A floodplain inundation model is not currently available for the Murrumbidgee region, therefore detailed information on the extent of river red gums inundated at various flow levels is not feasible at this time.

5.6 Lachlan River

The assessment for the Lachlan region includes:

- site characteristics and water requirements
- future water availability and flooding regimes
- the likely impacts of future water availability for the associated forests.

The Lachlan River has two WMUs of interest:

- the Booligal Wetlands
- the Great Cumbung Swamp.

Future flooding to these zones is expected to decrease in frequency and magnitude under climate change, which will likely result in a reduction of inundation extent of river red gum stands along the Lachlan River. A floodplain inundation model is not currently available for the Lachlan region, therefore detailed information on the extent of river red gums inundated at various flow levels is not feasible at this time.

5.6.1 Site characteristics

The Lachlan region is located within central western NSW and covers 85,532 km2 or 8 percent of the Murray Darling Basin. It is bounded to the east by the Great Dividing Range, to the north by the Macquarie-Castlereagh region, to the north-west by the Barwon-Darling region and to the south by the Murrumbidgee region. The region's topography varies from tablelands in the east, through the central slopes and onto the western plains where the Lachlan River terminates in the extensive wetlands of the Great Cumbung Swamp (Figure 42).

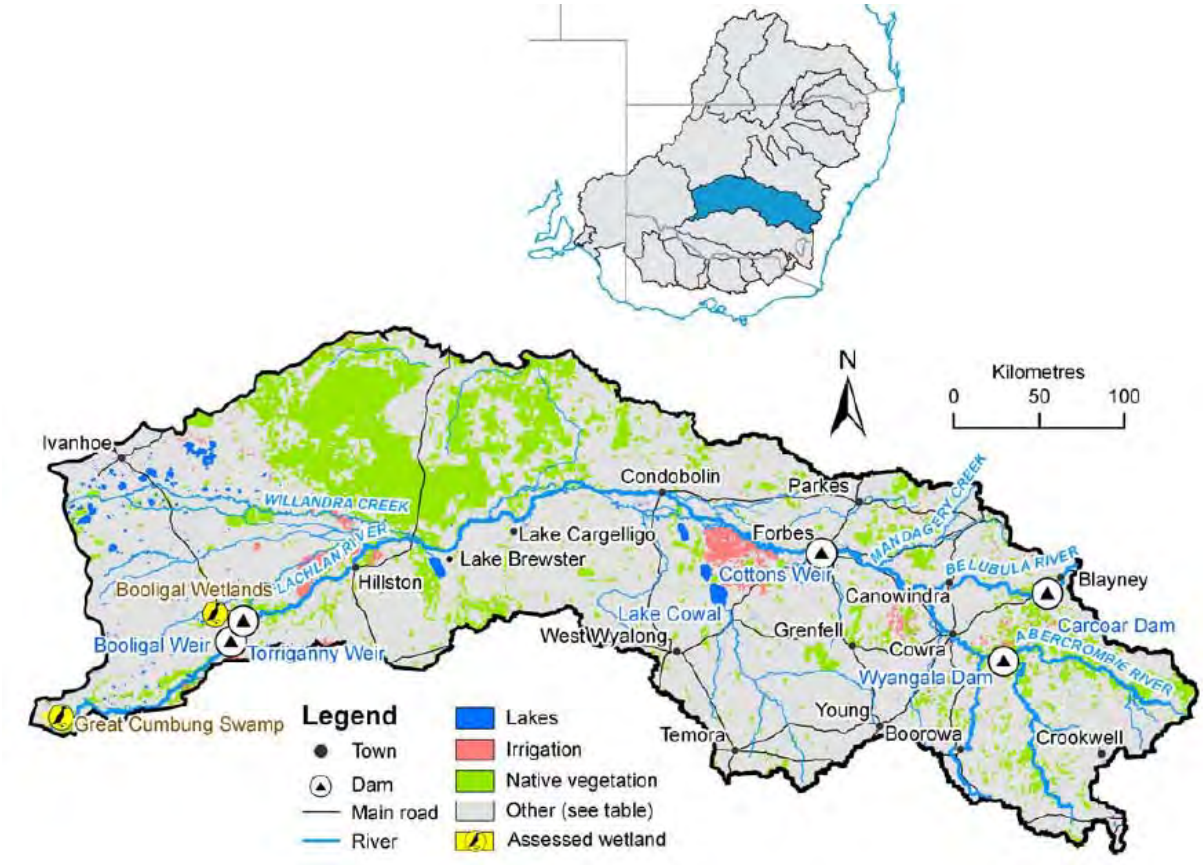

Figure 42 Landuse and key environmental assets in the Lachlan region (CSIRO 2008c, Figure 2-2, p. 16)

The Lachlan region contains several important and large wetlands of national significance, however there are no wetlands classified as Ramsar sites of international significance (CSIRO 2008c). The Booligal Wetlands and the Great Cumbung Swamp are amongst the most notable sites.

Booligal Wetlands

The Booligal Wetlands cover approximately 5000 ha on the lower Lachlan River, situated on the low-gradient braided channels of the Muggabah-Merrimajeel Creek, a distributary creek system which leaves the Lachlan River. The wetlands include the Booligal Swamp and Little Gum Swamp, the latter of which has a dominant over-storey of river red gum (CSIRO 2008c, Magrath 1992). Flood flows into the system are infrequent and the area drains rapidly once floods in the river recede (CSIRO 2008c, Environment Australia 2001). Large scale water bird breeding is understood to occur in the Booligal Wetlands when flows exceed 2500 ML/d for a period of two months at the Booligal gauge (CSIRO 2008c, Driver et al. 2005).

Great Cumbung Swamp

The Great Cumbung Swamp is around 16,000 ha at the terminus of the Lachlan River and is adjacent to the Murrumbidgee River and the Lowbidgee Wetlands. The swamp is dependent on flood flows in the Lachlan River (CSIRO 2008c, Environment Australia 2001). River red gum and black box cover large areas of the swamp (CSIRO 2008c). Broad scale flooding of the Great Cumbung Swamp is understood to occur when flows exceed 3000 ML/d at the Booligal gauge

(CSIRO 2008c, Brady et al. 1998), but an optimal duration has not been specified for these events.

Water regulation

The Lachlan River is regulated with large storages, and flows are also affected by major water extractions (CSIRO 2008c). As a result of water resource development, the average period between winter-spring floods entering the Booligal wetlands has increased from 6.2 years to 8.3 years (34 percent), and the maximum period between these events has increased from 18.7 to 22.2 years (9 percent) (CSIRO 2008c). The Great Cumbung Swamp has been similarly affected, with a substantial increase in the average period between winter-spring flood events from 1.2 years to 2.5 years (102 percent) (CSIRO 2008c). The maximum period between these events has also increased from 6.6 years to 16 years (143 percent). These changes are consistent with observed substantial reductions in the frequency and size of waterbird breeding events in the Booligal wetlands, and observed deterioration in the condition of vegetation in the Great Cumbung Swamp (CSIRO 2008c).

5.6.2 Future water availability

In 2008 the CSIRO completed an assessment of sustainable water yields in the Murray Darling Basin. Climate and hydrological modelling was conducted for a range of scenarios including:

- A – historical climate, with current development
- C – future climate to 2030, with current development.

Scenario B – step climate change was not modelled for the Lachlan.

Implications for flooding along the Lachlan River, particularly for the Booligal Wetlands and the Great Cumbung Swamp, were assessed by the CSIRO. Environmental indicators used were; flood frequencies exceeding 2500 ML/d at Booligal gauge, which represents the trigger for water bird breeding in the Booligal wetlands, and flood frequencies exceeding 3000 ML/d at Booligal gauge, which corresponds to significant flooding in the Great Cumbung Swamp (CSIRO 2008c).

Table 52 Definition of environmental indicators assessed by CSIRO (CSIRO 2008c, Table 7-1, p. 111)

Name	Description
Booligal Wetlands indicators	
Average period between high flow events	Average period (years between flows in excess of 2500 ML/day at Booligal gauge for 2 months between 15 May to 15 November
Maximum period between high flow events	Maximum period (years between flows in excess of 2500 ML/day at Booligal gauge for 2 months between 15 May to 15 November
Average flooding volume per year	Average flow volume above 2500 ML/d at Booligal gauge for 2 months between 15 May to 15 November per year
Average flooding volume per event	Average flow volume above 2500 ML/d at Booligal gauge for 2 months between 15 May to 15 November per event
Great Cumbung Swamp indicators	
Average period between high flow	Average period (years between flows in excess of 3000 ML/day

Name	Description
events	at Booligal gauge for 2 months between 15 May to 15 November
Maximum period between high flow events	Maximum period (years between flows in excess of 3000 ML/day at Booligal gauge for 2 months between 15 May to 15 November
Average flooding volume per year	Average flow volume above 3000 ML/d at Booligal gauge for 2 months between 15 May to 15 November per year
Average flooding volume per event	Average flow volume above 3000 ML/d at Booligal gauge for 2 months between 15 May to 15 November per event

Comparison of results between the modelled scenarios shows that high flow flooding sufficient to achieve water bird breeding and wetland inundation (Table 53) is, in general, likely to occur less frequently and be of lesser volumes per year (but not per event), under climate change (2030) (Table 53).

Table 53 Environmental indicator values under A and Cmid, and percentage change (from Scenario A) in indicator values under scenario Cmid (CSIRO 2008c, Table 7-2, p. 111)

	A	C mid	C mid
Booligal Wetlands indicators	years		percent change from A
Average period between high flow events	8.3	10.3	24
Maximum period between high flow events	22.2	22.2	0
	GL		
Average flooding volume per year	40.7	32.2	-21
Average flooding volume per event	376	394.8	5
Great Cumbung Swamp indicators	years		percent change from A
Average period between high flow events	2.5	3.1	24
Maximum period between high flow events	16	18.6	16
	GL		
Average flooding volume per year	47	36.2	-23
Average flooding volume per event	124	119.0	-4

For the Booligal Wetlands, under 2030 climate change the average period between winter-spring inflows into the wetlands would increase by a further 24 percent (CSIRO 2008c), which would likely reduce the frequency of waterbird breeding events in these wetlands (CSIRO 2008c). However the maximum period between events would not be effected.

For the Great Cumbung Swamp, under 2030 climate change the period between winter-spring flood events would increase by a further 24 percent, and the maximum period between these events would increase by a further 16 percent (CSIRO 2008c). These increases are likely to have an adverse affect on the vegetation of the swamp, of which a large portion is river red gum, and its use by waterbirds (CSIRO 2008c).

5.6.3 Future flooding regime

As indicated by the CSIRO modelling, future flooding is expected to decrease in frequency and magnitude (extent) which will likely result in a reduction of inundation extent of river red gum stands along the Lachlan River. A floodplain inundation model is not currently available for the Lachlan region, therefore detailed information on the extent of river red gums inundated at various flow levels is not feasible at this time.

5.7 Other forests and riparian zones

The assessment for other smaller forested areas and significant riparian zones across the bioregion includes (where information is available):

- site characteristics and impact of regulation on water availability
- comments on implications for flooding where possible.

Smaller pockets of river red gum stands are supported by the Murray River, Edward River and Wakool River riparian zones. The flow regimes of these sections of river are heavily modified by regulation upstream, and the delivery of irrigation water.

Some river red gum stands along the upper Murray River (including the Barooga group of forests) are currently benefiting from frequent flooding associated with the delivery of irrigation water to downstream. However, river regulation has also had negative impacts on other stands of river red gum further downstream. As a consequence of high levels of regulation and extreme drought conditions, water in the Wakool River has diminished to a series of disconnected waterholes. Further downstream again on the Murray River less than half the natural median annual discharge now reaches the border with South Australia, and the frequency, duration and magnitude of all but the largest floods have been reduced.

5.7.1 Upper Murray River riparian zone

The Upper Murray riparian zone is located between Albury and Tocumwal. The flow regime of this zone is heavily modified by the storages of Hume Dam, Yarrawonga Weir and the Snowy Mountains Scheme. The National Land and Water Resources Audit 2000, in its hydrological disturbance index rated the zone as moderately modified (NWC 2007).

The effect of regulation varies throughout the zone. At Albury the river flows have increased compared to natural flows as a result of extra water diverted from the Snowy scheme. Downstream of Yarrawonga, annual flow is 25 percent less than natural conditions, but summer flow is 19 percent greater than natural (Gippel et al, 2002). Flow variability has been decreased and water level is held at relatively constant near capacity discharge for much of the year. Seasonality has been altered, and the frequency and duration of winter/spring flooding has been reduced (Gippel et al 2002). The summer and autumn flows are higher than natural whilst winter and spring flows are lower. Overall, the average annual flow is approximately 6 percent higher than natural conditions (MDBC, 2008).

Regulation has increased the proportion of total flow passing down the river channel from about 88 percent to 94 percent. During high flows the remaining 6 percent overtops the bank and inundates the floodplain (MDBC 2008).

The Barooga group of forests along the upper Murray are known to be in good condition on account of their relatively regular flooding (due to irrigation releases). These forests are the most eastern in the NSW Riverina and are comprised almost entirely of river red gum of varying site quality.

However, other riparian vegetation in the zone is poor due to grazing and alterations to flow regimes (MDBC, 2006). River red gums have been cleared over much of the floodplain and riparian zone. There are however, isolated sections of riparian zone and floodplain that have reasonable Indigenous vegetation associations, particularly toward the upstream and downstream ends (ID&A, 2001). Regeneration is notable in several areas within the zone. Woody weeds, predominantly willows, are scattered throughout this zone with several sections dominated by exotic vegetation (ID&A, 2001).

To meet its commitments downstream for town water supply, irrigation and environmental flows the MDBC can legally release flows of up to 25,000 ML/d (extent of easements) along this reach between Hume Dam and Lake Mulwala (Peter Brown [GHD] pers. comm. 14 Sep 2009). One of the positive impacts identified when justifying the release of up to 25,000 ML/d is the potential for survival of river red gum stands. This volume is historically regarded as bank full. Due to the passage of time and an aggrading channel bed the definition of bank full has changed and a number of the Murray River channels have changed shape and dominance. Some of these channels are now located in private land. Due to this the 25,000 ML/d now impacts on private land. The MDBA has set up a framework and model for determining relief packages for landholders facing inundation and access issues due to the regulated river flow regimes (Peter Brown [GHD] pers. comm. 14 Sep 2009). This 25,000 ML/d is the same easement constraint referenced earlier under the Barmah-Millewa discussion, and may be increased in the future.

5.7.2 Wakool River riparian zone

Downstream of Deniliquin the Edward River emerges onto a broad, flat floodplain. Enclosed between the Edward and Murray Rivers and fed from the Edward River, is the Wakool River which is part of an extensive network of high level anabranches. During major flood conditions approximately 50 percent of the total flow passing Deniliquin leaves the Edward River via the Wakool and Yallakool Rivers (MCMA, 2006c). As a consequence of prolonged and extreme drought conditions and a high level of regulation upstream, the water in the system is diminishing to a series of disconnected waterholes (MDBC, 2007). In 2008 the continuous environmental flows for the system ceased. Now only occasional pulse flows are provided to the system (WSC 2009).

Parts of the Wakool River system adjoin the Koondrook-Perricoota Forest, one of The Living Murray six Icon Sites, and comprises hundreds of kilometres of rivers and creeks. The river system and adjoining forest are recognised as having high ecological value (MDBC, 2007).

5.7.3 Lower Murray River riparian zone

The hydrological regime of this section has been significantly changed. Less than half the natural median annual discharge now reaches the border with South Australia (Gippel et al 2002). Periods of prolonged low flow are more frequent. The frequency, duration and magnitude of all but the largest floods have been reduced (Gippel et al 2002). This results in a reduction in the inundation extent and frequency of the adjacent floodplain and associated vegetation.

5.8 Implications for environmental values supported by forests

5.8.1 Millewa Forests

Summary

Millewa is likely to be more resilient to adverse impacts of climate change compared to other river red gum forests in the Riverina. The forest is large and heterogeneous, providing opportunities for species to move and adapt within it. The forest requires relatively low flows (compared with downstream forests) to achieve reasonable levels of flooding, so a large proportion will retain its ecological structure and function. A small proportion of high productivity red gum is likely to transition to low productivity Red Gum, but with critical habitat such as large hollow trees and fallen dead timber persisting. Up to 5 percent of Red Gum and some wetland may be lost, but enough will remain to provide a refuge for individual species. Together with Barmah Forest to the south, Millewa is likely to be the future refuge for threatened species such as Superb Parrot, Barking Owl and Brush-tailed Phascogale.

Vegetation distribution response

In presenting the likely ecological response to reduced flows through the Millewa Forests, it is assumed that 18,300 ML/d can be delivered to the Barmah-Millewa Forest into the future. This volume is below the necessary volume to achieve the interim ecological objectives stated within the Icon Site Management Plan for Barmah-Millewa Forest to "*ensure healthy vegetation in at least 55 percent of the area of the forest (including virtually all of the Giant Rush, Moira Grass, river red gum forest, and some river red gum woodland)*" (MDBC 2006a). Revised projects suggest only 34 percent of river red gum SQ1, 13 percent of SQ2, and 3 percent of SQ3 will be regularly inundated in Millewa at 18,300 ML/d. The implications of this reduced volume on changes to vegetation structure and floristics within Millewa is difficult to predict in the absence of long-term monitoring data, and is complicated by a poorly understood sub-surface hydrology. However, broad assertions can be made about the distributional and structural response of vegetation communities in Millewa to changed flooding regimes, and likely ecological responses of key species that characterise these communities.

Along with the Albury to Tocumwal cluster of forests, the Millewa block is arguably more resilient to adverse impacts of climate change than those occurring along lower reaches of the Murray and branches, and those on the Lachlan and Murrumbidgee, as commence to flood volumes are generally lower. Thus we would expect that a relatively high proportion of the Millewa Forests will retain its broad structure and composition, particularly those forests areas in the 18,300 ML/d flood zone.

The magnitude and type of change to river red gum forests occupying more elevated parts of the Millewa floodplain is dependent on hydrological behaviour and access to sub-surface water. Change is likely to vary considerably across the extent of forest, with some pockets supported over a longer period by sub-surface aquifer flow while others are not.

In general terms it is likely that in the complete absence of rejuvenating floods the health of the river red gum forests would decline to a point at which the canopy will senesce completely, and the forest will no longer be able to produce seed and propagate. For forests to survive over time it is necessary for young saplings to be recruited to the population of mature trees (eucalypts live 200-500 years) which over time naturally thin to mature forests of greater intra tree spacing (Sutherland et al 2004). If all the trees die without seeding, in the absence of flooding the stand is likely to assume the structure of a derived community dominated by native tussock grasses

and perhaps a few native shrubs, with possible influx of more arid understorey species (e.g. chenopods such as copperburr) and weed species. It is not likely that other native canopy species such as black box will assume dominance or transition into these forests unless they are already present in the stand, or unless planting is considered as part of a silvicultural response, as seeds of most eucalypts fall close to the canopy of the parent tree (Doug Binns pers. comm.).

It is difficult to quantify the extent of the Millewa Forests which is susceptible to complete loss of river red gum forest and woodland through water stress. Given the relative ease of securing environmental flows in this forest, and the prerogative of doing so in the context of the adjacent Barmah reserves in Victoria, it is unlikely that more than 10 percent of the Millewa Forests will be lost over the next 50 years unless flow conditions worsen considerably. Those lost will be largely river red gum woodland stands, some of which may continue to support scattered Black Box or other Box species.

It is likely that a proportion of very tall red gum forest and tall open river red gum forest in the Millewa block will assume a structure and vigour of river red gum woodland stands over the long-term. Trees will generally survive but regenerating trees will not achieve the size and height of the parent trees. Sedge and herb elements of the understorey are also likely to be replaced by tussock grasses, and possibly native hardy shrubs.

Other vegetation communities in the Millewa Forests are likely to respond in different ways to a changed flooding regime. White cypress may slowly radiate from the sandhill cypress community over time as it assumes space within former red gum forest. The various wetlands in Millewa are likely to contract and be replaced by red gum, with the exception of those subject to regular flooding. The river red gum/box communities of the Millewa will persist, with box species becoming more dominant over the long term.

Ecological values response

The Millewa Forests contain a complex mosaic of integrated flood-dependent communities including:

- swamps and marshes in the lower, frequently flooded areas where water can pond to a degree
- rush beds surrounding these, also generally in wetter areas. These provide nesting and feeding habitat for ibis, waterfowl and frogs
- lakes and billabongs, generally deeper water environments, providing habitat for biota such as fish and macro-invertebrates. These are also very important in providing feeding areas for large colonial bird breeding events
- localised moira grass plains. When flooded, these are highly significant as breeding and feeding habitat for colonial breeding waterbirds like egrets, herons, spoonbills and marsh terns
- red gum forest of various qualities depending on inundation, with the lower elevation areas supporting larger and denser red gum forest
- black box woodland in the high, drier zones (MDBC 2006a).

The relatively large size of the Millewa Forests (in combination with the Barmah Forest to the immediate south) and its heterogeneity, as well as the relatively low flows required to flood large sections of the forest (for example, in comparison to other forested wetlands) provide its

fauna residents with a reasonable level of long-term resilience to the impacts of climate change. This is important as the Millewa Forests provide habitat for large numbers and a diverse group of fauna, with 54 species of waterbird known to breed (Leslie 2001), and many arboreal and ground-dwelling fauna (e.g. Webster et al. 2003). Amphibia, mammals and fish all benefit from the diversity of habitat, its large size, and frequent flooding. Millewa is arguably the best refuge for many fauna species dependent on river red gums along the Murray, and should be considered as the major refuge of the species assemblage typical of these forests.

5.8.2 Koondrook-Perricoota Forests

Summary

Koondrook-Perricoota Forests and Campbells Island provides further habitat security for ecological communities and individual species associated with river red gum in the NSW Riverina. The forest will continue to provide habitat for a range of resident communities and species into the future. Modification to vegetation community structure is likely to be significant, with much of the high productivity Red Gum transitioning to lower productivity Red Gum, but with critical habitat such as large hollow trees and fallen dead timber persisting. Perhaps 20 percent of the river red gum community will transition to a derived scrub on the outer floodplain in the absence of future floods, but sufficient core habitat will remain to provide a second refuge for individual species after Millewa. Species such as Superb Parrot and Gilbert's Whistler will be supported in Koondrook-Perricoota under projected flood regimes.

Superb Parrot

Vegetation distribution response

In presenting the likely ecological response to reduced flows through the Koondrook-Perricoota Forests, the minimum regime as modelled under the Works and Measures Program of 2,000 ML/d is selected, delivered into the forest via the Koondrook-Perricoota Forest Flood Enhancement Works from a total flow of more than 25,000 ML/d flowing from the Murray and Goulburn Rivers. An estimated 34 percent of the forest would be inundated under this scenario. It is acknowledged that a range of flows would be delivered to the forest through operation of the Enhancement Works. This event is adopted as a base, however this assessment considers the range of factors influencing flows to the forests.

The implications of this reduced volume on changes to vegetation structure and floristics within Koondrook-Perricoota is difficult to predict in the absence of long-term monitoring data, and is complicated by a poorly understood sub-surface hydrology. However, broad assertions can be made about the distributional and structural response of vegetation communities in the Koondrook-Perricoota Forests to changed flooding regimes, and likely ecological responses of key species that characterise these communities.

Located downstream of the Millewa forest group, the Koondrook-Perricoota Forests are likely to change somewhat more dramatically than Millewa in future, despite the proposed engineering works.

In general terms it is likely that a considerable proportion of the tall and very tall red gum forests will transition over time to a structure and vigour of river red gum / woodlands stands. Trees will generally survive but regenerating trees will not achieve the size and height of the parent trees. Sedge and herb elements of the understorey are also likely to be replaced by tussock grasses. In the absence of regular flooding the health of the river red gum woodland will continue to decline to a point at which the canopy will senesce completely, and the forest will no longer be able to produce seed and propagate. Similar to Millewa, parts of the stand are likely to assume the structure of a derived grassland or chenopod community.

It is difficult to quantify the extent of the Koondrook-Perricoota Forests which is susceptible to complete loss of river red gum forest and woodland through water stress. However, it is possible that 20-25 percent of the river red gum forest will be lost over the next 50 years, possibly more if flow conditions worsen. Those lost will be within the tall open red gum forests and red gum woodlands stands, some of which may continue to support scattered Black Box or other Box species, but many of which will convert to derived shrubland/grassland.

Other vegetation communities in the Koondrook-Perricoota Forests are likely to respond in different ways to a changed flooding regime. The various wetlands are likely to contract and be replaced by Red Gum, with the exception of those subject to regular flooding. The river red gum/box communities will persist, with box species becoming more dominant over the long term. There may be increased incursion of white cypress onto the outer margins of the floodplain.

Ecological values response

The river red gum forest in Koondrook Perricoota is the second largest in Australia behind Barmah-Millewa), with Black Box woodlands, Grey Box and Yellow Box woodlands, reed beds and grassland communities less dominant. The region comprises a diverse assemblage of flora and fauna, including species of state, national and international significance, and the wetlands themselves are of international importance. The site has particular significance for breeding colonies of Intermediate Egret (MDBC, 2005), Little Egret, Great Egret and Nankeen Night Heron (MDBC, 2006).

Most of the ecological values documented for these forests concern vegetation and birds (MDBC, 2006). These ecological values are threatened by water regulation, weeds, timber harvesting, in-stream barriers to fish and water movement, inappropriate fire regimes, pests and grazing (MDBC 2006). Water regulation and altered flow regimes present one of the highest risks to ecological function. There has been a 58 percent reduction in small floods, 77 percent reduction in medium to large floods and 55 percent reduction to large floods (URS, 2001, cited in MDBC 2005), resulting in decline in forest health (Turner and Kathuria, 2008).

More specifically MDBC (2005) note that these threats will lead to impacts such as reduced connectivity between wetlands and the river, reduced fish breeding, decreased diversity, loss of wetland types, reduction in wetland extent, and increased weed invasion.

Similar to Millewa, the Koondrook-Perricoota site is reasonably large and this forest will offer a reasonable level of resilient habitat for fauna assemblages in years to come. Habitat will be retained in the long-term for hollow dependent species such as superb parrot and Barking Owl, and various arboreal mammals. Much of the forest will retain a structure and mosaic which facilitates continued movement of these species. The diversity of permanent wetlands subject to planned environmental flows should also provide refuge for wetland dependent species such as Growling Grass Frog and Giant Banjo Frog.

Barking Owl
Courtesy: Russell Jago

5.8.3 Werai Forests

Summary

Of the three Ramsar sites, Werai is likely to be most degraded by water scarcity. Over 40 percent of the Red Gum stand and associated wetlands could be lost within 50 years if current conditions persist, or worse if conditions deteriorate, and as a result resident species will be forced into a contracting area of core habitat. This area may not be sufficient to support species with large home ranges such as the barking owl, and may not support the breeding requirements of wetland dependent fauna such as Blue-billed Duck and Freckled Duck. Breeding success of such species will depend on the health and persistence of other functional forests, where change is likely to be less severe.

Vegetation distribution and ecological values response

While no specific hydrologic modelling is available, the potential ecological impact of hydrological change in the Werai forests is likely to be more severe than that in the Millewa and

Koondrook-Perricotta. Flows of between 3,000 to 13,000 ML/d downstream of Stevensons weir are required for broadscale inundation of the Werai forests (GHD 2009).

If predicted flow reductions are correct, the likely implication for Werai is at least a 50 percent decline in the distribution of tall and very tall red gum forests as they either transition to river red gum woodland (and assume a changed floristic composition in the understorey), or transition to a derived grassland/scrub with widespread canopy mortality. The overall area of river red gum will also decline as the woodlands stand on the less frequently watered parts of the forest senesce and die, also replaced by a derived grassland/scrub. The extent of loss of woodland areas might be as much as 40 percent in the Werai forests over the next 50 years if current flow projections are maintained. Over 90 percent of stands in the Werai are currently unhealthy (GHD 2009).

The forecast magnitude of change in the Werai Forests raises questions about the capacity of some species to persist, particularly those with large home ranges such as forest owls and raptors, and wetland dependent species such as Blue-billed Duck and Freckled Duck. Of the three Ramsar sites, Werai is most susceptible to major ecological change and local species extinction.

Despite the bleak outlook for Werai, it is important to consider that imminent loss of a Red Gum ecosystem in Werai and other Red Gum forests does not necessarily mean that rejuvenation in future is not possible if long-term flooding regimes are restored. The geomorphological characteristics of Werai and other areas, to which river red gum stands have adapted over thousands of years, are not themselves likely to shift in response to climate change. Because river red gum seeds are sometimes carried significant distances by floodwaters, severely stressed and dead stands of river red gum could conceivably recover following a major flood, as a result of deposition of seed from elsewhere on the floodplain and subsequent regeneration. The ecological functionality of such a stand will be compromised as large hollow trees are replaced by regenerating saplings of lower habitat value, however, given persistence of favourable conditions, stands might assume an adequate level of functional habitat with 200-500 years (e.g. Sutherland et al. 2004), allowing species to recolonise. However, climate change scenarios do not suggest that climatic conditions will become more favourable over sustained periods in the foreseeable future.

5.8.4 Murrumbidgee River

Summary

The Murrumbidgee wetland areas have declined appreciably over the past 20 years, with major loss of wetland area and waterbird numbers in the catchment. This trend is likely to continue with climate change, as central-west NSW experiences drier, hotter conditions. Important wetland species such as Australasian Bittern, Blue-billed Duck, Freckled Duck and Southern Bell Frog will decline further as breeding habitat contracts.

Vegetation distribution and Ecological values response

While no specific hydrologic modelling is available, the Murrumbidgee system is forecast to receive less floodwater, with negative implications for the Mid Murrumbidgee and the Lowbidgee Floodplain Wetlands. As with other river red gum regions, the vegetation response to lower flows will be contraction of tall and very tall red gum forests stands to regularly flooded zones and subsurface aquifers, and loss of some stands on the outer floodplains. Ultimately Black Box will not survive because the flow regime to these parts of the floodplain

has changed so much from when they were recruited (Kingsford and Thomas 2001). These are likely to transition into native grasslands.

There is also likely to be continued loss of the extent of the major wetlands fed by the Murrumbidgee. Kingsford and Thomas (2001) used satellite imagery (Landsat MSS Imagery) for the period 1975 to 1998 to determine the extent of wetland loss in the Lowbidgee Wetlands, and bird counts to record losses in bird numbers from previous bird censes. The research found that to 2001 around 58 percent of the floodplain wetlands had been lost, much of the damage occurring between 1975 and 1998. Of those remaining at the time, 44 percent were degraded, with the floodplain vegetation having little chance of returning to health. The authors observed that flood-dependent aquatic vegetation at the margin of wetlands exhibited reduced health and poor canopy growth. Aquatic macrophytes were unlikely to establish except during extreme events. Even within core areas of the wetlands, reduced health with poor canopy growth was observed, apart from along the floodways where macrophytes such as cumbungi were well established in response to increased flows. Correspondingly lignum was observed to be in poor health in floodways because of increased flooding.

Waterbird numbers were observed by Kingsford and Thomas (2001) to have collapsed by more than 80 percent since 1983. Maher (1990) considered that the Lower Murrumbidgee floodplain was of national importance for nine species of waterbird (including Australian Bittern and Freckled Duck). For the six species for which data were available, Kinsgford and Thomas (2001) provided evidence that numbers of all six have declined, particularly after 1995, and that most other individual waterbird species had declined in numbers over an 18 year period. Kingsford and Thomas (2001) also suggest that invertebrates, fish, frogs (including the nationally significant Southern Bell Frog) and water plants which the birds feed on are in decline because of reduced habitat area, and that long-term reduction in breeding is expected.

Other studies have also shown a general decline in the condition of the Murrumbidgee River and its wetlands and floodplain (e.g. Jansen and Robertson 2005; Hillman et al 2000).

5.8.5 Lachlan River

Summary

The Lachlan River feeds the Booligal Wetlands and Great Cumbung Swamp. Similar to the Lowbidgee wetlands on the Murrumbidgee to the south, these wetlands are under severe stress as a result of river regulation and climate change, with flood events and breeding populations of waterbirds in decline. Wetland fauna such as Blue-billed Duck and Freckled Duck may not be supported by these wetlands in future. The associated river red gum stands of the Lachlan River are known to support Superb Parrot and other key species. If the condition of the Lachlan deteriorates further, such species may also disappear from the Lachlan over coming decades.

Vegetation distribution and Ecological values response

The major implication for reduced flows into the Booligal Wetlands and Great Cumbung Swamp relates to water breeding habitat and amphibian habitat. The Great Cumbung Swamp for example comprises one of the largest reed beds in south eastern Australia and provides important habitat for waterbirds, amphibians and other fauna (Inland Rivers Network 2007).

River regulation of these systems has resulted in an increase in the number of trees exhibiting signs of stress in the Booligal Wetlands (Armstrong et al 2009). Without periodic flooding (as frequent as 1 in 3 years for optimal growth), the health of river Red Gums will decline and

continued drought will result in loss of seed production, recruitment and crown cover. These will have flow on effects through the ecosystem, with implications for the food chain and thus function of the system. In the absence of a healthy tree crown there will be insufficient leaf fall to form a detritus layer, which flows onto the abundance of detritus dependant flora and fauna, affecting the food supply of higher organisms such as fish and waterbirds. Quantifying the impact is not possible.

The breeding cue is for many of the waterbirds and migratory shorebirds recorded in Booligal Swamp is flooding (Scott 1997) so that loss of species from these systems such as the Blue-billed Duck and Freckled Duck can be anticipated in the absence of periodic flooding events. Without substantial change to water allocation and flooding, there will be continual demise in the health of water dependant vegetation communities, irregular instances of breeding in waterbirds and declines in amphibian species. Terrestrial vegetation dominated by grasses and shrubs are likely to encroach into former wetlands and riparian sites.

5.8.6 Other forests and riparian zones

The relatively reliant floodwater received in Barooga and other state forests immediately west of Albury suggests that this system is least likely to change in terms of vegetation type or species composition (fauna and flora). SQ1, SQ2 and SQ3 stands should maintain their level of productivity and regeneration potential, and will continue to support key ecological values. These small forests provide a refuge for several fauna species known to rely on river red gum along the Murray, including Powerful and Barking Owls, Koala, Brush-tailed Phascogale and Superb Parrot.

In contrast, the Wakool and Edwards regions are relatively low in the catchment and are thus susceptible to low water allocations, as water is fed downstream for irrigation and domestic supply, or is absorbed upstream for irrigation or environment. The vegetation response is likely to be considerable, with most of the tall and very tall river red gum forest assuming a structure and productivity of open river red gum woodland over the long-term, and up to 40 percent of SQ3 transitioning from red gum to derived copperburr or grassland in the next 50 years.

The major icon species of the lower Murray is the Regent Parrot which is reliant on hollow trees within river red gum. The implication of a changing ecology in the western Red Gum stands for species such as Regent Parrot is very unclear. Available habitat within its current range will be reduced over the long-term, but the species may adapt by moving east into areas such as Koondrook-Perricoota Forests.

5.9 Implications for social and economic values supported by forests

5.9.1 Wood production

Available information on the impact of changes in flooding frequency on growth rates suggest significant reductions are likely if current conditions continue. Preliminary (unpublished) work by Forest NSW indicates that growth rates may have halved since 2003 when compared to the period between 1970 and 2002. While direct comparisons with other areas are not possible due to differences in water management and silvicultural practices, this trend is consistent with work conducted by the Victorian DSE that showed a decline in growth rates Barmah and Gunbower forests between 1998 and 2005 to 60 percent of the rates recorded in previous periods (VEAC, 2009, p. 68).

However, assessment of growth rates from past periods of drought, while useful, can only provide an indication of future yields should conditions remain within previous ranges. Preliminary (unpublished) work by Forests NSW indicates that, in addition to reductions in growth rates, mortality rates have doubled. As expected flooding frequencies under climate change scenarios are unlikely to sustain current vegetation communities, increasing mortality can be expected as natural processes act to reduce competition for available water.

The management implications of significant reductions in growth rates and increases in mortality are that long term sustainable yields will need to be revised downward with greater reductions likely for higher quality sawlogs than for low quality sawlogs or residue. As shown in Table 54, the most productive areas for wood production are in the Millewa Forests. As Table 55 shows, a reduction in net harvestable area or yields per hectare in the Murray Management Areas will have a greater relative impact on the production of high quality sawlogs than on other product classes.

Table 54 Proportion of Murray Management area wood yields by water management unit

Water management unit	Wood yield (percent of sustainable yield for Murray MA)
Millewa forests	56
Koondrook-Perricoota and Campbells Is	30
Werai forests	8
Upper River Murray Riparian Zone	3
Edward/Wakool and Edward River riparian zone	3

Notes:

1. 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.
2. 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.

Table 55 Proportion of Riverina wood yields from Murray Management Area

Product class	Wood yield (percent of sustainable yield across all Riverina MAs)
Quota (High quality sawlogs)	76
Ex-quota (Low quality sawlogs)	63
Residue	62

Forests NSW FRAMES model is currently being recalibrated to reflect the reduction in growth rates and increase in mortality rates observed since 2003. However, the empirical nature of the model means it assumes there will be cyclical drought and flooding events in the future to sustain the forests, and that the extent, structure and condition of the forests remain much as they have been for the past decade. The model is therefore not able to predict the impact of significant changes in vegetation classes.

5.9.2 Social values

In a future of increasing variability in climate, and reduced water allocations, the towns of interest in the bioregion will face increasing pressures. This is primarily due to the high reliance of these communities on agricultural industries.

Likely structural change in the irrigation sector, combined with increased variability in the income stream of dryland farmers, will place stress on the secondary and tertiary businesses that support agriculture. These include businesses that provide inputs (such as machinery, fuel, and fertiliser) and those that provide services (such as accountants and agronomists).

These financial pressures impact on the level of employment in these centres, can result in increased migration to larger regional centres or metropolitan areas and affect the overall cohesion of the community.

5.9.3 Economic values

The impacts of future change on river red gum milling businesses may be in a number of forms. These could include:

- changes to sawlog supply to the industry
- changes to sawlog supply to particular mills
- changes to the residue supply to the industry
- changes to the quality of sawlog supply which will affect the product output mix
- supply prices
- costs of harvest and/or haulage
- alterations to quota conditions
- specification of timeframes on supply, and
- effects on the perceived uncertainty of future supplies under an adaptive management approach.

Other studies such as the VEAC socio-economic study (Gillespie, 2008) have taken a linear approach to assessing impacts and have implemented this across the region. This assumes a mechanism for adjustment is either available at a mill or industry level to allow for reduced supply volumes.

The initial discussions with the eight mills reveals that each business has taken recent steps within their business that highlight a response to changes in likely supply or are increasing flexibility within the business to adjust to a variable future.

The broad options open to mill management and residue operations can be classed as:

- cease operations
- finetune existing operations to deal with lower throughput
- focus on increasing harvest efficiency and log utilisation as quality of supply changes
- seek alternative supply from outside the region, opportunistic supply such as thinnings tenders and/or private lands

- invest in value adding opportunities to seek greater returns from high quality logs
- diversify the existing business by adding firewood enterprises, and
- buy quota when it becomes available.

Businesses that have been surveyed as part of the profiling phase are distinctive. Each has taken different approaches to maximise their returns. The current status of plant and equipment, business focus, current supply volumes, log quality and the associated ability to adjust is variable.

Attachment 1 Terms of Reference

Premier of New South Wales

Australia

TERMS OF REFERENCE

ASSESSMENT OF RIVERINA RED GUM FORESTS

The New South Wales Government intends to make a forest agreement with respect to the river red gum and woodland forests within the NSW Riverina IBRA and the South-Western Cypress State Forests in order to determine conservation outcomes and a sustainable future for the forests, the forestry industry and local communities in the region.

To inform that agreement and in accordance with section 13 (1)(e) & (g) of the *Natural Resources Commission Act 2003*, I request that the Commission:

1. Carry out a regional forest assessment of the scientific bioregion:
   a) for the purposes of section 15 of the *Forestry and National Park Estate Act 1998* including an assessment of the following: environment and heritage values (including Indigenous heritage), economic and social values, ecologically sustainable forest management, and timber resources; and
   b) otherwise such that the assessment will also meet the requirements of the *Environment Protection and Biodiversity Conservation Act 1999 (C'th)*.
2. Recommend conservation, protection, economic and ecological sustainable use of public land in the bioregion.
3. Recommend water management and flooding requirements to sustain the forests and identified values and uses under the range of projected impacts of climate change.

The Commission should have regard to the following as they relate to the bioregion:

- Nationally agreed criteria for a comprehensive, adequate and representative reserve system;
- other complementary methodologies for protecting conservation values;
- the impacts of drought and climate change on the forests and communities;
- opportunities for ongoing and future employment within affected local communities;
- appropriate forest management practices in order to promote long term productivity and forest health;
- international or intergovernmental obligations, agreements or arrangements;
- NSW Government policies, programs and Catchment Action Plans;
- opportunities for Indigenous involvement in forest management;
- appropriate access for commercial, recreational and community uses; and
- the existing science and body of knowledge about the region.

The Commission should consult with relevant NSW agencies including the Department of Environment, Climate Change and Water, the Department of Industry and Investment, the Land and Property Management Authority, the Treasury, the Department of Premier and Cabinet. The Commission should also consult with relevant Traditional Owners, Local Aboriginal Land Councils, Elders groups and local government. The Commission should liaise with officers from the Commonwealth Department of the Environment, Water, Heritage and the Arts to inform the design and conduct of the assessment.

The Commission should undertake public consultation to inform the assessment.

The Commission is to deliver the assessment in two phases:

1. The Commission is to deliver in relation to the Riverina IBRA:
   - an assessment under reference 1 by 30 September 2009; and
   - a report on terms of reference 2 and 3 by 30 November 2009.

2. The Commission is to deliver in relation to the South-Western Cypress State Forests:
   - an assessment under reference 1 by 31 December 2009; and
   - a report on terms of reference 2 and 3 in relation by 28 February 2010.

Attachment 2 Acronyms and glossary

List of acronyms

AHIMS	Aboriginal Heritage Information Management System
AGS	Australian Group Selection
CMA	Catchment Management Authority
CAP	Catchment Action Plan
CAR	Comprehensive Adequate and Representative
CSIRO	Australian Commonwealth Scientific and Research Organisation
DAFF	Department of Agriculture Fisheries and Forestry
DECCW	Department of Environment Climate Change and Water
DEWHA	Department of Environment, Water, Heritage and the Arts (C'th)
DII	Department of Industry and Investment
DPC	Department of Premier and Cabinet
ECD	Ecological Character Description
EEC	Endangered Ecological Community
EIS	Environment Impact Assessment
ENSO	El Nino Southern Oscillation
EPBC	Environment Protection and Biodiversity Conservation Act 1999 (C'th)
EVC	Ecological Vegetation Class
EWA	Environmental Water Allocation
FAMC	Forests Aboriginal Management Committee
FMZ	Forestry Management Zone
FRAMES	Forest Resource Management Evaluation System
GL	Giga litre or 1 billion litres
IBRA	Interim Biogeographic Regionalisation of Australia
IFOA	Integrated Forestry Operations Approval
IU	Improved Utilisation
IUCN	World Conservation Union
IPCC	Inter-governmental Panel on Climate Change
JANIS	Joint ANZECC National Forest Policy Statement Implementation Sub-Committee
MDB	Murray Darling Basin
MDBA	Murray Darling Basin Authority
MDBMC	Murray Darling Basin Management Committee
MLDRIN	Murray Lower Darling Rivers Indigenous Nations
NES	National Environmental Significance
NGO	Non-Government Organisation
NRC	Natural Resources Commission
NRM	Natural Resource Management
NRMMC	Natural Resource Management Ministerial Council
NSWVCA	NSW Vegetation Classification Assessment
NWC	National Water Commission
RFA	Regional Forest Agreement between the Australian Government and a State Government
SEACI	South Eastern Australian Climate Initiative
STS	Single Tree Selection
TLM	The Living Murray
VEAC	Victorian Environment and Assessment Council
VCA	Vegetation Classification Assessment

Glossary

Term	Description
Adaptive management	A systematic and iterative process for decision-making that focuses on learning-by-doing.
Alluvium	Soil or sediments deposited by a river or other running water.
Anabranch	A secondary channel of a river or stream that leaves the main stream and re-joins it downstream.
Benchmark vegetation condition	A term which commonly refers to the condition of an undisturbed or minimally disturbed patch of vegetation.
Billabong	A small lake or a section of still water adjacent to a river, cut-off by a change in the watercourse. Billabongs are usually formed when the path of a creek or river changes, leaving the former branch with a dead end.
Biodiversity	The variety of all life forms: different plants, animals and microorganisms, the genes they contain and the ecosystems in which they live.
Bioregion	A region determine by vegetation cover and the earth's physical features and climate.
Carbon footprint	A measure of the impact our activities on the environment and in particular climate change. It relates to the amount of greenhouse gases produced in our day-to-day lives through burning fossil fuels for electricity, heating and transportation etc.
Carbon sequestration	Storage of carbon dioxide to prevent its release into the atmosphere where it contributes to global warming.
Ecologically Sustainable Development	Development which aims to meet our needs today, while conserving our ecosystems for the benefit of future generations.
Ecosystem	A community of naturally co-occurring and interacting species and their physical environment in which they live and with which they also interact.
Environmental water	An amount of water allocated to the environment under an environmental entitlement.
Ephemeral stream	Stream that flows for only short periods and then dries up.
Floodplain	Flat land besides a river that is inundated when the river overflows its banks during a flood.
Forest Management Zone	Identifies significant environmental assets and direct how these

	should be managed
Geomorphology	The study of the arrangement and form of the Earth's crust and the relationship between these physical features and the geologic structures beneath.
Habitat	A place or environment in which an organism naturally occurs.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust.
Hydrology	The science that deals with surface and groundwater – their occurrence, circulation and distribution, their chemical and physical properties and their reaction with the environment.
Improved Utilisation logging	Designed to remove a high proportion of the remaining mature to over-mature trees by logging or ring-barking and also thinning the re-growth
Inundation	To cover with water, usually by the process of flooding.
Lagoon	A body of comparatively shallow salt or brackish water separated from the deeper sea by a shallow or exposed sandbank, coral reef or similar feature.
Landscape	Comprises the visible features of an area of land, including physical elements such as landforms, living elements of flora and fauna, abstract elements like lighting and weather conditions, and human elements like human activity and the built environment.
Lunette	Crescent or semi-circular shaped aeolin deposits of fine sediment located on the eastern (or lee) side of lake beds in semi-arid areas.
National Water Initiative	An initiative of the Council of Australian Governments that aims to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use by optimising economic, social and environmental outcomes.
NSW Forest Agreements	Formal agreements between the NSW Minister for Environment and Climate Change, and the Minister for Primary Industries setting out how forests in particular regions will be managed as part of the NSW reserve system or as state forests.
Overstorey	The upper level of the forest created by the crowns of trees or shrubs.
Ramsar Convention	The Convention on Wetlands of International Importance is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

Ramsar site	A wetland nominated and listed on the Ramsar List of Wetlands of International Importance.
Regional Forest Agreements	20-year plans for the conservation and sustainable management of Australia's native forests to provide certainty for forest-based industries, forest-dependent communities and conservation.
Remnant vegetation	Vegetation remaining after an area has been cleared or modified.
Resilience	A measure of a system's capacity to cope with shocks and undergo change while retaining essentially the same structure and function.
Ringbarking	A process of completely removing a strip of bark around a tree's outer circumference, causing its death.
River red gum	A tree of the genus *Eucalyptus* is one of around 800 in the genus. It is a plantation species in many parts of the world but is native to Australia where it is widespread especially beside inland water courses.
Semi-arid	A climatic region that receives low annual rainfall (200-500 mm)
Silviculture	The art and science of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values of the many landowners, societies and cultures.
Stand	A group of trees in a forest that can be distinguished from other groups by their age, species composition and condition.
Tenure	A broad concept that includes ownership, tenancy and other arrangements for the use of forests
Thinning	Cutting down and removal of a proportion of trees in a forest to provide more growing space for the remaining trees, which leads to an increase in volume of individual trees.
Threatened species	Native plants and animals in danger of becoming extinct.
Understorey	The layer of vegetation that grows below the canopy formed by the tallest trees in the forest.
Vegetation classes	Groupings of vegetation communities based on floristic, structural and ecological features.
Water Management Unit	Relatively discrete geographical areas that have varying restrictions on flow delivery and manipulation, and have stands of high value forest
Western Lands Lease	A contract for sustainable land management in the Western Division of NSW, under the *Western Lands Act 1901*.

Attachment 3 References

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Attachment 4 Relevant legislation

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act, 1999

Water Act, 2007

New South Wales legislation

Catchment Management Authorities Act, 2003

Forestry Act, 1916

Forestry and National Parks Estate Act, 1998

National Parks & Wildlife Act, 1974

Protection of the Environment Operations Act, 1997

Threatened Species Conservation Act, 1995

Water Management Act, 2000

Attachment 5 List of Submissions

List of submissions received

During August-September 2009, the NRC received 130 submissions on the Terms of Reference and river red gum assessment. These include 33 submissions from organisations and 97 from individuals.

From organisations (33)

1. Arbuthnot Sawmills Pty Ltd
2. Balranald Shire Council
3. Berrigan Shire Council
4. Bird Observation and Conservation Australia
5. Bullatale Creek Landholders
6. Bullatale Creek Trust
7. Combined submission - Farmers, irrigators and landholders
8. Conargo Shire Council
9. Culpra Milli Aboriginal Corporation
10. Cummergunja
11. Ecological Surveys and Planning
12. Falbrook Wildlife Refuge
13. Friends of the Earth Australia
14. Hunter Community Environment Centre
15. J and G Coulter Pty Limited
16. Lower Murray Darling CMA
17. Murray Shire Council
18. Nambucca Valley Conservation Association
19. National Parks Association of NSW
20. Nature Conservation Council NSW
21. North East Forest Alliance
22. Northern Inland Council for the Environment
23. NSW Forest Products Association (10.8 MB)
24. NSW Red Gum Forest Action Inc.
25. South East Forest Rescue
26. The Colong Foundation for Wilderness Ltd
27. The Friends of Eastern Otways
28. The Nationals, Member for Burrinjuck
29. The Wilderness Society Sydney
30. Timber Communities Australia

31. Total Environment Centre Inc
32. Victorian National Parks Association
33. Wiringal

From individuals (97)

1. Alan and Anea Hurdle
2. Alison Dunne
3. Andrew Luke and Helen Gargan
4. Angela Munro
5. Annabelle Ford
6. Annette Hollingworth
7. Barry Allen
8. Beverley Warren
9. Brendan Nugent
10. Carl Gosper
11. Carol Collins
12. Caroline Williams
13. Carrie Rieden
14. Catriona Lamberton
15. Chris and Dawn Crump
16. Chris Littlemore
17. Colin Smith
18. Connie Campbell
19. Damien Langlois
20. David Joss
21. Deborah Kellock
22. Denise Lytle
23. Elaine Bayes
24. Elizabeth Makin
25. Faye O'Brien
26. Genevieve Moore
27. Geoff and Todd Gelletly
28. Graeme Butterbury
29. Gray Ardern
30. Ian and Marjo Chambers

31. Ian Price
32. Ilona Renwick
33. Irene Richardson
34. Irene Schardijn
35. Ivor Morton
36. Jacquie Kelly
37. Jaden Harris
38. Jim Kelton
39. Joel Smith
40. John Sampson
41. John Thompson
42. Karinda Stone
43. Kim Lowe
44. Linda Thomas
45. Lucia Fischer
46. Lucy Palmer
47. Margaret and Peter Kurz
48. Margaret MacDonald
49. Marie-Claire Porcedo
50. Martin Lippmann
51. Mervyn Colville
52. Michael Easton
53. Michael Mardel
54. Michael Mizzi
55. Michele Damschke
56. Michelle da Silva
57. Naomi Hodgson
58. Nathan Tremain
59. Nick Pastalatzis
60. Nicole Cranston
61. Patricia Hale
62. Patricia Rovik
63. Patrick Taggert
64. Penny Davidson
65. Peter Lister

66. Peter McCarthy
67. Petra Riverani
68. Piers Gooding
69. Rachel Melrose
70. Regina Bos
71. Rita Fox
72. Roman Suwald
73. Ron Sharples
74. Rosie White
75. Russell Moore
76. SA Sullivan
77. Sally Millington
78. Sarah Neal
79. Sophian Aubin
80. Stephanie Burke
81. Sue Adams
82. Susan Peake
83. Tanys Boschma
84. The Wilderness Society Sydney Campaign [(a)]
85. Thomas Colley
86. Tim Scrace
87. Tim Thorncraft
88. Todd Gelletly
89. Valerie Valuntas
90. Vanessa Culliford
91. Vicky McCleary
92. Victor Eddy
93. Warwick Sprawson
94. Wendy Auton
95. Wendy Renehan
96. Yuki Schofield
97. Zoe Melville

(a) Submission includes 500 campaign letters from individuals

Attachment 6 State, regional and local socio-economic profile

A6 State, regional and local socio-economic profile

A6.1 Assessment approach

The assessment of socio-economic values has been conducted on a state, regional and local scale. Previous studies have shown that in the state and regional context, the timber industry has a relatively minor contribution to employment and the overall economy. However, the industry has very localised impacts, particularly on small rural towns. For this reason, efforts have been focused on local scale assessments on towns where the timber industry relies on resources from public lands.

The NRC has defined 'region', for the purpose of analysis of ABS statistics, as being the statistical subdivisions of Murray Darling, Central Murray, Lower Murrumbidgee, Lachlan, Central Murrumbidgee (excluding Wagga Wagga), and the Upper Murray (excluding Albury). This is consistent with the approach taken in the EIS.

To assess the local level socio-economic values of the industry, towns of interest were identified on which to focus analysis. The criterion for selecting towns of interest was towns for which employment in the timber industry is greater than 1 percent. This identified seven towns, one of which (Narrandera) was excluded as industry representatives indicated the timber industry was predominantly based on white cypress rather than river red gum. Table A6.1 indicates the six towns included in the study.

Table A6.1 Towns of interest for social and economic research

Area of focus	Towns of interest
Central Area	Barham/ Koondrook Deniliquin Mathoura
Northern Area	Darlington Point
Western Area	Balranald; and Merbein (Victoria).

For each of these towns key socio economic attributes such as population, elderly dependency ratio, unemployment, median incomes, employment profile and levels of volunteering were collated. Such measures assist in portraying the resilience and cohesiveness of the town.

A6.2 NSW State-wide profile

Table A6.2 shows selected socio-economic indicators for NSW, as a basis for comparison with the region and the towns of interest.

Table A6.2 Selected NSW socio-economic indicators (ABS, 2001 & 2006)

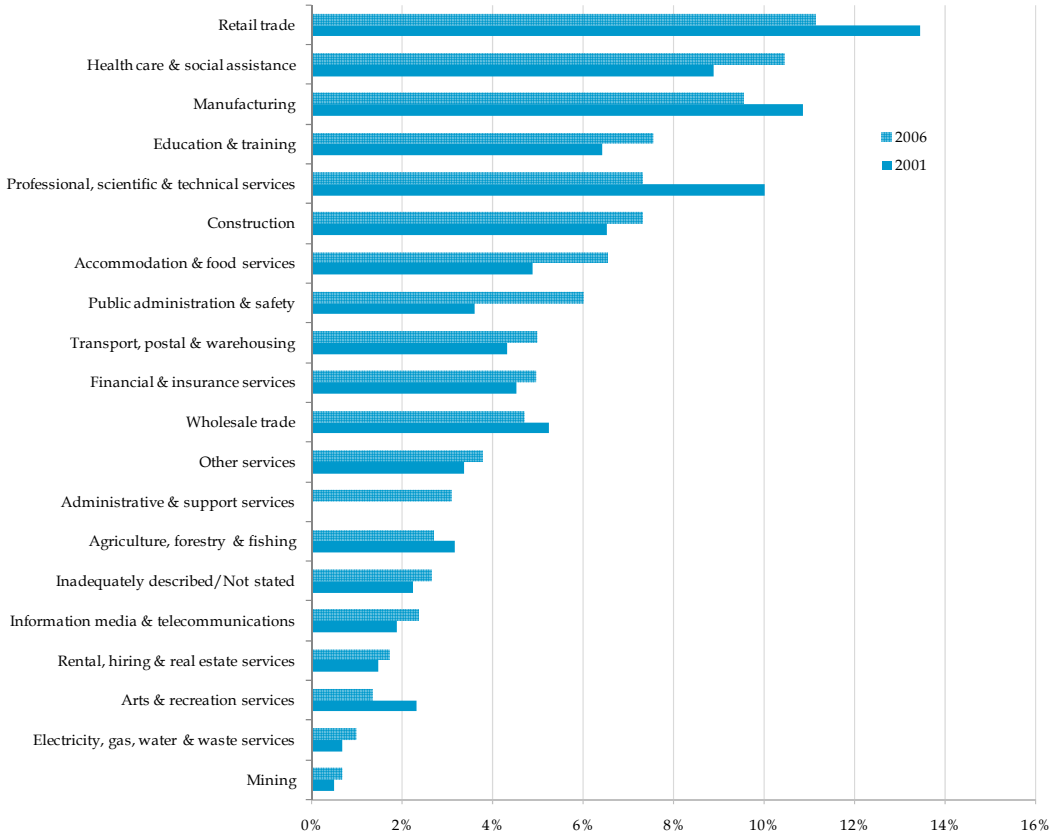
Socio-economic indicators	2001	2006
Population (number)	6,311,168	6,549,177
Population growth (percent)	-	3.8
Indigenous population (percent)	1.9	2.1

Socio-economic indicators	2001	2006
Elderly dependency ratio	51	51
Sex ratio (number of males per 100 females)	97.57	97.22
Unemployment rate (percent)	7.2	5.9
Labour force participation rate (percent)	46.9	47.2
Occupied dwellings (percent)	91.1	90.5
Median individual income ($/week)	-	461
Median family income ($/week)	-	1,181
Median household income ($/week)	-	1,036

Note: - = not calculated for the purpose of this study

Figure A6.1 shows that employment in NSW in 2006 was dominated by the retail trade, health care and social assistance and manufacturing sectors.

Figure A6.1 Employment by industry within NSW, 2006 Census (ABS, 2001 & 2006)



A6.3 Regional Context

For the purpose of this profiling, the NSW Riverina bio-region is defined as being the statistical subdivisions of Murray Darling, Central Murray, Lower Murrumbidgee, Lachlan, Central Murrumbidgee (excluding Wagga Wagga), and the Upper Murray (excluding Albury). Table A6.3 shows a concise summary of the local, state and regional socio-economic population context for this assessment. In the state context, the region accounts for 3.2 percent of the NSW population, and the towns of interest accounts for 0.2 percent of the population.

Table A6.3 Summary of state, region and local population context (ABS, 2001 & 2006)

Socio-economic indicators	2001	2006
Proportion of NSW population in the region (percent)	3.4 percent	3.2 percent
Proportion of NSW population in the towns of interest (percent)	0.2 percent	0.2 percent
Proportion of region population in towns of interest (percent)	6.6 percent	6.8 percent

ABS statistics from the 2006 census indicates that 7,875 persons are employed in the forest and timber industries state wide. Employment in the region (Table A6.4) in the forest and timber industries accounts for approximately 13 percent of the total employment in these industries in NSW.

Table A6.4 Summary of key employment indicators of the timber industry (ABS, 2006)

Key indicator	Estimated employment (number of persons)
Number employed in timber industry (NSW)	7,875
Number employed in timber industry (Region)	1,008
percent of State timber employment in region	12.8

Table A6.5 shows selected socio-economic indicators for the region. Since 2001, the region has shown a decline in population and a decline in the proportion of dwellings occupied. Compared to NSW, the region has a higher proportion of Indigenous persons in the population, a higher elderly dependency ratio, higher labour force participation rate, lower unemployment rates and lower individual incomes.

Table A6.5 Selected socio-economic indicators for the region (ABS, 2001 & 2006)

Socio-economic indicators	Region 2001	Region 2006	NSW 2006
Population (number)	217,695	208,129	6,549,177
Population Growth (percent)	-	-4.4	3.8
Indigenous population (percent)	3.7	4.4	2.1
Elderly dependency ratio	63.5	62.3	51
Sex ratio (number of males per 100	101.7	103.8	97.22

Socio-economic indicators	Region 2001	Region 2006	NSW 2006
females)			
Unemployment rate (percent)	5.7	5.3	5.9
Labour force participation rate (percent)	62.0	62.1	47.2
Occupied dwellings (percent)	87.5	86.4	90.5
Median individual income ($/week)	-	386	461

Note: - = not calculated for the purpose of this study

The employment profile for the region is shown in Figure A6.2. In 2006, employment in the combined agriculture, fishing and forestry industries accounted for 22 percent of total employment in the region, followed by manufacturing, retail trade and health care/social assistance.

Forests NSW (2009a) reported that agriculture accounts for 95 percent of the combined agriculture, fishing and forestry industries in the region. The regional value of agriculture within the region was $4.7 billion in 2006 (Forests NSW, 2009a). Irrigated agriculture in the region is a mix of horticulture (grapes, citrus, and vegetables) and broad acre irrigation (rice, cereal, pasture and hay production).

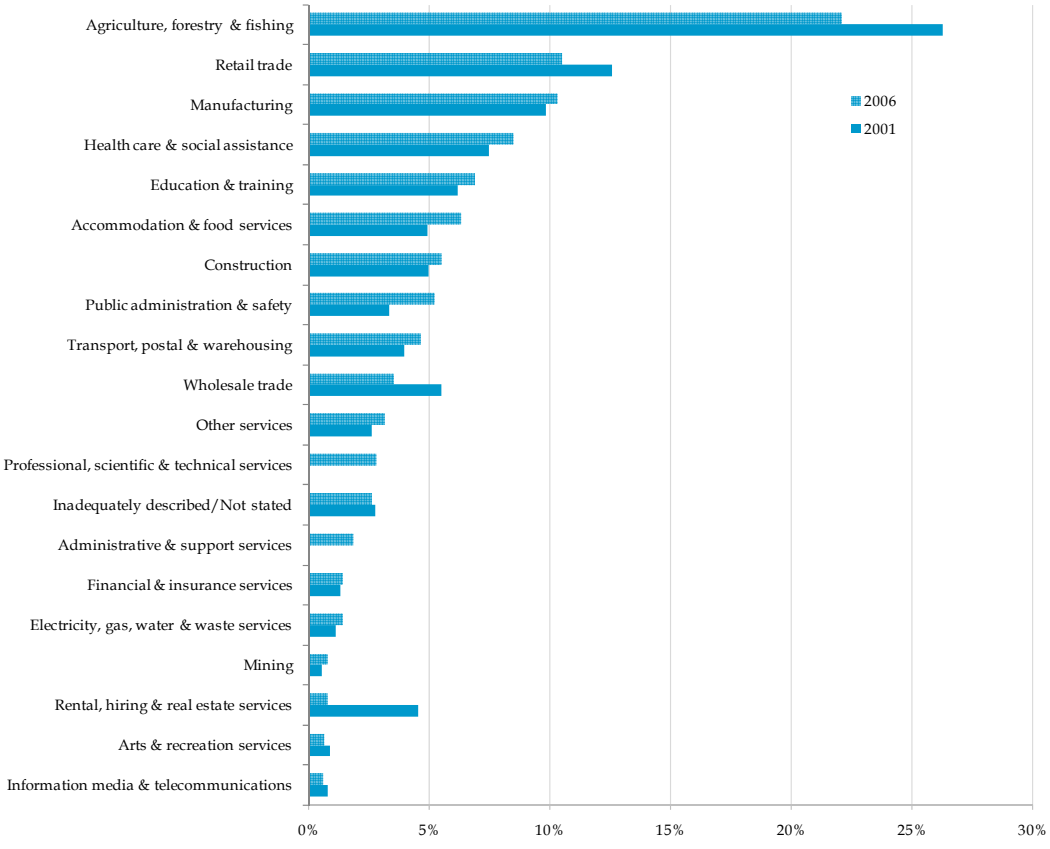


Figure A6.2 Employment by industry within the study area, 2006 Census (ABS, 2001 & 2006)

The 2006 Census indicated that a total of 1,008 persons were employed in all forestry and timber industries in the region. This is approximately 1.1 percent of total employment in the region and 4.9 percent of jobs in the combined agriculture, fishing and forestry sectors. A detailed breakdown of this figure for each relevant ANZSIC classification is provided inTable A6.6.

Table A6.6 Number of persons employed in the forestry and timber industries in the region (ABS, 2006)

	Males	Females	Persons
Forestry Support Services	52	13	65
Forestry and Logging, nfd	10	0	10
Forestry	163	26	189
Log Sawmilling and Timber Dressing, nfd	93	8	101
Log Sawmilling	320	67	387
Logging	88	8	96
Other Wood Product Manufacturing, nfd	17	7	24
Other Wood Product Manufacturing, nfd	24	0	24
Timber Resawing and Dressing	87	7	94
Wood Chipping	0	0	0
Wood Product Manufacturing, nfd	18	0	18
Sub-total	872	136	1,008

Note: nfd = not further defined

Tourism data collected at regional scale aligns with defined tourism regions. The relevant tourism regions for this assessment are the Murray[14], Riverina[15] and Outback[16] regions. It should be noted that these tourism regions do not align with the study region and that visitors numbers and expenditure includes those travelling for business purposes.

The tourism expenditure by domestic day and overnight visitors for the year ending March 2009 for the NSW Murray, Riverina and Outback regions is estimated to be $1.165 billion (Tourism NSW, 2009a - c). Tourism data provides an indicator of the importance of tourism at a regional level. Available data sources describe tourism activity as a whole, and not specifically tourism that is connected to river red gum forests.

14 The Murray tourism region comprises the local government areas of Albury; Berrigan; Corowa Shire; Greater Hume Shire; Jerilderie; Murray; Urana; and Wakool.

15 The Riverina tourism region covers the local government areas of Bland; Carrathool; Conargo; Coolamon; Cootamundra; Deniliquin; Griffith; Gundagai; Hay; Junee; Leeton; Lockhart; Murrumbidgee; Narrandera Temora; and Wagga Wagga.

16 The Outback tourism Region covers the local government areas of Balranald; Bogan; Bourke; Brewarrina; Broken Hill; Central Darling; Cobar; Unincorporated Far West; Walgett; and Wentworth.

A6.4 Socio-economic profile of towns of interest

The towns of interest included in the study were:

- Central Area
  - Barham/ Koondrook
  - Deniliquin
  - Mathoura
- Northern Area
  - Darlington Point
- Western Area
  - Balranald
  - Merbein (Victoria).

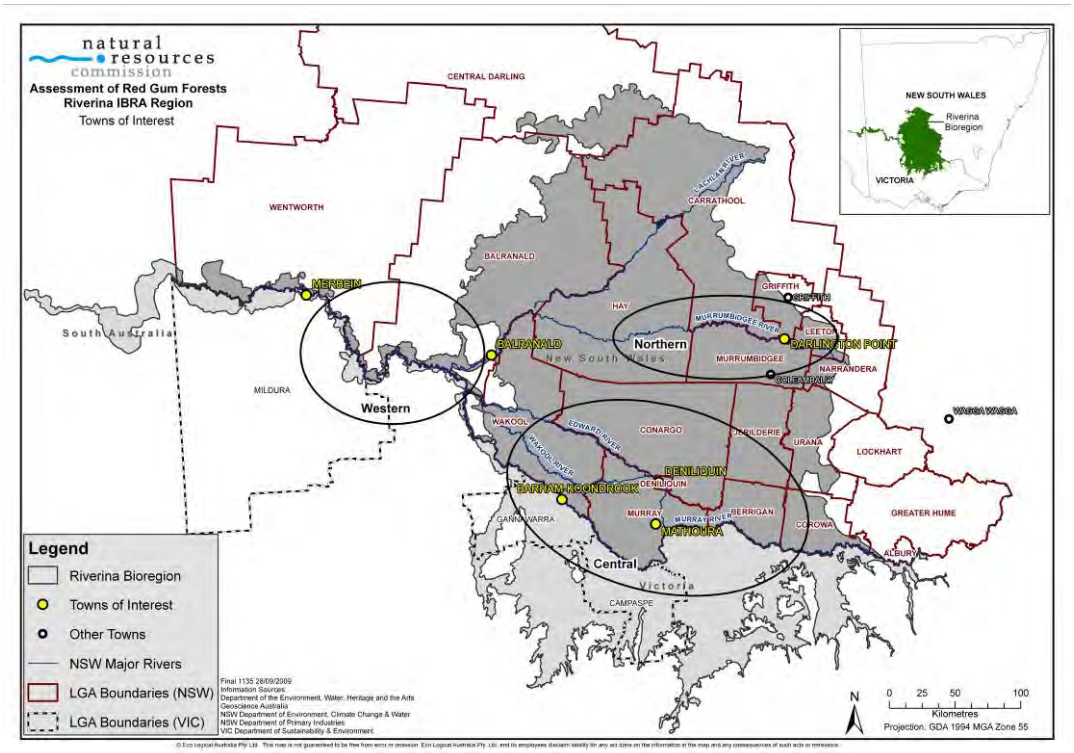


Figure A6.3 Towns of interest

A6.4.1 Barham-Koondrook

Barham (NSW) and Koondrook (VIC) are twin towns in the Murray River, with a combined population of approximately 2,000. Barham is the largest town in the Wakool Local Government Area, with other towns in the shire including Moulamein, Tooleybuc and Wakool. Koondrook is located in the Ganawarra Shire (Victoria), which includes the larger centres of Kerang and Cohuna. Swan Hill (75 kilometres), Deniliquin (98 kilometres) and Moama/ Echuca (90 kilometres) are the nearest larger service centres for the twin towns.

The towns have a number of local services including a hospital, medical centres, schools, banks, post office and police station, as well as retail and dining businesses. Key local tourism attractions include river based activities such as fishing, camping and river cruises, sports and recreation (e.g. golf). The red gum industry in addition to the forests themselves is also a key tourist attraction.

Barham Bridge
Photo: Gekko Images

A summary of the recent trends in key socio-economic indicators for Barham-Koondrook is provided in Table A6.7. Barham-Koondrook has lower unemployment and a higher labour participation rate than both NSW and the wider region. Barham-Koondrook has experienced population growth since 2001, though the region has seen overall population decline.

Table A6.7 Summary of key socio-economic indicators for Barham-Koondrook (Forests NSW, 2009a; ABS, 2006)

Socio-economic indicators	2001	2006	2006 Region	2006 NSW
Population (number)	1,852	1,934	208,129	6,549,177
Population Growth (percent)	1.1	4.4	-4.4	3.8
Indigenous population (percent)	1.1	1.4	4.4	2.1
Elderly dependency ratio[17]	37.3	55.2	62.3	51
Sex ratio (number of males per 100 females)	98.7	99.8	103.8	97.22
Unemployment rate (percent)	4.2	3.2	5.3	5.9
Labour force participation rate (	50.0	50.3	62.1	47.2

Socio-economic indicators	2001	2006	2006 Region	2006 NSW
percent)				
Occupied dwellings (percent)	87.0	83.8	86.4	90.5

Figure A6.4 shows the employment profile of Barham. In 2006, employment was greatest in the accommodation and food services sector and agriculture, fisheries and forestry[18]. Since 2001, there has been a decline in the retail, manufacturing, wholesale trade and construction sectors. Public administration and safety sector has had the strongest proportional growth.

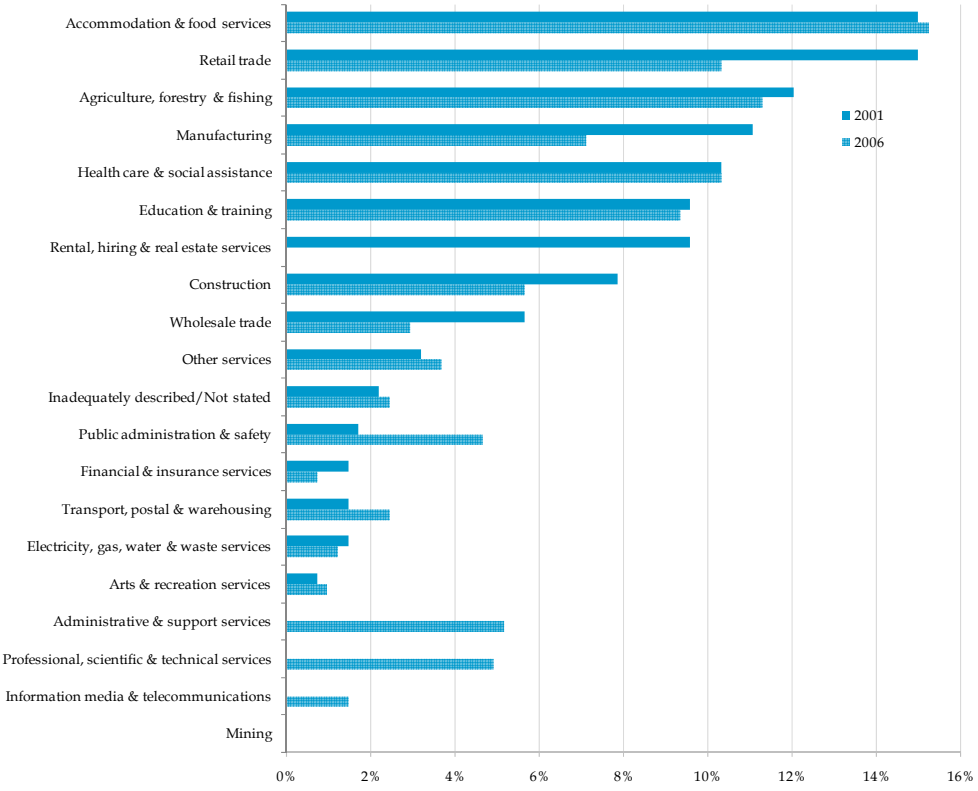


Figure A6.4 Employment profile of Barham (ABS, 2001 & 2006)

Figure A6.5 shows the employment profile of Koondrook. In 2006, retail, manufacturing and agriculture, fisheries and forestry were the three largest employment sectors. Since 2001, there has been a decline in retail, manufacturing and construction and an increase in the proportion of employment in manufacturing, agriculture, fisheries and forestry and accommodation and food services.

[18] Across the region, 4.9% of the employment in the ABS category of agriculture, forestry and fishing is estimated to be forestry by Forest NSW (2009).

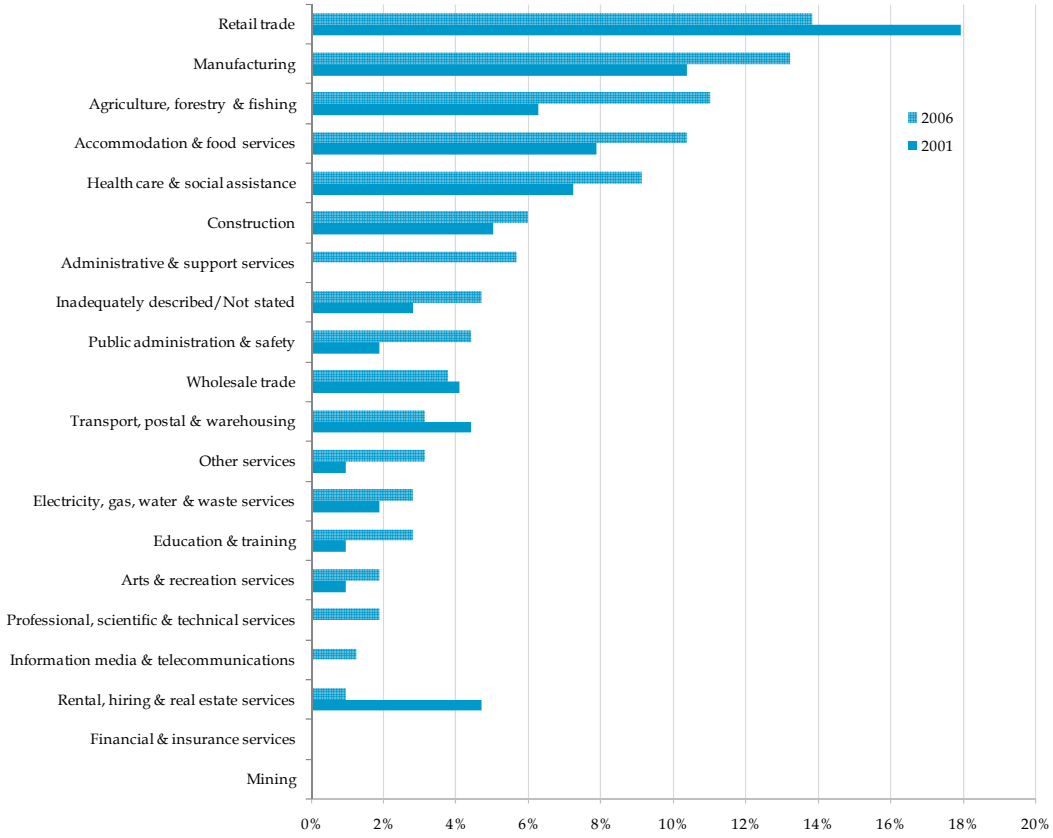


Figure A6.5 Employment profile of Koondrook (ABS, 2001 & 2006)

Note: There were changes in classifications between 2001 and 2006 census

Table A6.8 shows that the median individual, household and family income of the Barham-Koondrook population is lower than the NSW median.

Table A6.8 Comparison of Barham-Koondrook incomes with those of NSW and the region (ABS, 2006)

Income	Barham-Koondrook	Region	NSW
Median individual income ($/week)	348.5	386	461
Median household income ($/week)	617	-	1,036
Median family income ($/week)	840	-	1,181

Note: - = not calculated for the purpose of this study

There is a strong local connection to the forests of Koondrook-Perricoota and Gunbower.

The timber industry in Barham-Koondrook is focused on milling and processing enterprise cutting quota, ex-quota and residue grade logs. The three quota mills that also have ex-quota allocations include Arbuthnot's Sawmill, Rowes Timber Industries, and O'Brien's Sawmilling. There are mills that only produce ex-quota logs and these are GJ Hull and JM O'Neil. There are

four residue processors operating in Barham area including LWT & M Patten, G&T Gelletly, O'Brien Sawmilling, BK&W Campi and P Strange.

Veneer production at Bonum Sawmill in Barham

The town also has two river red gum furniture businesses. The twin towns host the annual Red Gum Showcase – an event that highlights the importance of the industry to the local community.

Tourism Research Australia (2008d) estimates a total of 80,000 people visit the broader Wakool Shire area, and spend a total of $26 million. For the Ganawarra Shire (Victoria), which also includes the larger centres of Kerang and Cohuna, Tourism Research Australia (2008e) estimates a total of 62,000 visitors with a total spend of $14 million.

It is estimated that the level of volunteering[19] in Barham-Koondrook is approximately 26 percent (Forests NSW, 2009a).

A6.4.2 Deniliquin

Deniliquin, a town of approximately 7,400 people located on the banks of the Edward River is the centre of the Deniliquin LGA. The Deniliquin LGA is small in area (approximately 140 square kilometres) and encompasses the town and its outskirts. Being the third largest town in the Riverina, Deniliquin is a service town for a number of smaller towns in the region including Wakool, Conargo, Berrigan, Finely and Jerilderie.

[19] Per cent of people aged over 15 years

Deniliquin
Photo: Wikimedia Commons

Key community services in Deniliquin include health, education (including primary and secondary schools, a community college and campus of the TAFE Riverina Institute), commercial, government and social services. Deniliquin is the administrative centre of Murray Irrigation Limited, which provides irrigation infrastructure services to an estimated 1200 farmers in the Murray Irrigation Area, and the town has an active chamber of commerce.

Tourism in Deniliquin is focused on the region's natural attractions. State Forests are destinations for camping, biking and bird watching, and the Edward River attracts visitors for river-based recreation such as kayaking, swimming, fishing, and water-skiing. The town is host to the Deni Ute Muster, a major annual event that attracts generated an estimated #13 million for the town and region in 2008. Tourism Research Australia (2008c) estimates a total of 97,000 people visit the region, and spend approximately $25 million.

A summary of the recent trends in key socio-economic indicators for Deniliquin is provided in Table A6.9. Approximately consistent with the region, Deniliquin has experienced a faster rate of population decline than NSW overall. Compared to the region and the state, Deniliquin has a lower elderly dependence ratio and a slightly lower rate of unemployment.

Table A6.9 Summary of key socio-economic indicators for Deniliquin (Forests NSW, 2009a; ABS, 2006)

Socio-economic indicators	2001	2006	2006 Region	2006 NSW
Population (number)	7,781	7,431	208,129	6,549,177
Population Growth (percent)	-0.5	-4.5	-4.4	3.8
Indigenous population (percent)	2.6	2.8	4.4	2.1
Elderly dependency ratio	26.8	32.2	62.3	51
Sex ratio (number of males per 100 females)	97.9	99.4	103.8	97.22
Unemployment rate (percent)	6.5	5.1	5.3	5.9
Labour force participation rate (percent)	61.8	60.7	62.1	47.2

Occupied dwellings (percent)	91.8	88.5	86.4	90.5

Figure A6.6 shows the employment profile of Deniliquin. The sectors with the largest proportion of employment in 2006 were the retail and health care and social assistance. There was a decline in the proportion of the population employed in the retail trade and agriculture, fisheries and forestry[20] between 2001 and 2006.

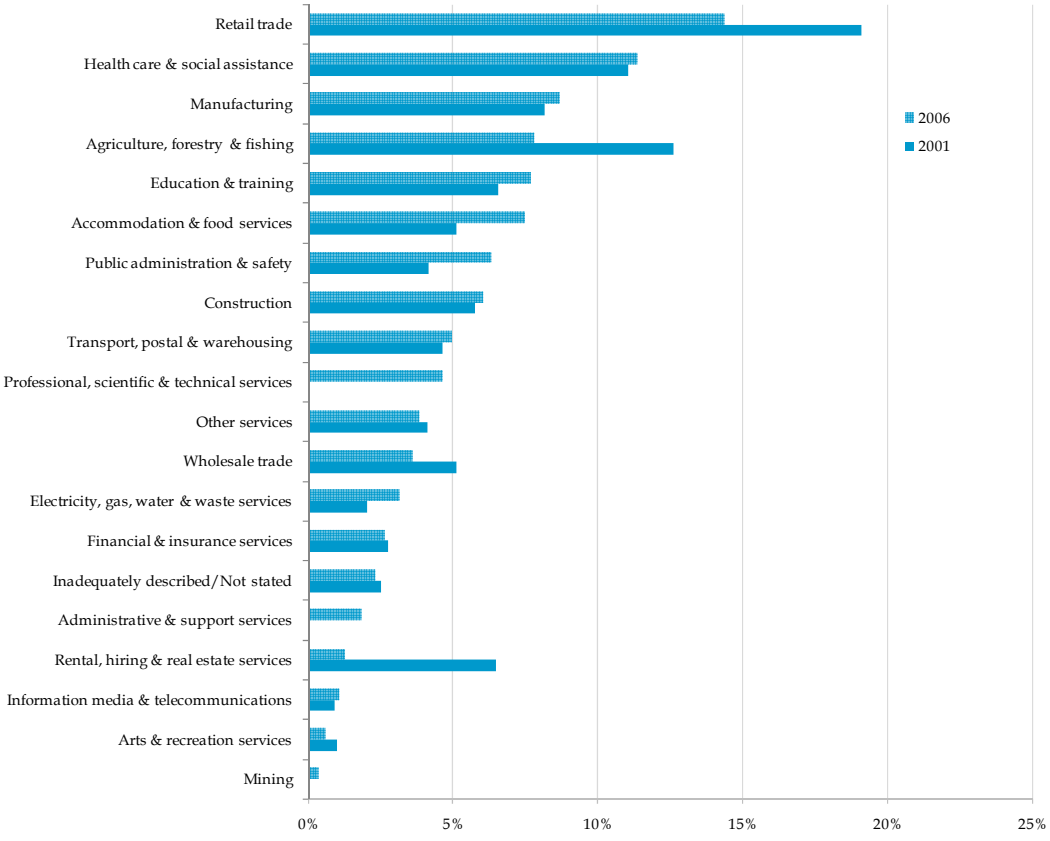


Figure A6.6 Employment profile of Deniliquin (ABS, 2001 & 2006)
Note: There were changes in classifications between 2001 and 2006 census

Table A6.10 shows that the median individual, household and family income of the Deniliquin population is lower than the NSW median.

[20] Across the region, 4.9% of the employment in the ABS category of agriculture, forestry and fishing is estimated to be forestry by Forest NSW (2009).

Table A6.10 Comparison of Deniliquin incomes with those of NSW and the region (ABS, 2006)

Income	Deniliquin	Region	NSW
Median individual income ($/week)	404	386	461
Median household income ($/week)	755	-	1,036
Median family income ($/week)	1,023	-	1,181

Note: - = not calculated for the purpose of this study

The Deniliquin economy has historically relied on the irrigation sector (predominantly rice and dairy), though the drought has seen significant decline in these industries. The town's rice mill and abattoir have closed in the past three years.

The timber industry in Deniliquin is focused on the Gulpa Saw Mill. The operation has recently invested in new buildings and has established a dedicated enterprise that is focused on providing high quality building timbers. The mill is one of the largest employers outside of local government, health and education. In addition to this mill, there are also two major residue processing operations (Montalto and Hannan).

It is estimated that approximately 25 percent of Deniliquin's population in 2006 was involved in volunteer work (Forests NSW, 2009a).

A6.4.3 Mathoura

Mathoura, with a population of approximately 650 is located in the Murray LGA. The major town in the Murray LGA is Moama (and its twin town Echuca located in Victoria), which is approximately 42 kilometres away. Moama-Echuca is a major service centre for Mathoura.

A multipurpose Visitor and Business Information Centre is the focal point for the delivery of services in the town. This centre houses a sub-branch of Bendigo Bank, access points for Centrelink and Medicare, tourism information and various business services. Other services in Mathoura include a primary school, post office and police station. There are two hotels and one club. Mathoura has an active Chamber of Commerce and a local newspaper.

The Murray River and its forests are the focus of tourism in Murray Shire. Mathoura hosts several annual events that attract visitors, including the Mathoura Fishing Classic and the Cadell Country Fair.

A summary of the recent trends in key socio-economic indicators for Mathoura is provided in Table A6.11. Compared to NSW and the region, Mathoura has a lower elderly dependence ratio and a much higher rate of unemployment.

Table A6.11 Summary of key socio-economic indicators for Mathoura (Forests NSW, 2009a; ABS, 2006)

Socio-economic indicators	2001	2006	2006 Region	2006 NSW
Population (number)	643	653	208,129	6,549,177
Population Growth (percent)	-1.53	1.56	-4.4	3.8
Indigenous population (percent)	1.1	2.1	4.4	2.1

Elderly dependency ratio	35.4	41.5	62.3	51
Sex ratio (number of males per 100 females)	110.8	112.7	103.8	97.22
Unemployment rate (percent)	13.5	9.8	5.3	5.9
Labour force participation rate (percent)	50.9	47.8	62.1	47.2
Occupied dwellings (percent)	78.0	85.8	86.4	90.5

Figure A6.7 shows the change in employment profile in the town of Mathoura between 2001 and 2006. In 2006, the sectors with the largest proportion of employment were manufacturing and retail trade, followed by construction, public administration and agriculture, fisheries and forestry[21]. Whilst public administration and safety and agriculture, forestry and fishing, and wholesale trade recorded decreases in employment proportion, several others grew in proportion, including retail, manufacturing and construction.

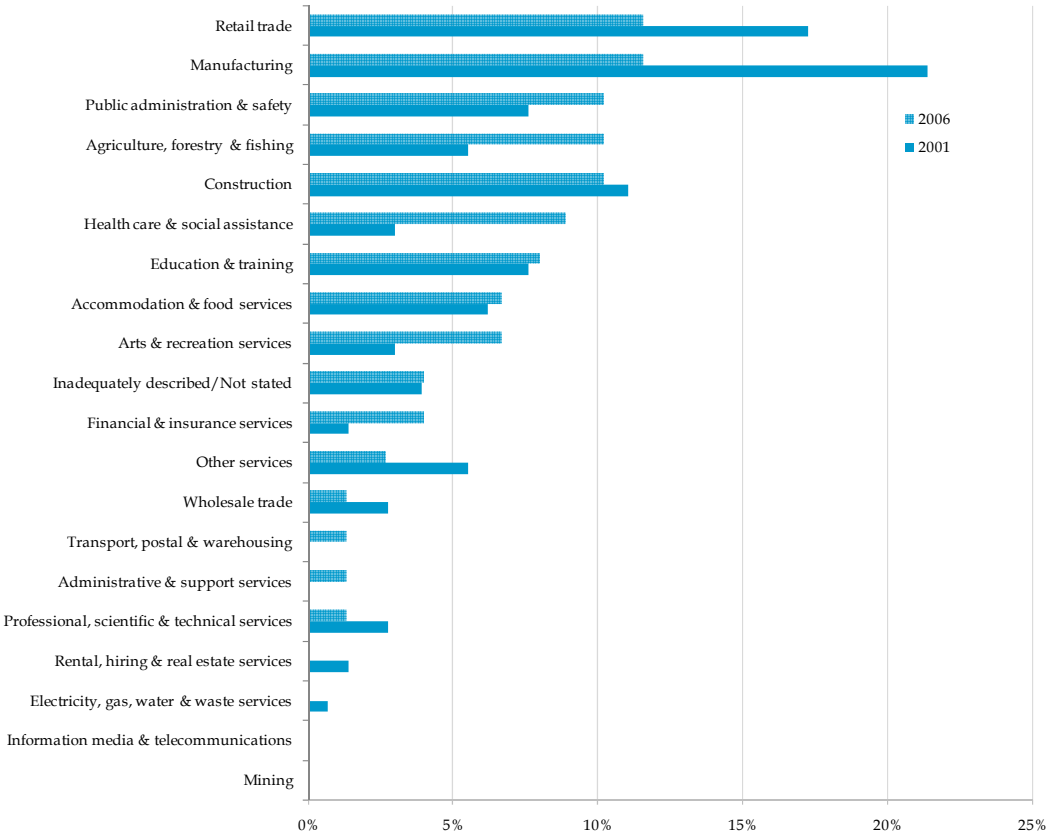


Figure A6.7 Employment profile of Mathoura (ABS, 2001 & 2006)
Note: There were changes in classifications between 2001 and 2006 census

Table A6.12 shows that the median individual, household and family income of the Mathoura population is lower than the NSW medians. Mathoura has the lowest median individual, household and family incomes of all towns included in this study.

[21] Across the region, 95% of the employment in the ABS category of agriculture, forestry and fishing is estimated to be agricultural by Forestry NSW (2009).

Table A6.12 Comparison of Mathoura incomes with those of NSW and the region (ABS, 2006)

Income	Mathoura	Region	NSW
Median individual income ($/week)	311	386	461
Median household income ($/week)	552	-	1,036
Median family income ($/week)	626	-	1,181

Note: - = not calculated for the purpose of this study

There is a strong local connection to the nearby State Forests including the Barmah, Millewa Moira and Gulpa Island State Forests.

The town is supported by five ex quota sawmills. Carrol, Colturi, Crump, Hill and Crane and three major residue processing operations, Colturi, Crump and Ulunja.

Approximately 25 percent of the Mathoura population (older than 15 years) was involved in volunteering (Forests NSW, 2009a).

Tourism statistics are not available for the town of Mathoura. For the whole of the Murray Shire, which includes the larger centre of Moama, Tourism Research Australia (2008b) estimates approximately 78,000 people visit the region who spend a total of $33 million.

A6.4.4 Darlington Point

Darlington Point is a small town of approximately 1,000 people located on the banks of the Murrumbidgee River in the north of the Murrumbidgee LGA. Coleambally, the other main town within the LGA, is approximately 30 kilometres away, and Griffith (38 kilometres) in the adjoining shire is a major service centre for Darlington Point.

Key services in Darlington Point include a police station, post office, a primary school, community health service and swimming pool.

A summary of the recent trends in key socio-economic indicators for Darlington Point is provided in Table A6.13. When compared to NSW and the broader region, Darlington Point has a much higher proportion of Indigenous persons in the population, a very low elderly dependency ratio and lower unemployment.

Table A6.13 Summary of key socio-economic indicators for Darlington Point (Forests NSW, 2009a; ABS, 2006)

Socio-economic indicators	2001	2006	2006 Region	2006 NSW
Population (number)	993	1,026	208,129	6,549,177
Population Growth (percent)	12.7	3.3	-4.4	3.8
Indigenous population (percent)	14.8	17.2	4.4	2.1
Elderly dependency ratio	16.4	19.6	62.3	51
Sex ratio (number of males per 100 females)	114.5	111.1	103.8	97.22
Unemployment rate (percent)	5.5	4.4	5.3	5.9

Labour force participation rate (percent)	62.4	62.1	62.1	47.2
Occupied dwellings (percent)	92.5	90.7	86.4	90.5

Figure A6.8 shows the employment profile of Darlington Point. Manufacturing and agriculture, fisheries and forestry are the two largest employment sectors. Since 2001, there has been an overall decline in the proportion of agriculture, fisheries and forestry [22]sectors and wholesale trade. Public administration and safety has recorded the largest proportional growth in employment, similar to other towns of interest.

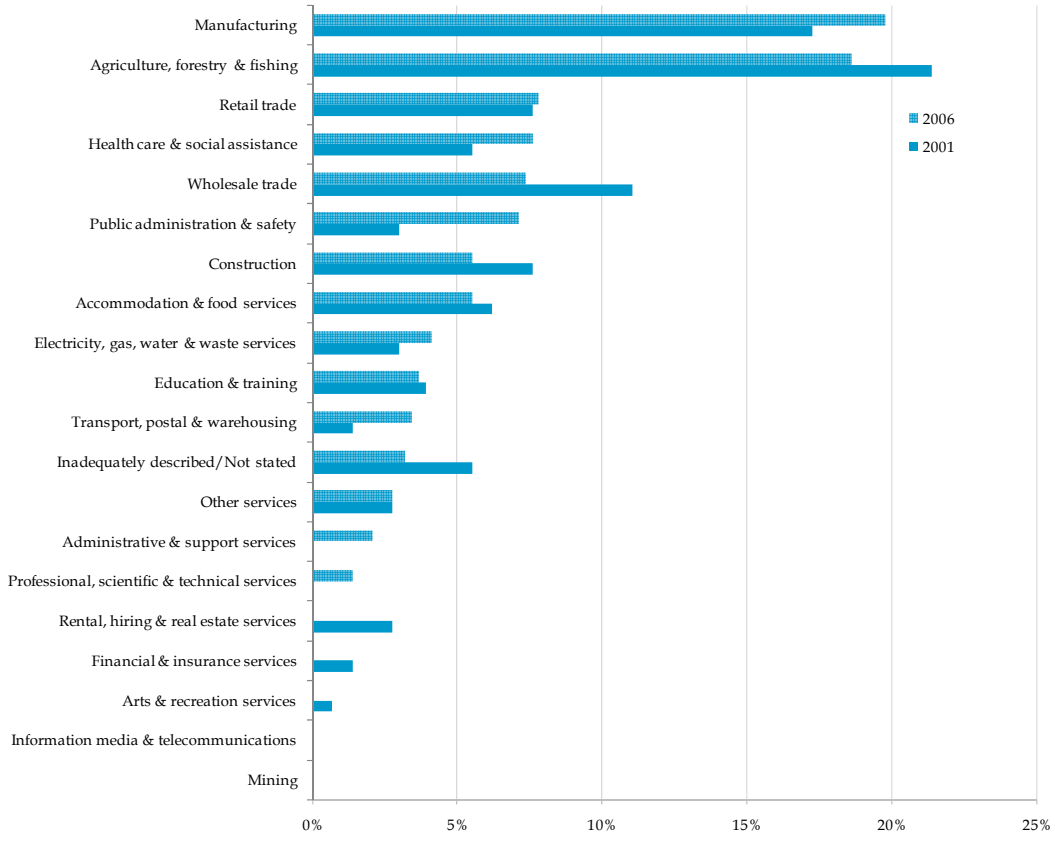


Figure A6.8 Employment profile of Darlington Point (ABS, 2001 & 2006)

Note: There were changes in classifications between 2001 and 2006 census

Table A6.14 shows that the median individual, household and family income of the Darlington Point population is lower than the NSW median. Darlington Point has the highest median household income of the towns of interest in this study.

[22] Across the region, 95% of the employment in the ABS category of agriculture, forestry and fishing is estimated to be agricultural by Forestry (2009).

Table A6.14 Comparison of Darlington Point incomes with those of NSW and the region (ABS, 2006)

Income	Darlington Point	Region	NSW
Median individual income ($/week)	448	386	461
Median household income ($/week)	758	-	1,036
Median family income ($/week)	993	-	1,181

Note: - = not calculated for the purpose of this study

Historically, irrigated agriculture and the processing of agricultural products especially rice have been key industries in Murrumbidgee Shire. The recent drought and low water allocations have resulted in a decline in production and income based on irrigated agriculture.

Walking, camping, fishing and other water based activities on the Murrumbidgee River is the focus of tourism activities in the district. Tourism data for Darlington Point and the broader Murrumbidgee Shire is not available.

The timber industry in Darlington Point is focused on a major fixed mill (Darlington Point Sawmill). The mill is the only significant holder of quota within the Narrandera and Murrumbidgee Management Areas. The business is a highly integrated mill. As the mill has adjusted to lower timber supply volumes and quality it has extended its firewood enterprise through investment in additional machinery. The mill is one of the few secondary industries in a town dominated by service industries. It is noted that many people who reside in the town are employed in Griffith.

Darlington Point has sporting, charity and community groups, and has a volunteering rate of 16.5 percent of the population over the age of 15 (Forests NSW, 2009a).

Firewood cutting at Darlington Point

A6.4.5 Balranald

Balranald, located on the Sturt Highway and on the banks of the Murrumbidgee River is the main town in Balranald Shire Council. The total shire area is approximately 21,400 square kilometres, with a total population of 2,440 (ABS, 2006). Other towns and localities in the shire include Euston, Kyalite, Hatfield, Penarie, Clare and Oxley.

Key services in Balranald include retail (supermarkets, clothing); accommodation (motels, caravan park), registered clubs, hotels, restaurants and food outlets; health and emergency services (medical centre, pharmacy, hospital, ambulance, fire brigade and rescue service); and education (primary school). The regional centres of Swan Hill (a distance of 92 kilometres) and Mildura (158 kilometres) provide services not available in Balranald.

A summary of the recent trends in key socio-economic indicators for Balranald is provided in Table A6.15. When compared to NSW and the broader region, Balranald has experienced a greater rate of population decline, has a higher proportion of Indigenous persons in the population and a higher rate of unemployment.

Table A6.15 Summary of key socio-economic indicators for Balranald (Forests NSW, 2009a; ABS, 2006)

Socio-economic indicators	2001	2006	2006 Region	2006 State
Population (number)	1,284	1,216	208,129	6,549,177
Population Growth (percent)	-9.51	-5.3	-4.4	3.8
Indigenous population (percent)	8.9	8.1	4.4	2.1
Elderly dependency ratio	25.2	31.5	62.3	51
Sex ratio (number of males per 100 females)	109.6	98.4	103.8	97.22
Unemployment rate (percent)	4.6	6.7	5.3	5.9
Labour force participation rate (percent)	59.6	61.6	62.1	47.2
Occupied dwellings (percent)	85.3	86.1	86.4	90.5

Figure A6.9 shows the employment profile of Balranald. The three largest employment sectors are retail, education and agriculture, fisheries and forestry[23]. Since 2001, there has been a decline in employment in the retail sector. Since 2006, there has also been a reduction in an estimated 24 jobs in education as a result of the relocation of distance education services. Public administration and safety and health care and social assistance have grown and continue to grow with the building of a new hospital.

[23] Across the region, 4.9% of the employment in the ABS category of agriculture, forestry and fishing is estimated to be forestry by Forest NSW (2009).

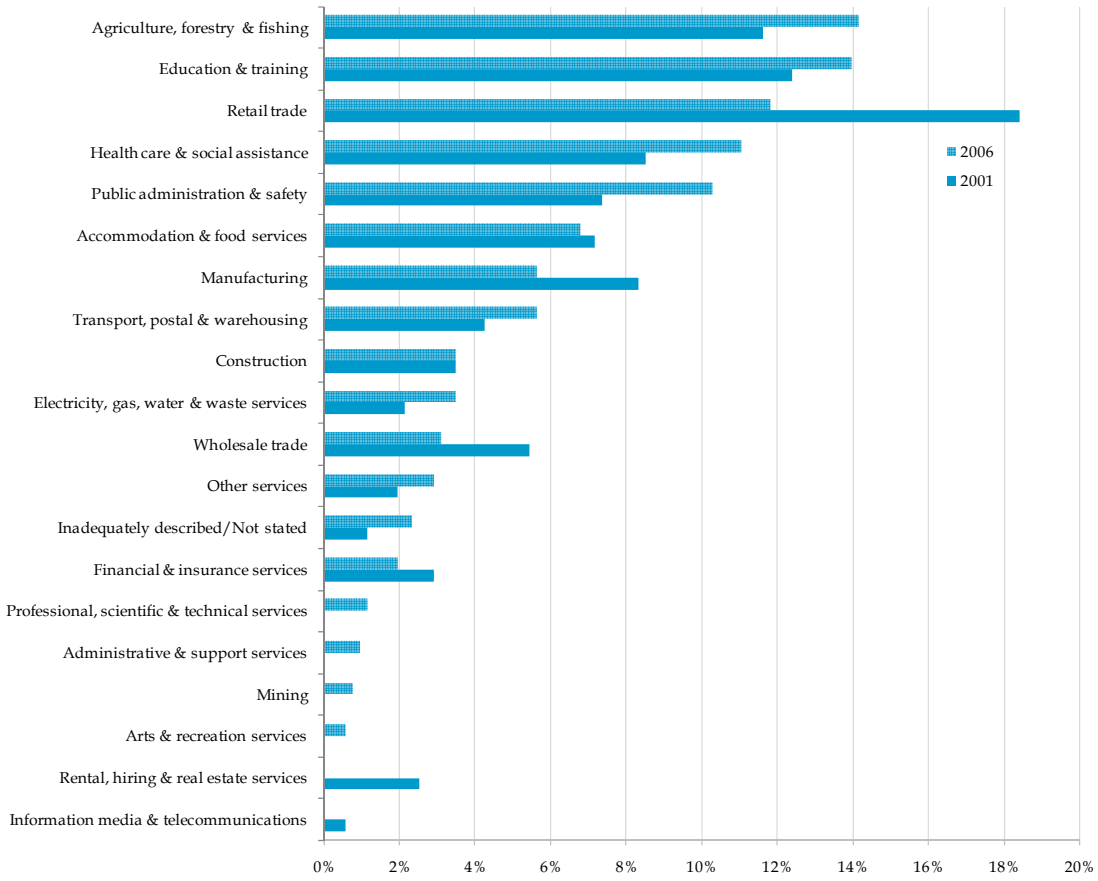


Figure A6.9 Employment profile of Balranald (ABS, 2001 & 2006)
Note: There were changes in classifications between 2001 and 2006 census

Table A6.16 shows that the median individual, household and family income of the Balranald population is lower than the NSW median.

Table A6.16 Comparison of Balranald incomes with those of NSW and the region (ABS, 2006)

Income	Balranald	Region	NSW
Median individual income ($/week)	381	386	461
Median household income ($/week)	696	-	1,036
Median family income ($/week)	957	-	1,181

Note: - = not calculated for the purpose of this study

The timber industry in Balranald comprises of a major wholesale timber company – Campbell's Sawmills, and smaller operations that supply Campbell's with sleepers and firewood, or source firewood to on-sell direct to other wholesalers or consumers.

The industry is generally reliant on timber resources sourced from private land. However, Campbell's Saw Mill sources timber products (predominantly sleepers) from a total of eight small operations and Redgum Timber Producers Pty Ltd that source products from both public and private land.

Recent investigations by Balranald Shire Council estimate that 65 people rely on the timber industry for their primary source of income, while an additional 61 have a secondary reliance. In addition there are local businesses that supply inputs such as fuel and tyres and services such as auto-electric and engineering to timber industry businesses.

Balranald is the closest service centre to Yanga and Mungo National Parks. Camping and fishing on the Murrumbidgee River is the focus of tourism activities in the district. Tourism data for Balranald Local Government Area estimates that the shire receives 38,000 visitors, who spend a total of $7 million (Tourism Research Australia, 2008a).

Compared to other towns of interest in this study, Balranald has high levels of community volunteering, with almost 34 percent of the population involved in community organisations or other activities (Forests NSW, 2009a).

A6.4.6 Merbein

Merbein, located in Victoria, is a satellite town of the large regional centre of Mildura, which is approximately 12 kilometres away. Within the Mildura Rural City Local Government Area, with a total population in excess of 60,000, Mildura is the primary service centre for residents and businesses in Merbein.

Located within the Sunraysia region, Merbein is a centre of irrigated horticulture production including wine grapes, dried fruits and citrus. There has been some decline in horticulture in recent years with periods of low commodity prices and reduced water allocations. Two large processors, McGuigan's Wines and SDS Beverages are major employers in the Merbein district.

A summary of the recent trends in key socio-economic indicators for Merbein is provided in Table A6.17. Compared to NSW and the broader regional population, Merbein has experienced a greater rate of population growth, has a lower elderly dependence ration and a higher unemployment rate.

Table A6.17 Summary of key socio-economic indicators for Merbein (Forests NSW, 2009a; ABS, 2006)

Socio-economic indicators	2001	2006	2006 Region	2006 NSW
Population (number)	1,820	1,974	208,129	6,549,177
Population Growth (percent)	4.8	8.3	-4.4	3.8
Indigenous population (percent)	4.2	4.9	4.4	2.1
Elderly dependency ratio	31.0	29.6	62.3	51
Sex ratio (number of males per 100 females)	95.7	99.6	103.8	97.22
Unemployment rate (percent)	9.9	8.1	5.3	5.9
Labour force participation rate (percent)	53.9	52.2	62.1	47.2
Occupied dwellings (percent)	94.2	93.9	86.4	90.5

Figure A6.10 shows the change in employment profile in the town of Merbein between 2001 and 2006. Retail trade and manufacturing are the two largest sectors of employment, although there has been decline in the importance of retail since 2001.

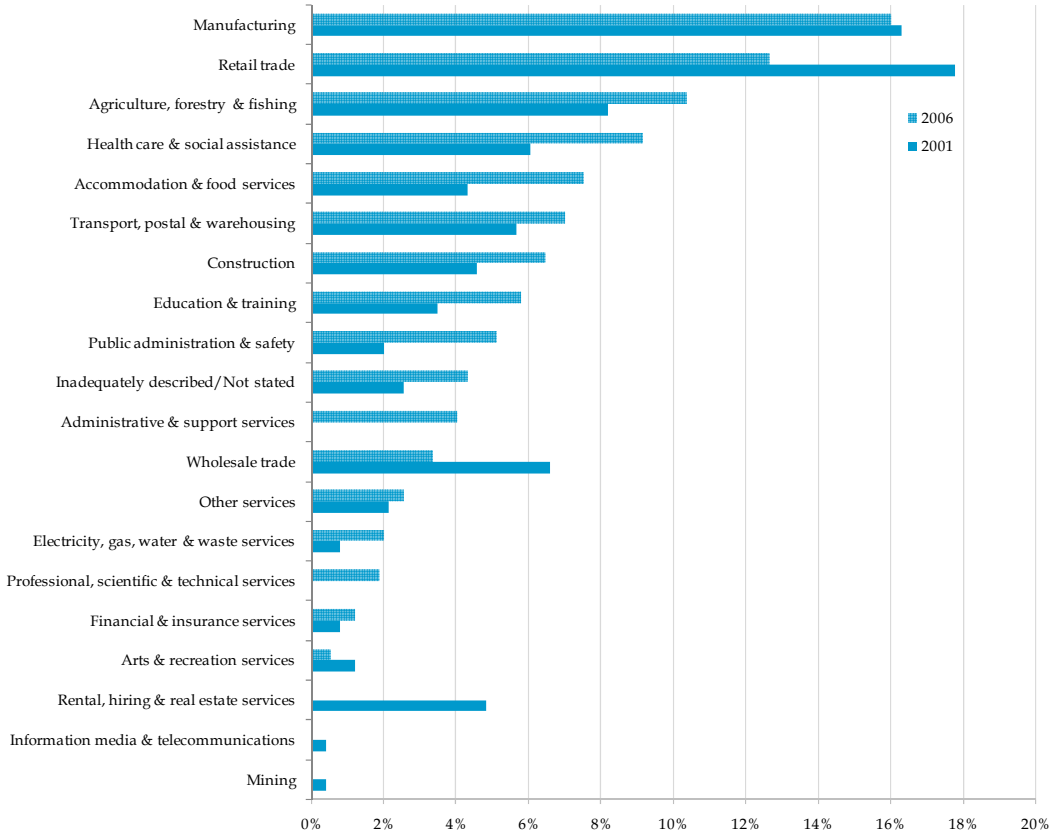


Figure A6.10 Employment profile of Merbein (ABS, 2001 & 2006)
Note: There were changes in classifications between 2001 and 2006 census

Table A6.18 shows that the median individual, household and family income of the Merbein population is lower than the NSW median.

Table A6.18 Comparison of Merbein incomes with those of NSW and the region (ABS, 2006)

Income	Merbein	Region	NSW
Median individual income ($/week)	332	386	461
Median household income ($/week)	596	-	1,036
Median family income ($/week)	764	-	1,181

Note: - = not calculated for the purpose of this study

The timber industry in Merbein is centred on the Merbein Saw Mill. Merbein Saw Mill relies on timber resources from NSW – with logs and residue sourced from State Forests, Western Lands Leases and private land.

Tourism data is not available for the town of Merbein. Tourism Research Australia (2008e) estimates that, in total, the Mildura Regional Local Government Area receives a total of 465,000 visitors who spend $153 million.

Attachment 7 Technical Review Panel Members

Technical Review Panel members	Role(s) and Organisation
Professor Andy Bennett	School of Life and Environmental Sciences Deakin University
Di Bentley	Natural Resources Commission
Ian Burns/Mr Michael Jones	Murray Darling Basin Authority
Dr Leon Bren	Associate Professor Department of Forest and Ecosystem Science University of Melbourne
Dr Matthew Colloff	Floodplain Ecosystem Function Commonwealth Scientific Research Organisation
Dr Michael Harris	Faculty of Agriculture Food and Natural Resources
Professor Barry Hart	Emeritus Professor Water Studies Monash University
Dr Terry Hillman	Former Director Murray Darling Freshwater Research Centre
Professor Peter Kanowski (Technical Chair)	Forest and Environment Policy Australian National University
Dr Glen Kile	Director Plant Health Australia
Dr Ian Lunt	School of Environmental Sciences Charles Sturt University
Dr David Williams	Institute for Applied Ecology University of Canberra

Attachment 8 Tables and Figures

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