River Red Gum Forests Investigation

DISCUSSION PAPER OCTOBER 2006

Victorian Environmental Assessment Council

State Government Victoria

WHAT IS VEAC?

The Victorian Environmental Assessment Council (VEAC) was established in 2001 under the *Victorian Environmental Assessment Council Act 2001*. VEAC replaced the Environment Conservation Council (ECC) as the body providing the State Government with independent and strategic advice on public land use. The five Council members are:

Mr Duncan Malcolm (Chairperson) – Mr Malcolm has a long career in natural resource management. He is currently the Chairperson of the Gippsland Coastal Board, Watermark Inc., a member of the Victorian Coastal Council and former Chair of Lakes and Wilderness Tourism and The Irrigation Association of Australia Ltd.

Associate Professor David Mercer – Associate Professor Mercer is with the School of Social Science and Planning at RMIT University. He has a background in natural resource management, recreation and tourism. The author of over 130 academic publications, Associate Professor Mercer is an elected Fellow of the Environment Institute of Australia and New Zealand and sits on the editorial board of the Australian Journal of Natural Resources and Policy.

Professor Barry Hart – Professor Hart has expertise in environmental science, particularly in water quality management and ecological risk assessment. He has published extensively and received several awards for his work in the scientific underpinning of natural resource management. Professor Hart also has considerable experience in catchment management issues across Victoria, having served on the Victorian Catchment Management Council for almost 10 years. He is also a Board member of the Victorian Environment Protection Authority.

Ms Jan Macpherson – Ms Macpherson is a lawyer with expertise in environmental and planning law. She also has an extensive background in Indigenous heritage and land management having worked for several years in northern Australia. Ms Macpherson has formal qualifications in corporate governance and is currently a Board member of Greening Australia.

Ms Jill McFarlane – Ms McFarlane comes from a background in family farming enterprises in both western Victoria and South Australia and also spent time as a social worker in rural areas of South Australia, NSW and Victoria. Ms McFarlane now lives in Central Victoria. Having completed two terms on the board of the North Central Catchment Management Authority (CMA), she has experience in the complexities of natural resource management issues across public and private land. She has a strong focus on community engagement and involvement in natural resource management.

MAKING SUBMISSIONS

The primary purpose of this Discussion Paper is to inform and initiate submissions from interested people and organisations. All stakeholders are encouraged to make a submission to VEAC—these submissions will be considered in detail by VEAC when developing specific proposals for public land in the study area for the Draft Proposals Paper, scheduled for publication in mid 2007. There will be further opportunities for submissions following publication of the Draft Proposals Paper.

The closing date for written submissions on this Discussion Paper is Thursday, 7 December 2006.

ONLY SUBMISSIONS SENT DIRECTLY TO VEAC CAN BE TREATED AS SUBMISSIONS.

All submissions to VEAC become public documents, unless otherwise requested. If you wish your submission to be considered confidential, a written request must accompany the submission. If the confidentiality request is not accepted, your submission will be returned to you.

Information contained in all submissions may also be stored and used by VEAC or the Department of Sustainability and Environment, for purposes relating to the River Red Gum Forests Investigation and subsequent government considerations of matters related to the Investigation.

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DISCUSSION PAPER

Victorian Environmental Assessment Council

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MESSAGE FROM THE COUNCIL

The river red gum forest area is one of Victoria's, indeed Australia's, most significant ecological and economic regions. It supports a wide diversity of environmental, economic and cultural values. People readily identify with the majestic River Murray and the landscape through which it flows, dominated by awe-inspiring red gum trees and the ecologically rich wetlands within the river system.

The river red gum forests and wetlands have seen major changes in use. Over the last 50,000 years Indigenous Traditional Owners have established a special relationship to ancestral lands. This spiritual connection is described as caring for country rather than ownership of land. Today, Aboriginal people have retained this association with ancestral lands, evolving and adapting over time.

Over recent centuries the River Murray has been used for large scale transport by paddle-steamers with extensive river regulation for agriculture. The region has seen major environmental devastation including the collapse of the Murray cod fishery and deforestation of the floodplains for agriculture, to fuel paddlesteamers and to supply railway transport.

Today we acknowledge the intrinsic biodiversity values of the region and the need for their protection, yet the riverine system remains under threat. Salinity is a major environmental concern with the expectation that by 2020 Adelaide's water supplies from the River Murray may be too salty to drink on two out of every five days. Population increases are placing pressures on waterfront access and natural values, particularly in relation to tourism and recreation activities.

However, the most significant threat to the river red gum forests and wetlands is insufficient water to maintain natural flood regimes. Without adequate water for the environment large areas of riverine ecosystems may be lost forever. Climate change is likely to compound this serious situation.

We encourage everyone to participate in this Investigation process and in so doing help us develop a shared vision for the river red gum forests on public lands. We look forward to your input and feedback on this Discussion Paper as we move into the next phase of the River Red Gum Forests Investigation.

Mr Duncan Malcolm (Chairperson)

Associate Professor David Mercer

Ms Jan Macpherson

Professor Barry Hart

Ms Jill McFarlane

ACKNOWLEDGMENT OF COUNTRY

The Victorian Environmental Assessment Council acknowledges Traditional Owners within the study area, their rich culture, and their spiritual connection to Country. This includes the Bangerang, Bararapa, Dhudoroa, Dja Dja Wurrung, Jarra Jarra, Jupagulk, Latje Latje, Ntait, Nyeri Nyeri, Robinvale, Tati Tati, Taungurung, Wadi Wadi, Wamba Wamba, Way Wurru, Wergaia, Yorta Yorta, and Yulupna peoples.

VEAC also recognises and acknowledges the contribution and interests of Indigenous people and organisations in the management of land and natural resources.

Finally, we acknowledge that past injustices and continuing inequities experienced by Indigenous peoples has limited, and continues to limit, their participation in land and natural resource management processes.

Acknowledgments

The Victorian Environmental Assessment Council (VEAC) would like to formally acknowledge the contribution all individuals and government, community and industry groups have made to the development of this Discussion Paper. In particular, VEAC would like to acknowledge the information and feedback provided by the Community Reference Group during the development of this Paper. Members of this group are listed in Appendix 1. A large proportion of the data, information and in some cases draft text used in the Paper has been received from various government agencies involved in the Government Contact Group, including the Department of Sustainability and Environment (DSE). A list of the members of this group is at Appendix 2.

Many other technical experts and consultants have provided valuable input and information, including some draft text for this Discussion Paper. These include: Chapter 2, Fons Vandenberg, Department of Primary Industries, DPI and Dr Susan White and Gresley Walklin-King; Chapter 4, David Rees, DPI; Chapter 5, Alan Yen, DPI, Ian Mansergh, Nevil Amos, and the entire Biodiversity and Natural Resources Team, DSE, and Christine Kenyon; Chapter 6, William Glenbar and Karen Milward, Chapter 7, Robyn Ballinger; Chapter 8, Fiona McKenzie, Spatial Analysis and Research, DSE; Chapter 12, William Glenbar and Karen Milward, Joy Elley Aboriginal Affairs Victoria, and Daniel Catrice, DSE; Chapter 13, Gary Niewand, DSE and Russell Goodman, DPI; Chapter 14, Mal McKinty, Barry Dexter and Leon Bren, University of Melbourne; Chapter 15, Geoff Earl, Simon Casanelia and Keith Ward, Goulburn Broken CMA, Paul Sinclair, Environment Victoria, Jane Doolan, Paulo Lay, Julia Reed, Phil Heaphy, Rebecca Curran, and John Cooke, DSE, Tony Ladson, Monash University and Christine Forster, Victorian Catchment Management Council. Assistance and advice was also provided by DSE regional services staff as well as Parks Victoria and DPI.

Since the start of the Investigation VEAC members and staff have had many discussions with numerous stakeholders and experts, in the study area and elsewhere. While these people may not have been directly involved in the preparation of this Paper, their perspectives and information contributed greatly to our understanding of the study area and key issues.

The Discussion Paper was prepared by the River Red Gum Forests Investigation team: Paul Peake, (Project Leader), Kaye Follett, Dr Natasha McLean and Dr Mel Mitchell. Joan Phillips, Director and earlier in the project, Shane Dwyer as the then CEO, Simon Ransome, Naomi Withers, Sue Street, Fred Cumming, James Fitzsimons, Amanda Stajewski, Sharon Edwards, and Belinda Irwin also provided invaluable assistance to the team. Special thanks also go to Naomi Withers and Mark Worthing for all the in-house mapping and spatial advice and to Alison Oates, Matt White and David Parkes, DSE and Doug Frood, consultant for their extensive work on the pre-1750 Vegetation Map.

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HOW TO USE THIS DISCUSSION PAPER

This Discussion Paper is the first report published in VEAC's River Red Gum Forests Investigation. As the name suggests, its principal purpose is to generate discussion that will inform later stages of the Investigation process—VEAC will be receiving submissions in response to this Paper until Thursday, 7 December 2006 (details inside front cover).

The Discussion Paper is divided into four parts.

Part A provides background and details on the values and assets of public land in the study area, including biophysical, socio-economic, Indigenous land associations and historical aspects of the study area. Part A covers chapters 2 to 8 of the paper.

Part B explains in detail the public land use framework as it applies to the River Red Gum Forests study area. This includes the various public land use categories represented in the study area and the management arrangements associated with them. Chapter 9 is the only chapter in this part of the paper.

Part C of the Discussion Paper provides details on the various uses of land within the study area and the implications of these uses on the values and assets of the River Red Gum Forests as a whole. It covers chapters 10 to 17.

Part D explores the issues emerging from the material in Part C and raised through community input to the investigation processes. This part of the Discussion Paper covers chapters 18 to 19.

The paper is divided into these four parts to reflect the four objectives sought through the development of the Discussion Paper. The objectives are to:

- provide detailed information on the various values and assets found within the study area (Part A);
- provide the reader with some context around how public land is categorised (Part B);
- explain the links between the various values and assets identified in Part A with the various land use categories outlined in Part B (Part C); and
- raise potential issues associated with the River Red Gum Forests Investigation and encourage submissions responding to the Discussion Paper (Part D).

The Discussion Paper is first and foremost a detailed resource document. This type of document enables any stakeholder to gain sufficient information and knowledge about the study area in its entirety to make an informed response to the Discussion Paper. It also ensures all information and knowledge is available in the public domain for all to read.

VEAC is aware that the document is of considerable length and, in some situations, this length could deter some readers. To overcome this and make the material contained in the Discussion Paper more accessible a summary brochure is available free through Information Victoria and at VEAC's website: www.veac.vic.gov.au.

Additional detailed and background material related to the Investigation is contained in the appendices at the back of this Discussion Paper. Maps showing relevant information are interspersed throughout the document and large scale maps are located inside the back cover.

Terms of Reference for the River Red Gum Forests Investigation

Pursuant to Section 15 of the *Victorian Environmental Assessment Council Act 2001* the Minister for Environment hereby requests the Council to carry out an investigation of public land within the area shown on the accompanying plan.

The purposes of the investigation are to:

(a) Identify and evaluate the extent, condition, values, management, resources and uses of riverine red gum forests and associated fauna, wetlands, floodplain ecosystems and vegetation communities[1] ; and

(b) Make recommendations relating to the conservation, protection and ecological sustainable use of public land as specified in Section 18 of the *Victorian Environmental Assessment Council Act 2001*.

In addition to the considerations specified in Section 18 of the *Victorian Environmental Assessment Council Act 2001*, the Council must also take into consideration the following matters:

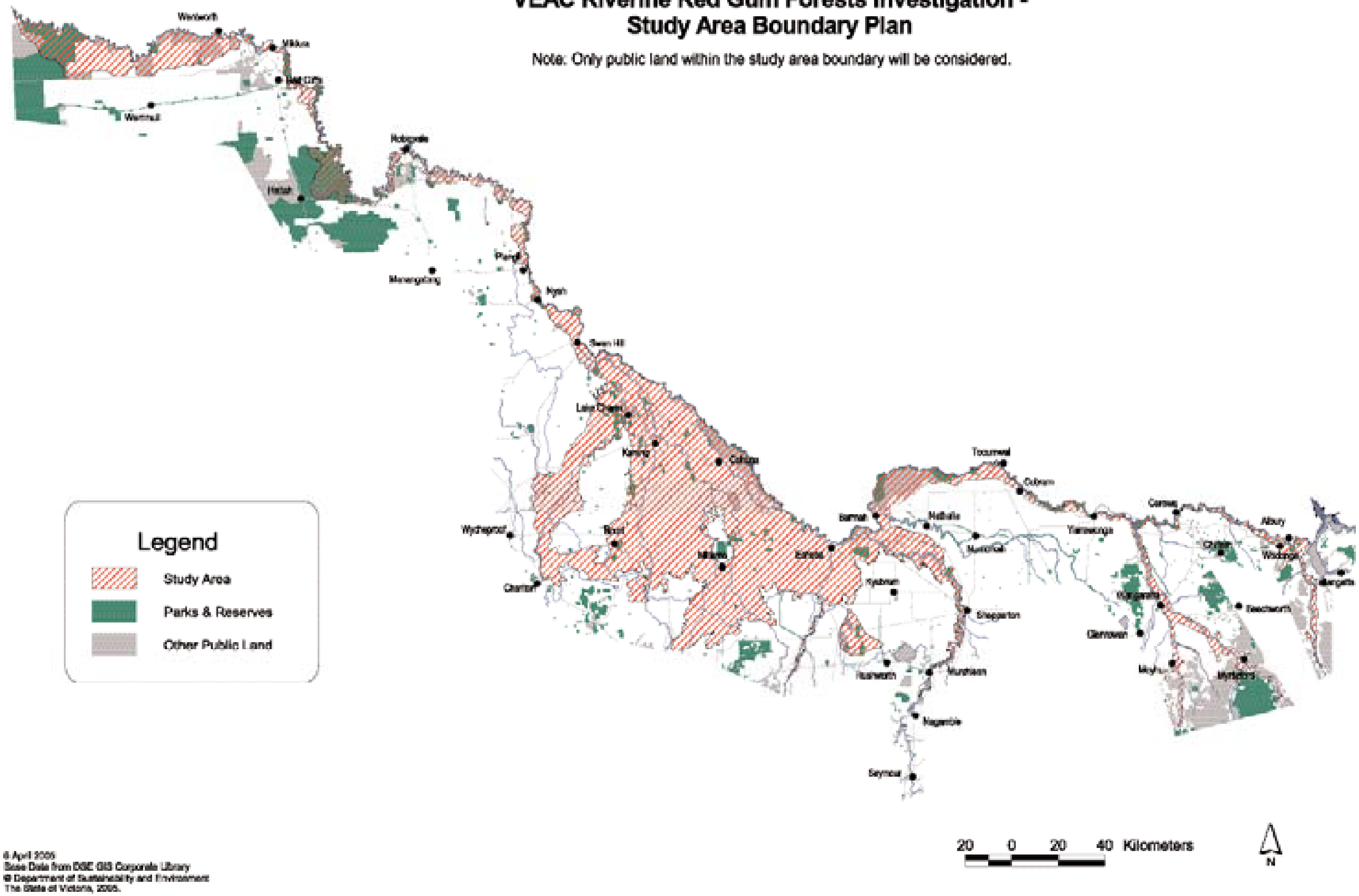
- Policies, programs and reports, as well as obligations, resulting from International, Commonwealth-State and Interstate agreements or arrangements, as they relate to the investigation;
- Existing State Government policies, programs, strategies and Ministerial Statements, as they relate to the investigation;
- Regional programs, strategies and plans, as they relate to the investigation;
- Possible opportunities for indigenous management involvement;
- The Yorta Yorta Co-operative Management Agreement;
- Appropriate access for commercial opportunities (eg timber, grazing, apiaries, and other resource industries), for appropriate recreation activities, and for community values and uses;
- Nationally agreed criteria for a comprehensive, adequate and representative reserve system, and;
- Opportunities for a joint management regime with the New South Wales Government for the Murray River and public land on its floodplains.

The Council is required to release a Discussion Paper, a Draft Proposals Paper, and submit a Final Report on the results of its investigation. The Final Report must be submitted by 1 February 2008.

[1] This includes all Ecological Vegetation Classes (EVCs) occurring within the study area boundary.

VEAC Riverine Red Gum Forests Investigation - Study Area Boundary Plan

Note: Only public land within the study area boundary will be considered.



1 Introduction

BACKGROUND TO THE RIVER RED GUM FORESTS INVESTIGATION

One thousand years ago a visitor to the Murray Valley would have seen Aboriginal people living alongside the River Murray as they have done for tens of thousands of years. The people utilised the river red gums to make bark canoes for transport across the river. They hunted, fished and foraged, drawing on the abundant natural resources of the region. The people had then—and continue to have—an inherent spiritual relationship with their traditional country.

One hundred years ago the visitor would have seen large river paddle-steamers laden with wool bales off-loaded at Echuca for the rail trip to Melbourne and then world markets. They would have seen timber cutters harvesting the red gums and box trees to power the paddle-steamers, to build wharves and railways, and for a myriad of other purposes. The Murray River was the life-blood of the region for transport, communication and access to markets.

Today, visitors go to the region for many different reasons. The scenic landscapes, magnificent red gum forests and wetlands, diverse recreational opportunities and dynamic industries draw people to the Murray Valley. Many of these industries, such as timber harvesting, honey production and grazing, have been active in forest areas since the early days of European settlement. The two largest river red gum forests in the world occur within the region: the Gunbower-Perricoota and Barmah-Millewa forests. The region is also ecologically diverse and the river, its floodplains, billabongs and tributaries, provide significant habitat for threatened flora and fauna species. The river remains the life-blood of the region but now with a different emphasis on industry for local communities, providing water for irrigation and a focus for recreation and tourism. The area's popularity places pressure on the region and its resources.

Despite the region's significance, it has been twenty years since the last broad-scale systematic survey of public land use. Consequently, the Victorian Government has requested VEAC to investigate the River Red Gum Forests of the Murray Valley. VEAC will consult widely with the community and stakeholders and consider all values and issues before making recommendations to Government on the appropriate public land use (e.g. state forest, national park, regional park) for the various areas of public land in the study area. The Council hopes that its final recommendations to Government for the area will provide a useful framework for public land into the future.

The Victorian Environmental Assessment Council

The Victorian Environmental Assessment Council Act 2001 (VEAC Act) came into effect in December 2001. This Act repealed the *Environment Conservation Council Act 1997* and established the Victorian Environmental Assessment Council to conduct investigations and make recommendations relating to the protection and ecologically sustainable management of the environment and natural resources of public land. The current five members appointed to VEAC by the Minister for Environment are Mr Duncan Malcolm (Chairperson), Associate Professor David Mercer, Professor Barry Hart, Ms Jan Macpherson and Ms Jill McFarlane. A brief biography of each of the Council members is provided on the inside front cover of this Discussion Paper.

The Council conducts its affairs in accordance with the VEAC Act 2001. In particular, Section 18 specifies that "Council must have regard to the following considerations in carrying out an investigation and in making recommendations to the Minister—

(a) the principles of ecologically sustainable development;

(b) the need to conserve and protect biological diversity;

(c) the need to conserve and protect any areas which have ecological, natural, landscape or cultural interest or significance, recreational value or geological or geomorphological significance;

(d) the need to provide for the creation and preservation of a comprehensive, adequate and representative system of parks and reserves within Victoria;

(e) the existence of any international treaty ratified by the Commonwealth of Australia which is relevant to the investigation;

(f) any agreement at a national, interstate or local government level into which the Government of Victoria has entered, or under which the Government of Victoria has undertaken any obligation in conjunction with the Commonwealth, a State, Territory or municipal council, which relates to the subject matter of the investigation;

(g) the potential environmental, social and economic consequences of implementing the proposed recommendations;

(h) any existing or proposed use of the environment or natural resources."

In carrying out its investigations, Council has the task of considering all the complex issues and views involved and then providing integrated recommendations that form the basis of future public land use and management in the study area. In particular, Council must take into account the protection of biodiversity and other environmental values along with the competing demands on the land and its resources as well as the full range of social and economic considerations.

Terms of Reference for the River Red Gum Forests Investigation

On 19 April 2005, the Minister for Environment, the Hon. John Thwaites, requested that VEAC undertake an Investigation into River Red Gum Forests. The Terms of Reference together with a map of the Investigation study area are presented earlier.

The Terms of Reference specify eight matters that VEAC must take into consideration. Some of these matters are quite specific and are explored in more detail in relevant chapters of this Discussion Paper. The Yorta Yorta Co-operative Management Agreement and possible opportunities for Indigenous management are described in chapters 6 and 19. The nationally agreed reserve system criteria are discussed in chapters 5 and 10. Other matters to take into consideration arise in several chapters or are less specific (such as access for the timber industry in chapter 14).

The Investigation Process

The process for the River Red Gum Forests Investigation is formally specified in the VEAC Act and the Terms of Reference for the Investigation. The process is shown in Figure 1.1. There are three submission periods (each a minimum of 60 days) and the Investigation is scheduled to be completed by 1 February 2008 when the Final Report is given to the Minister for Environment.

Over 580 submissions were received in response to the Notice of Investigation (listed in Appendix 3). These submissions contain a vast amount of valuable information and perspectives on the Investigation, and have formed a major input to this Discussion Paper and the Investigation as a whole. A summary of some of the major matters raised in submissions is contained in chapter 18. VEAC is very grateful for the large amount of time and effort that members of the community have put into their submissions, and looks forward to receiving further submissions in response to this Discussion Paper. Details for making submissions are provided on the inside front cover of this paper.

Figure 1.1 VEAC's public consultation process for the River Red Gum Forests Investigation.

19 April 2005
Minister requests VEAC undertake River Red Gum Forests Investigation

↓

30 April 2005
Notice of Investigation published in local and statewide papers

↓

65 day formal submission period

↓

October 2005
Publication of Discussion Paper

↓

Minimum 60 day formal submission period

↓

Mid 2007 (projected)
Publication of Draft Proposals Paper

↓

Minimum 60 day formal submission period

↓

1 February 2008
Final Report submitted to Minister

↓

State Government responds to VEAC's recommendations

Principles and Objectives

Ecologically Sustainable Development

The principles of ecologically sustainable development (ESD) are key considerations under Section 18 of the VEAC Act. Broadly, ESD embraces economic development that provides for biodiversity protection, inter-generational equity, and enhanced social welfare.

ESD came to prominence in the early 1990s. Since that time many definitions, concepts and publications have been developed at all levels from international to local. In Victoria, the *Commissioner for Environmental Sustainability Act 2003* defines ESD as development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. Under this legislation the objectives of ESD are:

(a) to enhance individual and community wellbeing and welfare by following a path of economic development that safeguards the welfare of future generations;

(b) to provide for equity within and between generations;

(c) to protect biological diversity and maintain essential ecological processes and life support systems.

This Act also articulates a set of guiding principles for ESD, namely:

(a) that decision making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations;

(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

(c) the need to consider the global dimension of environmental impacts of actions and policies;

(d) the need to develop a strong, growing and diversified economy which can enhance the capacity for environment protection;

(e) the need to maintain and enhance international competitiveness in an environmentally sound manner;

(f) the need to adopt cost effective and flexible policy instruments such as improved valuation, pricing and incentive mechanisms;

(g) the need to facilitate community involvement in decisions and actions on issues that affect the community.

The Victorian Government has developed two major ESD documents: *Our Environment Our Future: Victoria's Environmental Sustainability Framework (2005)* and *Our Environment Our Future: Sustainability Action Statement (2006)*. These are designed to inform and guide community, industry and government in how to go about their business in a more sustainable manner.

Objectives of the Investigation

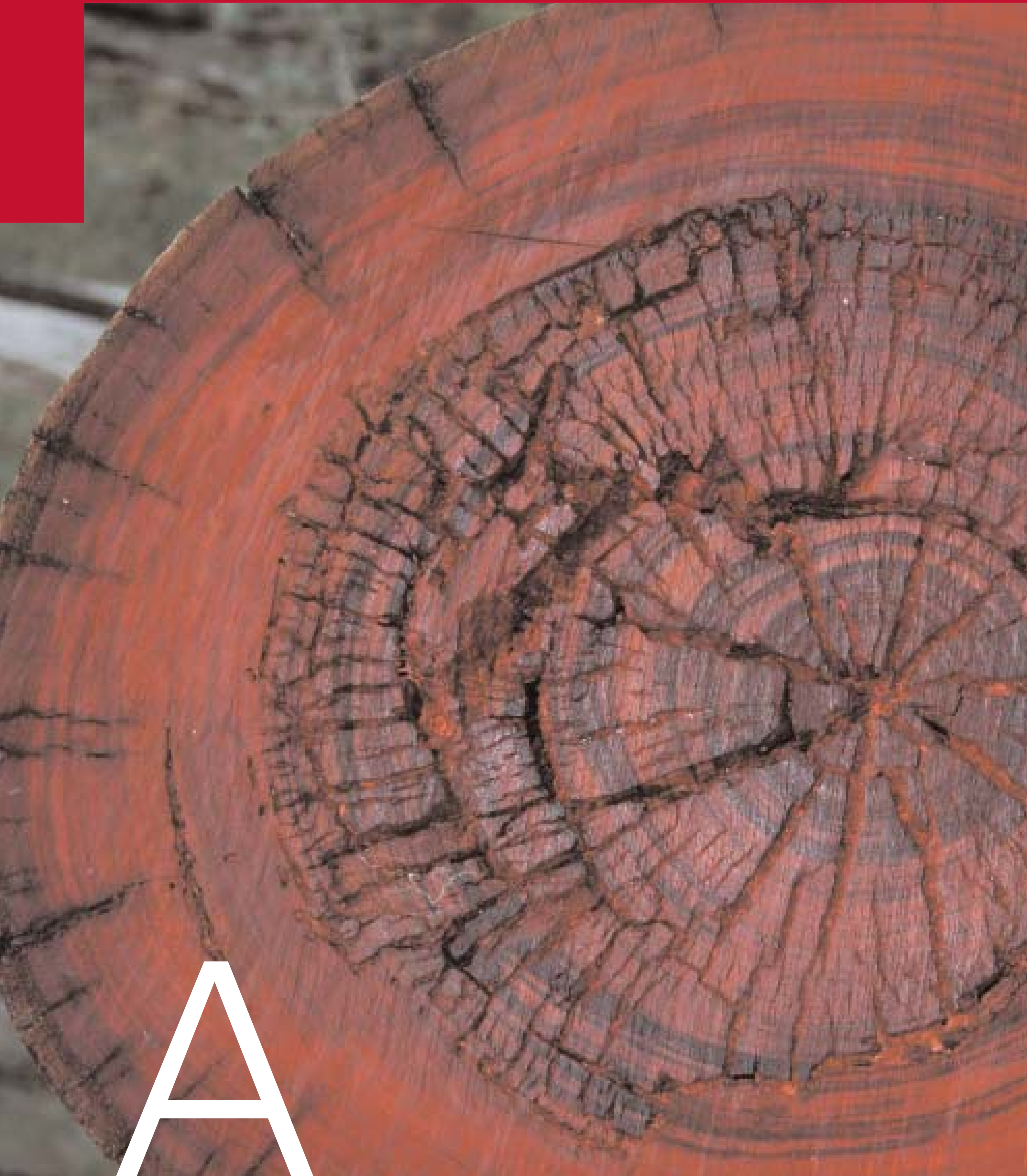
After considering the Terms of Reference, inspecting the study area, talking to stakeholders, and considering submissions, the Council has developed a set of objectives for the Investigation to address the Terms of Reference. These will help the Council identify and focus on the key issues, guide the consultation process, and provide a framework to ensure the Council has adequate information upon which to base its recommendations to Government.

In addressing the purposes of the Investigation outlined in the Terms of Reference, Council will recommend a pattern of land use for public lands in the study area that will facilitate their sustainable management, in the context of the overall pattern of land use, within and contiguous to the study area.

In achieving this objective, the Council will develop recommendations that will reflect:

- A high level of community involvement in the Investigation and the ongoing management of public land, including:
  - > Local residents
  - > Indigenous people and groups
  - > Commercial and industry interests
  - > Conservation and recreation groups
- Protection of natural values, including:
  - > Adequate representation of all Ecological Vegetation Classes (EVCs) of the study area in the park and reserve system
  - > Protection of biodiversity including rare and threatened flora and fauna
- Protection of catchments and water quality
- Protection of landscape values and cultural heritage
- Integration of opportunities for a wide range of uses and activities within the area, including:
  - > Provision for appropriate resource use from the different categories of public land
  - > Provision for appropriate recreation in the different categories of public land
  - > Development of a culture of integrated conservation and land management involving farmers, resource users, tourism operators and the public
  - > Accessible and well-managed natural areas for public recreation and enjoyment
- Maintenance of options for possible infrastructure development in the future such as:
  - > New roads and other public facilities
  - > Tourism development
- Consideration of the management demands created by various land use categories, including:
  - > Control of pest plants and animals
  - > Fire management
  - > Access, interpretation and education for visitors

General community acceptance of the Council's recommendations is particularly important since one of the outcomes of the Investigation should be to ensure public land in the area is managed to meet the needs and aspirations of both the local communities and the wider Victorian community, both now and into the future. In reaching its conclusions the Council will weigh up competing views and it is likely that not all of these will be accommodated to the extent that their advocates would see as appropriate. In recognition of this, the Council will ensure that processes are transparent and assessment of views and information are fair, reasonable and supportable.



A

Environmental, Social and Economic Setting

Part A provides details on the values and assets of public land in the study area, including biophysical, socio-economic, Indigenous land associations and historical aspects of the study area.

2 Geology

Geology underpins the diversity of all life on earth. The interaction between weather and landscape has provided a range of niches and habitats in which the enormous variety of life has evolved and flourished. Both subtle and dramatic changes in these elements have caused extinctions and adaptations over thousands of millions of years. This chapter describes these landscape foundations and changes recorded over geological time in southeastern Australia and, specifically, within the study area.

Over millions of years, geological processes have all left their mark on the Australian landscape and within the River Red Gum Forests study area. More recently, climatic changes have left a distinct imprint with changing sea levels and river flows, extinctions of the unique Miocene-Pleistocene Australian megafauna (giant marsupials and birds) and the arrival of the first people in the last 50,000 years. The unique character, features and resources of the study area can only be fully understood in the broader context of the underlying geology. This chapter provides an overview of the geological history of Victoria with specific reference to the study area. Although few outcrops of older or 'basement' rocks occur in the study area, these form the foundations for the overlying rocks and contain economic resources. More recent sedimentary processes and geomorphology are described in chapter 3.

GEOLOGY OF SOUTHEASTERN AUSTRALIA

Australia's geological history is extensive, beginning with some of the oldest rocks on earth. Australia's continental history began as part of the great Gondwanan supercontinent and continued through its gradual separation from other Southern Hemisphere land masses until final separation from Antarctica and northward drift away from the polar regions. In the western portion of Australia, rocks dated at 3800 million years ago (Ma) with individual mineral grains up to 4000 million years old have been recorded (see timescale in Table 2.1). This region of the continent is known as the Australian Craton (Figure 2.1). The eastern portion of Australia, including parts of Victoria, NSW, Queensland and Tasmania consists of significantly younger rocks—largely from the Phanerozoic eon (542 Ma to present day). These rocks were joined to the much older, consolidated and metamorphosed western rocks of the Australian Craton during a series of tectonic events and now form a belt of folded sedimentary and igneous rocks (known as the Tasman Fold Belt) extending along the east of the Australian continent (Figure 2.1).

Geological Time Scale

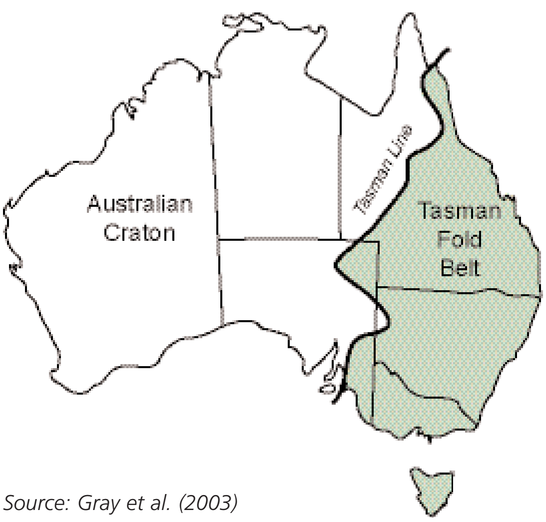
The initial occurrence of abundant multi-celled life is preserved in Proterozoic (2500–542 Ma) rocks in the South Australian Flinders Ranges—specifically the Ediacaran period (600–542 Ma). A rapid increase in the number of life forms marks the beginning of the Phanerozoic eon (542 Ma to present day) comprising three eras: Palaeozoic (542–251 Ma), Mesozoic (251–65 Ma), and the Cainozoic (65 Ma to present day). These eras are separated by mass extinctions events. At the end of the Palaeozoic more than 80 percent of all life forms became extinct (Permian extinction), while the end of the Mesozoic is correlated with a meteorite impact event and the decline of a large range of life-forms including the extinction of dinosaurs (Cretaceous extinction) (e.g. Keller 2005). Within each of these eras there is a number of sub-eras or time periods (Table 2.1).

Victoria's Geology

In Victoria, Tasman Fold Belt rocks are subdivided into two major structural divisions—the Delamerian Fold Belt and the Lachlan Fold Belt (Figure 2.2). Both fold belts consist of a similar suite of rocks—mainly marine sedimentary rocks with minor occurrences of submarine volcanics, and granitic intrusions and lavas. The Delamerian Fold Belt is significantly older and comprises Proterozoic and Cambrian age (600–490 Ma) rocks that were folded and faulted during a mountain-building episode, the Delamerian Orogeny (520–490 Ma), followed by intrusion of granites in the Cambrian and Ordovician (520–480 Ma).

The younger Lachlan Fold Belt rocks have a much broader age range, from Early Cambrian (about 530 Ma) to Early Carboniferous (about 340 Ma) and have had a much more complex history, with major mountain-building (or orogenies) occurring during four main events: the Benambran Orogeny (450–425 Ma), the Bindian Orogeny (415–405 Ma), the Tabberabberan Orogeny (400–390 Ma) and several minor events during the Kanimblan Orogeny (370 and 340 Ma). The Lachlan Fold Belt probably formed during the collision of an island arc—such as the present Indonesian island chain—with the Australian Craton (VandenBerg et al. 2000) during which sedimentary and volcanic rocks were fractured and traversed by major thrust faults, and intruded by numerous granitic bodies.

Figure 2.1 Structural architecture of the Australian continent showing the largely Palaeozoic fold belts along the east coast and the older Australian Craton to the west. The boundary between these two regions is described as the Tasman Line.



Source: Gray et al. (2003)

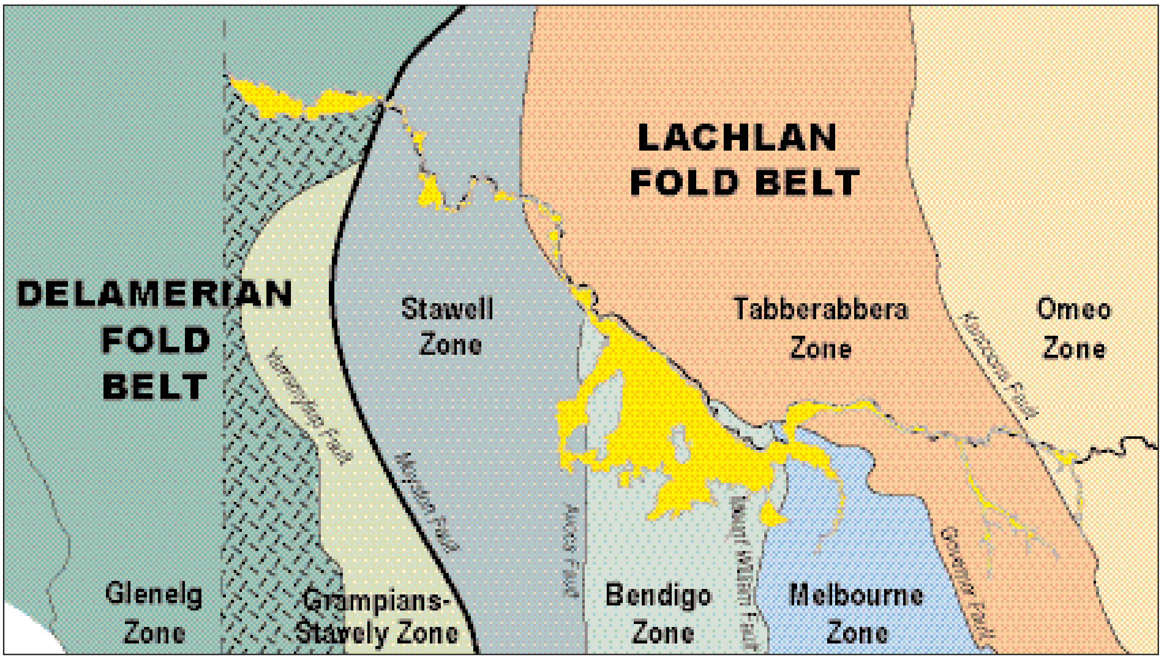
Table 2.1 Geological time scale and major geological events.

Eon	Era	Period		Epoch	Major Geological Event
Phanerozoic 0–542 Ma	Cainozoic 0–65 Ma	Quaternary 0–1.8 Ma		Holocene	Humans arrive in Australia ~50,000 years ago Extinction of Australian megafauna
				Pleistocene	
		Tertiary 1.8–65 Ma	Neogene 1.8-24 Ma	Pliocene	First upright walking hominids ~4 Ma
				Miocene	Diversification of mammals and birds
			Palaeogene 24-65 Ma	Oligocene	
				Eocene	Australia separated from Antarctica
				Paleocene	
	Mesozoic 65–251 Ma	Cretaceous 65–141 Ma		Late	Mass extinction of life at 65 Ma Australia separates from New Zealand at ~80 Ma
				Early	Eastern Highlands uplifted ~90 Ma Otway and Gippsland basins formed across the southern margin rift
		Jurassic 141–205 Ma		Late	Break-up of Gondwana commenced—initial separation of Australia and Antarctica commences at ~140 Ma
				Middle	
				Early	First appearance of birds
		Triassic 205–251 Ma		Late	
				Middle	First appearance of dinosaurs
				Early	
	Palaeozoic 542–251 Ma	Permian 251–298 Ma		Late	Mass extinction of >80 % of all life forms at 251 Ma
				Early	
		Carboniferous 298–352 Ma		Late	
				Early	
		Devonian 352–410 Ma		Late	
				Middle	Kanimblan Orogeny 340 and 370 Ma
				Early	Tabberabberan Orogeny 390–400 Ma
		Silurian 410–434 Ma		Late	Bindian Orogeny 405–415 Ma
				Early	
		Ordovician 434–490 Ma			Benambran Orogeny 425–450 Ma
		Cambrian 490–542 Ma		Late	Delamerian Orogeny 490–520 Ma
				Middle	
				Early	First abundant life on Earth
Proterozoic 542–2500 Ma		Ediacaran 542–600 Ma			Oldest known multi-cellular organisms 600 Ma
Archaean 2500–4560 Ma					Oldest life known at ~3500 Ma
Hadean >4560 Ma					Origin of the Earth

*Ma denotes millions of years

Source: modified after Gradstein et al. (2004)

Figure 2.2 Schematic diagram of fold belt for south-eastern Australia. The boundary between two major geological provinces, the Delamerian Fold Belt and the Lachlan Fold Belt is located along the Moyston Fault (e.g. Cayley & Taylor 1997), as well as the boundary faults separating the structural zones. The River Red Gum Forests study area is shown in bright yellow.



Source: modified after VandenBerg et al.(2000)

The Lachlan Fold Belt can be divided into several zones of similar character (Figure 2.2). Each of these is separated by a major structural fault line within which the rocks are often highly deformed and much older slivers have been emplaced from great depth. A brief description of each of these zones is provided below (Table 2.2). The distribution of these rocks is important for understanding the occurrence of mineral resources throughout Victoria.

These fold belt rocks are known as bedrock or basement and form a solid layer below a more recent—largely Cainozoic—sedimentary cover sequence, deposited by streams flowing out of the highlands of the Great Dividing Range.

Towards the end of the Palaeozoic, erosion exposed the roots of these mountain chains and global cooling formed a large ice sheet over Gondwana, with fingers extending north into what is now Australia. In the Permian (300–250 Ma), these glaciers flowed into a shallow sea with a shoreline that lay in an east–west direction at the latitude of Ballarat.

Prolonged erosion in the early Mesozoic removed much of the rock laid down in the late Palaeozoic, and by Jurassic time (about 200 Ma) Victoria was a land of low relief, with north-flowing river systems that drained into the Sydney Basin and later into a vast sea that became the Great Australian Basin (formerly called the Great Artesian Basin). Around 160 Ma the Gondwanan supercontinent (Antarctica, South America, Africa, India, Australia and New Zealand) began to break-up, a process which continued over a long period with Australia and Antarctica being the last landmasses to separate. The initial stage of the separation in the Early Cretaceous (145 Ma) opened a rift valley, forming a series of depositional basins across southern Victoria (Otway, Bass and Gippsland Basins). In the Late Cretaceous (95 Ma) continental break-up uplifted the mountain chain that became the Great Dividing Range. At the same time, a large shallow sea formed from Queensland to South Australia called the Eromanga Basin. The Murray Basin (Figure 2.3) was established across northern Victoria in the Eocene (55 Ma) with a thin veneer of sediment laid down from rivers flowing north from the Great Dividing Range. Rifting completely separated the two continents during Eocene times (~45 Ma) with the newly formed Australian continent drifting towards the equator while Antarctica remained near polar latitudes (Veevers 1984).

GEOLOGICAL HISTORY OF THE STUDY AREA

The geological history of Victoria is extremely complex. The following account provides an overview of the geology of the study area and describes the main geological rock sequences and events within it, both outcropping and subsurface. This geology, and the major outcropping rocks, is shown on Map 2.1. Pre-Permian geology is shown on Map 2.2. This history provides a background for the region's current natural resources (see chapter 16 Earth Resources). Greater emphasis is placed upon outcropping sequences and those that contain economic resources within the study area. For more scientific or comprehensive descriptions see Cochrane et al. (1999) and Birch (2003).

Table 2.2 Structural zones identified within Victoria.

Structural zones	Rock types	Main deformation episodes
Delamerian Fold Belt		
Glenelg Zone	Deep-marine sedimentary rocks and very minor basalt of Proterozoic to Early Cambrian age. Deformation and heating converted some of the rocks into schist and gneiss, and granitic rocks. Rocks are mostly buried beneath younger sequences.	Delamerian Orogeny
Grampians-Stavely Zone	Cambrian age volcanics and sedimentary rocks of the Glenthompson Sandstone. Minor occurrences of serpentinite and ultramafic rocks occur in thin slivers, and have been intersected in drill holes at depth (e.g. Dimboola Igneous Complex).	Delamerian Orogeny
Lachlan Fold Belt		
Stawell Zone	Deep-marine sedimentary rocks and minor basalt of Early Cambrian age overlain by extensive Cambro-Ordovician quartz-rich turbidites (Cambrian St Arnaud/ Early to middle Ordovician Castlemaine Group)	Delamerian Orogeny
Bendigo Zone	Three main sequences: deep-marine sedimentary rocks and minor basalt of Cambrian to Ordovician age comprising Ordovician turbidites (Castlemaine Group); Upper Cambrian shales and cherts; mid to lower Cambrian volcanics and volcanoclastics	Benambran Orogeny
Melbourne Zone	Deep to shallow marine sedimentary rocks of Early Ordovician to Early Devonian age	Tabberabberan Orogeny
Tabberabbera Zone	Deep-marine sedimentary rocks and minor basalt of Cambrian to Ordovician age	Benambran Orogeny
Omeo Zone	Deep-marine sedimentary rocks and minor basalt of Cambrian to Ordovician age, deformed at relatively deeper level so that much of the rock has undergone high-grade metamorphism to schist and gneiss, and melting to migmatite and granite.	Benambran Orogen

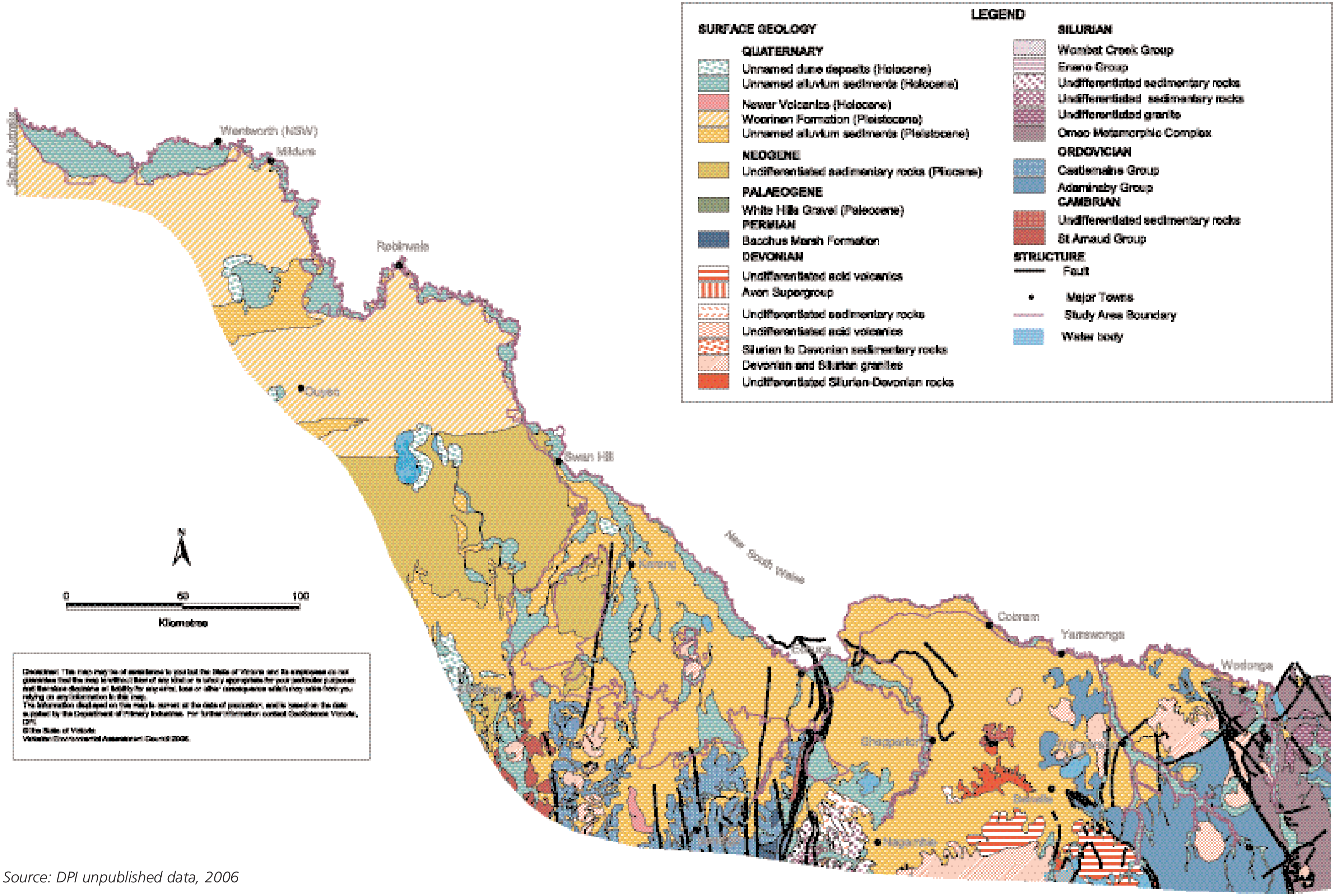
Source: VandenBerg et al. (2000)

The major events in Victoria's geological history occurred in three eras. Rocks from the earliest or Palaeozoic era (542–251 million years ago) form the basement underlying the entire study area, but few outcrops occur (see Map 2.1). Mesozoic era (251–65 Ma) rocks are only found at depth within depositional troughs of the Murray Basin (Figure 2.3) and near the eastern part of the study area in the King River valley. Most surface geology is from the extensive Cainzoic era (65–0 Ma) sediments of the riverine plain.

Palaeozoic

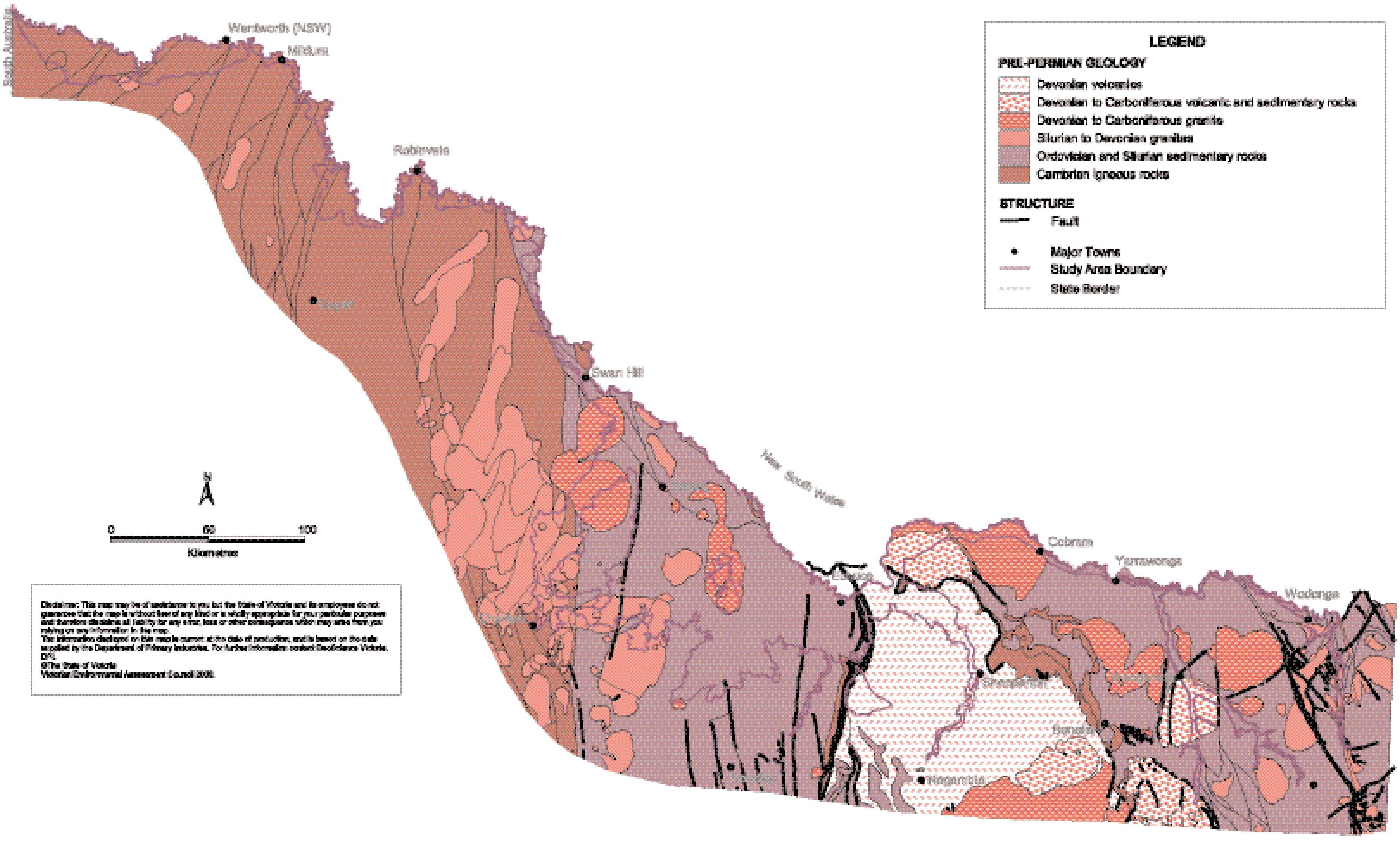
The Lachlan Fold Belt (Figure 2.2) comprises most Palaeozoic age rocks in Victoria, specifically from the Cambrian until the Carboniferous. Each structural zone within this sequence has experienced a unique geological history including periods of orogenic mountain building, sediment deposition and granite intrusion, leading to the diverse character of landscape across Victoria today, described in Table 2.2.

Map 2.1 Surface Geology Map.



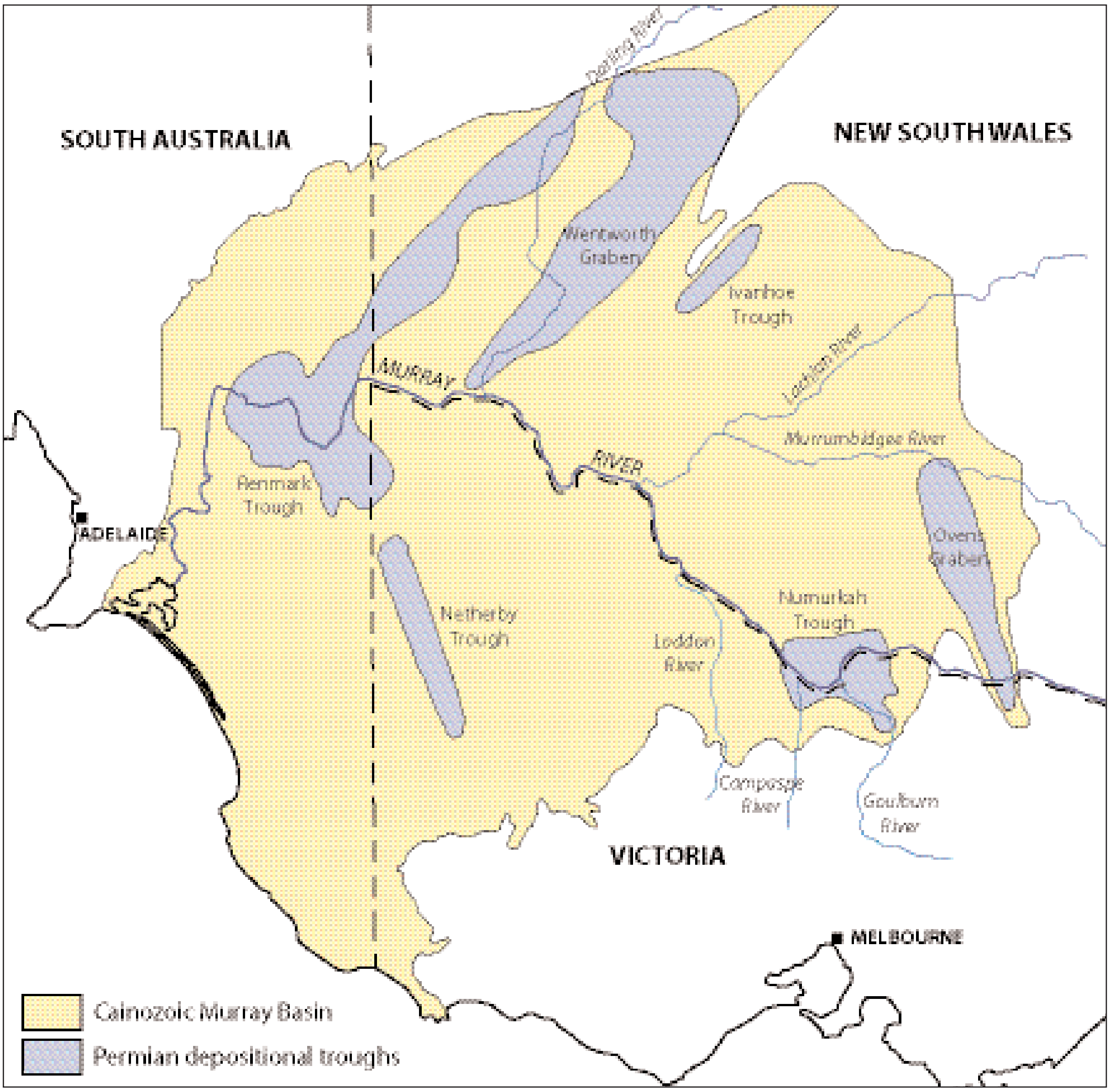
Source: DPI unpublished data, 2006

Map 2.2 Pre-Permian Geology Map.



Source: DPI unpublished data, 2006

Figure 2.3 Murray Basin extent and subsurface depositional troughs.



Source: modified after Belperio (1995)

The oldest Victorian rocks are deep marine sedimentary and minor volcanic rocks of Late Proterozoic to Late Cambrian age (550–490 Ma). These rocks extend from within South Australia, east to the Avoca Fault—encompassing the Glenelg and Grampians-Stavely zones of the Delamerian Fold Belt, and the Stawell Zone of the Lachlan Fold Belt (Figure 2.2). Shallow boreholes have intersected these sequences at various locations below the much younger Murray Basin sediments, but none outcrop within the River Red Gum Forests study area.

Other Cambrian rocks including volcanics, shales and cherts occur along the edge and within major structural faults in the Lachlan Fold Belt. Cambrian rocks of the Delamerian Fold Belt and the Stawell Zone of the Lachlan Fold Belt were deformed during the Delamerian Orogeny (520–490 Ma). Cambrian to Early Ordovician granites intruded the Cambrian rocks of the Delamerian Fold Belt but are not present in the Lachlan Fold Belt. Following the mountain building of the Delamerian Orogeny, deep-marine sedimentation occurred in a basin located within central Victoria, and extending across the whole of the Lachlan Fold Belt east of the Avoca Fault. These thick Ordovician sediments overlie extensive Cambrian volcanic rocks and consist predominantly of sandstone and mudstone, with a small but important component of black shale.

Within the Melbourne Zone, Early and Middle Ordovician rocks are either absent or represented by thin chert, shale or sedimentary phosphate. There seem to have been major regional differences at this time, with thick sedimentary sequences deposited on both sides of a high area described as the Selwyn Block (VandenBerg et al. 2000). This Selwyn Block is thought to underlie the Melbourne Zone and extend from similar rocks in Tasmania (Fergusson & VandenBerg 2003).

The Benambran Orogeny had variable effects across the Lachlan Fold Belt and occurred in several pulses between 460 and 420 Ma. This orogeny affected rocks on both sides of the Selwyn Block but not the Selwyn Block itself, which by that time was overlain by the sediments of the Melbourne Zone. Older sedimentary rocks of the Bendigo and Stawell Zones were folded and faulted in a single short-lived but major event during this period. In eastern Victoria the Benambran Orogeny folded and faulted Cambrian, Ordovician and Early Silurian sedimentary rocks, and is associated with granite intrusion and regional metamorphism. Elsewhere, especially in the Bendigo Zone, regional metamorphism was very low and the orogeny is associated with gold and quartz mineralisation within Ordovician sedimentary sequences.

The regional differences between western, central and eastern Victoria that first appeared in the Ordovician became more pronounced after the Benambran Orogeny (450–425 Ma). These differences divide the Lachlan Fold Belt into two belts of different structural evolution from the Ordovician to the Middle Devonian—the Benambra and Whitelaw terranes (VandenBerg et al. 2000). The Benambra Terrane of eastern Victoria comprises the Lachlan Fold Belt east of the Selwyn Block and Governor Fault (Tabberabbera zone and those to the east) and was subject to two episodes of rifting, one in the Late Silurian and the other in the Early Devonian, with an intervening orogeny at about the Silurian–Devonian boundary (Bindian Orogeny described below). The Whitelaw Terrane comprises the Lachlan Fold Belt that lies west of the Governor Fault including the Selwyn Block (Stawell, Bendigo and Melbourne zones). Unlike the Benambra Terrane, the Whitelaw Terrane shows only mild effects from the Bindian Orogeny. The Whitelaw terrane contains the richest gold deposits in the Tasman Fold Belt.

A major episode of granite intrusion occurred in the Benambra Terrane, and also in the Stawell Zone in western Victoria during the Bindian Orogeny (405–415 Ma). In the Stawell Zone this was associated with a major phase of gold mineralisation, and a second phase of gold mineralisation occurred in the adjacent Bendigo Zone. The Melbourne Zone is characterised by continuing deep-marine sedimentation with conditions gradually becoming shallower in the western part of the zone.

Thick and diverse sediments characterise the Lachlan Fold Belt from the Cambrian until the Middle Devonian. Deformation and faulting of these thick sediments, and the later intrusion of granites and eruption of volcanics, forms Victoria's basement geology. In the Melbourne Zone, the Silurian to Middle Devonian sedimentary rocks lie conformably upon Ordovician rocks, as is the case in the Tabberaberra Zone.

In the Silurian to early Devonian, magmatism and granite intrusion occurred in the Grampians–Stavely Zone and in the eastern and western portions of the Lachlan Fold Belt, but not in the central area. This was reversed in the Late Devonian when central Victoria became the focus with several large granitic bodies intruded during that time (e.g. Cobaw, Harcourt, Strathbogie).

The Tabberabberan Orogeny (385 Ma) affected the whole of Victoria, although its expression varied strongly. The most pronounced effects are observed in the previously undeformed Melbourne Zone, where the thick Ordovician to Devonian sediment succession was strongly folded and faulted. Kilometre-scale movement occurred along the two bounding faults of the Melbourne Zone. West of the Melbourne Zone its effects were very mild, limited to rejuvenation of older faults and generation of strike-slip faults ('cross-courses') in the Bendigo and Stawell zones. Gold mineralisation occurred in the Melbourne Zone, and in the Bendigo Zone to the west, where it was the third phase of mineralisation. The two terranes were amalgamated in the Middle Devonian.

The Kanimblan Orogeny (~340 Ma) was the last of the deformation episodes that built the Lachlan Fold Belt in Victoria. Its effects were mild in Victoria, as the crust across the state had already been deformed and was, by that time, quite strong (VandenBerg et al. 2000). A period of tectonic stability followed that lasted through the Permian until the onset of the break-up of Gondwana in the late Jurassic and Cretaceous. Deposition during this stable interval is most extensive in lows or troughs some of which are preserved below the cover of more recent sediments in the Murray Basin (Figure 2.3).

During the Permian, Victoria lay on the edge of an ice-sheet extending south. Sediments from this time are preserved as a marine and glacial sequence at Bacchus Marsh and Lake Eppalock and smaller scattered patches elsewhere, and marine black mudstone (Urana Formation) within the Numurkah Trough of the Murray Basin (Figure 2.3). The periglacial sediments include fluvial (river-borne) sandstone and mudstone, as well as lacustrine (lake-bed) sediments with 'drop stones'.

Within the River Red Gum Forests study area, basement rocks rarely appear above the largely flat riverine plain, with notable exceptions at Pyramid Hill, Terrick Terrick, Lake Boga, and along the river valleys that extend into the Eastern Highlands.

Mesozoic

The rock record of the Triassic through Jurassic is poorly represented in Victoria and not known from the study area. Triassic granites and volcanics occur in the highlands near Benambra, and a small isolated sedimentary sequence at Bacchus Marsh has also been identified as Triassic (Webb & Mitchell in prep). The absence of Mesozoic deposition may be due to Victoria being an elevated area at the time. Very little definitive Jurassic material has been identified within Victoria—perhaps only limited volcanics and intrusives from the Casterton and Bendigo areas could be reasonably attributed to this time period.

Early Cretaceous age (145–95 Ma) rocks are well represented across southern Victoria with extensive outcropping and subsurface sequences of volcanogenic and fluvial sandstones and siltstones (Otway, Bass and Gippsland basins) and minor occurrences within the Murray Basin at depth. During the Late Cretaceous (95–65 Ma), the mountains of the Great Dividing Range rose as the rift between Australian and Antarctica spread. Downwarping on the northwestern side of the range enhanced the broad depression of the Murray Basin which rests upon basement rocks with a hilly topography much like the adjoining landscape. Stream deposits on both sides of the Great Dividing Range contain rich alluvial gold deposits accumulated during the prolonged erosion following the Permian glaciation. Subsequent basalt eruption, especially south of the Divide during the Cainozoic, buried the river sediments and gold-rich gravels that are now known as 'deep leads'.

Cainozoic

Sedimentation in the Murray Basin and the rivers draining into it was largely regulated by sea level changes with fault movements throughout the Cainozoic influencing deposition patterns and hydrology more generally (Figure 2.3). For example, movement on the Tawonga Fault influenced the development of the Ovens and King Rivers in the eastern part of the study area. Across much of the study area only small tectonic movement has occurred in the Cainozoic, although even small vertical offsets have resulted in major deflections of drainage lines on the flat land of northern Victoria. The most significant of these is the Cadell Fault near Echuca where the fault block diverted both the Murray and Goulburn rivers prior to 35,000 years ago (see chapter 3 Geomorphology and Land Systems).

Cainozoic sediments, of both marine and terrestrial origin, blanket and infill the basement surface across nearly the entire study area (Map 2.1). Conditions for accumulation of sediments were favourable during three major episodes of the Cainozoic era (65–0 Ma) reflected in three layers comprising the Renmark, Murray and Wunghnu groups. These sediments consist of fluvial-lacustrine sandstones, claystones and minor coals of the Renmark Group (Palaeocene–Early Oligocene), the predominantly marine carbonate Murray Group (Oligocene–Middle Miocene), overlain unconformably by the Late Miocene–Pliocene marine to fluvial Wunghnu Group. In the eastern part of the basin the marine Murray Group is replaced by non-marine sediments.

In general, Palaeocene to Pliocene sediments have limited outcrop in the study area and are largely blanketed by the younger Quaternary sediments of the riverine plains, and the aeolian (wind-blown) sequences of the dunefields and sand plains (Map 2.1).

Renmark Group

The Palaeocene to Oligocene Renmark Group rests unconformably on older basement rocks, infilling the pre-existing topography. The sequence has variable thicknesses up to a maximum of 300 m in the Mildura area, and up to 60 m in the palaeo-drainage systems of the Loddon, Campaspe and Goulburn rivers but less over the palaeo-topographic highs. Renmark Group sand units are important groundwater recharge sources for overlying aquifers. Brown coal seams occur at the top of the Renmark Group, especially in the Kerang, Torrumbarry and Echuca areas (see chapter 16 Earth Resources). The Renmark Group is overlain by the marine Oligocene–Miocene Murray Group or its non-marine equivalents and does not outcrop in the study area.

Murray Group

The Murray Group refers to all marine carbonate sediments between the top of the Renmark Group and the base of the Late Miocene or Early Pliocene Wunghnu Group. The limited Murray Group outcrop consists predominantly of exposures along river incisions and over the Gredgwin Ridge south of Kerang. It is not present in the Kerang–Cohuna and Goulburn areas of the Murray Basin and non-marine sediment equivalents occur to the east of this region. A complex mix of marine and non-marine sediments occurs across a poorly defined boundary between these areas. The Murray Group comprises a mixture of marine muds, clays and limestones (Ettrick Marl, Duddo Limestone, Geera Clay) and their non-marine equivalents such as the Calivil Formation. The Geera Clay is an important barrier to groundwater and provides a salt source to underlying Renmark Group aquifers, as well as restricting upwards-moving groundwater.

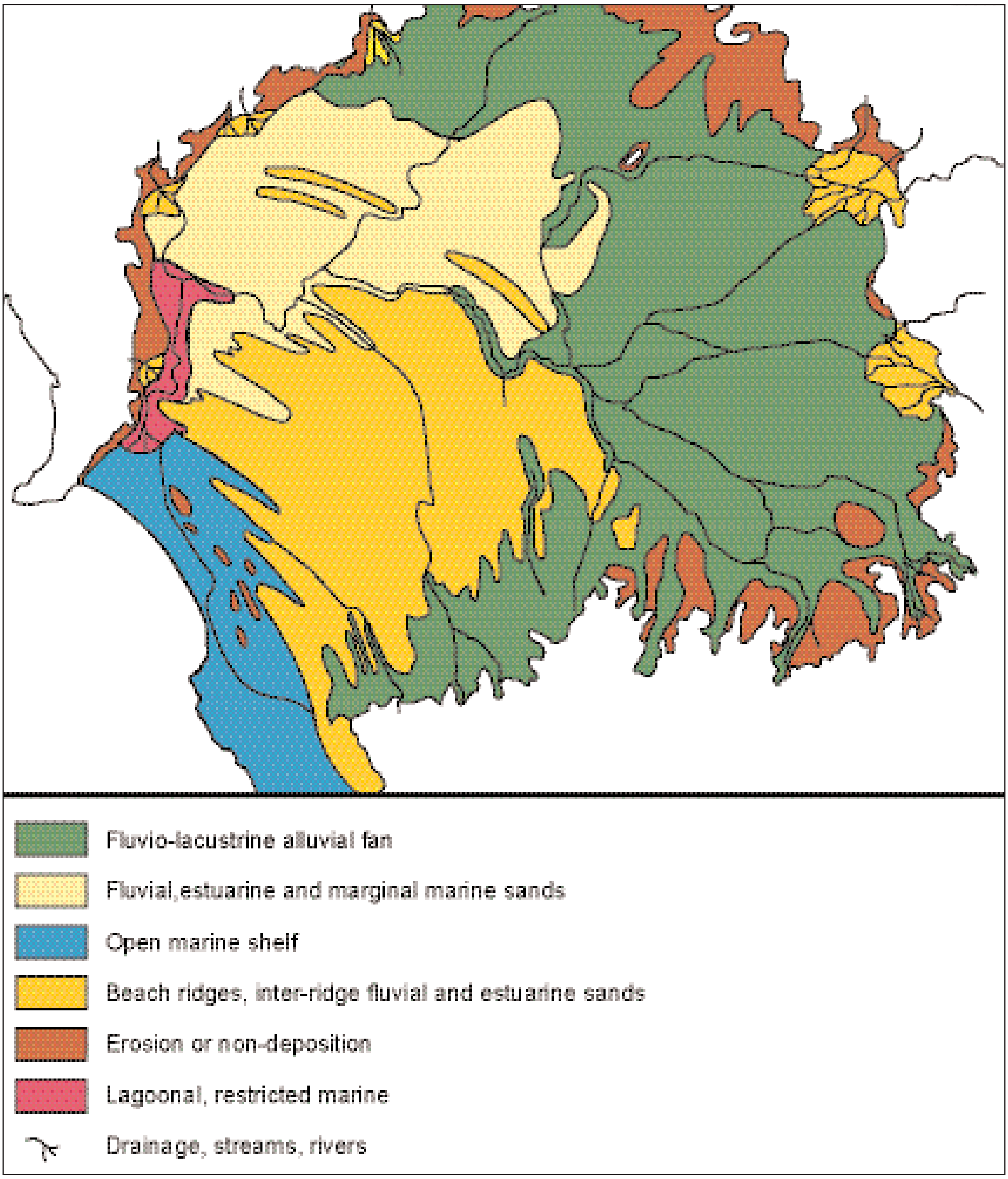
Wunghnu Group

The deposition of the Late Miocene to Pliocene Wunghnu Group commenced with a short-lived marine transgression followed by a slower regression of the sea. Sediments deposited during this time include marine units such as the green micaceous glauconitic marls of the Bookpurnong Beds, marginal marine units such as the Parilla Sand and non-marine equivalents such as the Shepparton Formation. These units are all unconformable on the underlying rocks. The unconformity is likely to represent a Late Miocene–Pliocene tectonic event similar to that identified in other areas of Victoria. This sequence comprises the majority of outcropping rocks throughout the study area and is therefore described in detail below.

The Wunghnu Group is highly variable with both marine and non-marine units from changing conditions of the Murray Basin including increasing climate variability (which affected both drainage and sediment derived from the Eastern Highlands) and changing sea levels. Sandstone aquifers and claystone units within this sequence have varying degrees of groundwater interconnection, both vertically and horizontally, providing significant groundwater resources in the eastern part of the Murray Basin.

The Pliocene Parilla Sand forms a series of sub-parallel ridges separated by swales across the western half of the Murray Basin in Victoria. It extends into the subsurface forming widespread sheet sandstones. These variably ferruginous quartz sands are cross-bedded, medium to fine-grained, and contain some bands of heavy minerals. Individual ridges can be up to 50 m high and several kilometres wide and extend for several hundred kilometres in a north-northwest direction. Beneath the Loddon Plains the formation is subdivided into the Kerang Sand (which laterally replaces the Bookpurnong Beds), an intermediate Tragowel Clay Member and the upper Wandella Sandstone, which is the main outcropping unit.

Figure 2.4 Murray Basin during the Pliocene showing palaeogeography and depositional environment.

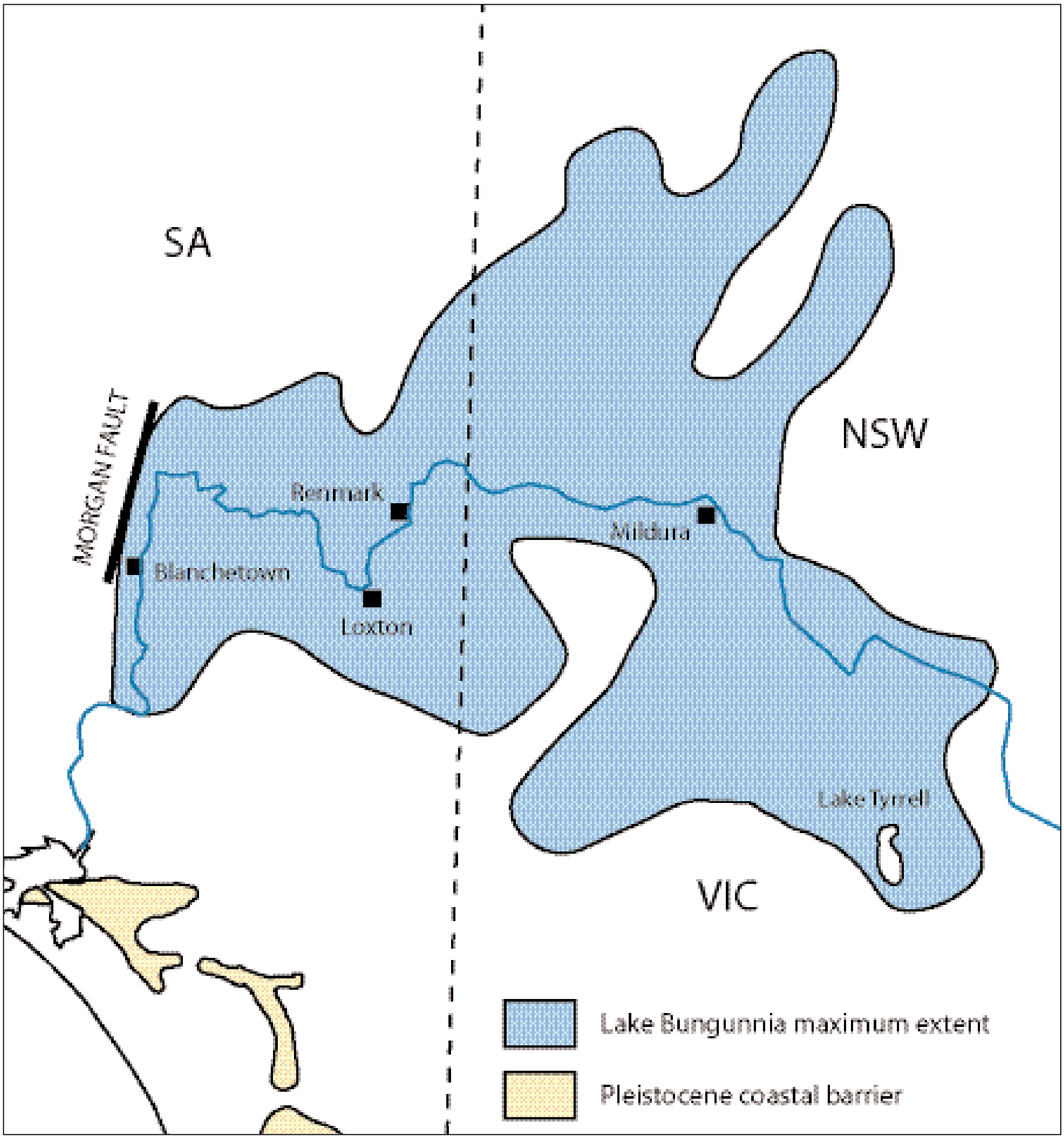


Source: Evans et al. (1990)

A suite of heavy minerals (zircon, ilmenite, rutile, tourmaline and monazite) in low concentration bands has attracted mining companies to the Parilla Sand (see chapter 16 Earth Resources). Where the Parilla Sand overlies Miocene sands, the heavy mineral grain-size appears to increase along with the total heavy mineral content.

Deposition in the Murray Basin in the late Neogene was strongly influenced by sea-level changes. Sea levels peaked in the Late Miocene to Early Pliocene (about 5 Ma) at about 65 m above present. The sea encroached from the present coast between the Fleurieu Peninsula and Mount Gambier in South Australia, forming a large gulf that extended towards the northeast (Figure 2.4). Continental or non-marine deposition continued in the eastern and northern parts of the basin. Sand, gravel and clay of the Calivil Formation represent river valley fill and alluvial-fan sediments deposited over earlier units of the Renmark Group.

Figure 2.5 Maximum extent of Lake Bungunnia: formed when river flow to the sea was blocked in the Pliocene.



Source: modified after Belperio (1995)

During the Late Pliocene and into the Pleistocene, terrestrial processes predominated in the eastern and northern parts of the basin and deposited poorly sorted sediments of the Shepparton Formation in river, overbank and lacustrine settings associated with river sediment accumulation. Parts of the Shepparton Formation have ancient soil remnants known as palaeosols, typically disconformably buried by younger sequences, relating to discrete episodes of high or low river discharge, as part of an evolving sequence.

Towards the basin margins, the Shepparton Formation appears to cross-cut upper units of the Calivil Formation, suggesting the two are separated by a disconformity. Channel deposits of Late Pleistocene and Holocene rivers and floodplain sediments comprise the modern-day alluvium of the Coonambidgal Formation.

Pliocene (~3.2 Ma) deposition in the western part of the basin was influenced by tectonism when uplifted areas, impeded outflow and formed a shallow (less than 70 m deep) freshwater to brackish mega-lake, known as Lake Bungunnia, in the western part of the basin (Figure 2.5). These relatively thin locally variable fluvio-lacustrine sediments comprise the greenish-grey, white or mottled red–yellow–brown silty to sandy Blanchetown Clay, with

quartz sand and gravel beds, carbonates and gypsum-bearing layers. Large shoreline migrations and terrestrial channels reworked the underlying Parilla Sand, depositing up to 10 m of clayey fine- to medium-grained quartz sand of the Chowilla Sand and the Irymple Member, lateral equivalents of the fluvio-lacustrine Shepparton Formation. Lake Bungunnia dried out during the Middle Pleistocene (about 0.6 Ma), due to increasing aridity and probably tectonic movement draining the basin or breaching a barrier to the sea. The uppermost Blanchetown Clay sediments are increasingly gypsiferous, suggesting that Lake Bungunnia was quite saline in its later days, when it may have split into smaller lakes (Cupper & White 2003).

During the Quaternary, the eastern part of the basin has remained predominantly riverine plain with aeolian features such as source-bordering dunes and lunettes. Alluvial features are associated with the Murray River and its tributaries, including the Kiewa, Ovens, King, Goulburn, Campaspe and Loddon rivers. Rivers located further west, such as the Avoca and Wimmera, fail to reach the Murray and show river features characteristic of the increasing aridity that occurred during the Quaternary. Fluvial and aeolian sedimentary processes have periodically varied in relative importance with Quaternary climatic changes. By the late Quaternary, widespread river deposition was restricted to the eastern Riverine Plain, with wind-blown deposition predominant in the west.

The evaporitic and siliceous deposits of the Yamba Formation are widely dispersed in the northwest of the state, occupying topographic low-points such as the Raak Plain west of Hattah, and becoming sites of groundwater discharge. These gypsiferous clay and sand sediments overlie Blanchetown Clay in places, and were deposited since the Middle Pleistocene.

Aeolian dune deposits of the Woorinen Formation and the Lowan Sand form a thin cover over the earlier sediments and are a further example of the increasing influence of aridity on the late Quaternary landscape. Quaternary sediment input to the Murray Basin was minimal and dune sands were mainly derived from erosion of the underlying Parilla Sand.

Deposition of the Woorinen Formation occurred episodically, with the silty sand, sandy and silty clay members within the dune sequences capped by distinct, often calcareous, palaeosols (fossil soil horizons) perhaps indicating prolonged periods of dune stability. The youngest Piangil Member lacks soil development, suggesting recent mobilization, and the underlying Kyalite Member was probably mobile at the time of the Last Glacial Maximum (23,000–19,000 years ago).

The Lowan Sand consists of linear, irregular and sub-parabolic dunes and sand plains characterised by a paucity of clay, as they are derived from re-working of Parilla Sand. Irregular to sub-parabolic dunefields have migrated in east-northeast from their source, forming elongated plumes across southeastern South Australia and northwestern Victoria (e.g. the Big Desert and Sunset Country). The study area boundary in this area is essentially where these dunefields end and the riverine plain starts.

Late Pleistocene and Holocene river systems form a contrasting landscape to that of the aeolian dunefields and sand plains. However, many of the river channels and their associated lakes and floodplains are relict or ephemeral features overprinted with a more recent signature indicating a much more efficient hydrological regime operated during the Middle and Late Pleistocene (Cupper & White 2003). Modern rivers form the youngest of a sequence of four alluvial terraces that comprise the Coonambidgal Formation. On the riverine plain these features occur within the elevated alluvial terraces of the Shepparton Formation. Many of the present lakes in the Murray Basin are ephemeral or relict features. These features are described in detail in chapter 3 Geomorphology and Land Systems.

Future developments

GeoScience Victoria (Department of Primary Industries) has acquired an enormous amount of new geological and geophysical information from regional Victoria in order to encourage mineral exploration and development in regional Victoria. New, high-quality aerially mapped geophysical data are now available for most of the state, and the geology of important bedrock areas has been remapped in greater detail. New geological investigations by industry in combination with the scientific community has greatly advanced our understanding of the geology and mineral potential of the region. In particular, the complexity of the bedrock, particularly that beneath a cover of younger rocks is now being unravelled. This work provides a greatly improved framework for new mineral exploration, supported by Government funding (see chapter 16 Earth Resources).

3 Geomorphology and Land Systems

This chapter provides an overview of a system for characterisation of land based on the integration of several biophysical components. At the broadest level these are geomorphological characteristics, while detailed land systems are correlated with indigenous vegetation and soil types.

GEOMORPHOLOGY AND GEOMORPHOLOGICAL REGIONS

Geomorphology—or physiography as it was previously known—is the study of the Earth's surface and processes that form natural features such as mountains, plains, coastlines and rivers. These processes may occur in the present or the past and be influenced by land use practices such as the building of dams, irrigation channels or other structures. This section describes geomorphological processes and landforms within the River Red Gum Forests study area.

The River Red Gum Forests Landscape

The diversity of landscapes in Victoria is due to variations in geomorphological processes across regions with different topography, tectonism, geological history and rock lithology, sea level and climate changes (Joyce et al. 2003). The physical landscape on which we live can be divided into regions of similar character in several ways. Previously divisions were based exclusively on landform or physiography. Other characteristics were subsequently incorporated, such as underlying geology, groundwater systems, climate and elevation. More recently land systems have integrated geomorphological and ecological characteristics. Victoria has been divided (starting with Rowan 1990) into geomorphological regions and further subdivided into geomorphological units on a regional or local scale. Land systems form the third tier of this division of physical characteristics.

The statewide land systems and geomorphological regions and units are currently under review by the Geomorphological Reference Group (GRG), coordinated by Department of Primary Industries. The revised scheme encompasses seven geomorphological regions, including four that are found in the study area: Eastern Uplands, Western Uplands, Northern Riverine Plains and the North West Dunefields and Plains. These regions and their component units are shown in Map 3.1. This section describes the geomorphology of the study area broadly and then in terms of its geomorphological regions. Subsequent sections examine the more detailed sub-divisions— geomorphological units and land systems.

Recent geomorphological processes in southeastern Australia have preserved the soil horizons, dunes and lake sediments that reveal evidence of past climate and changing landscapes. Sea level fluctuations and climate changes during the Quaternary (1.8 million years ago (Ma) to the present), especially increasing aridity in the Pleistocene (1.8 Ma to 10,000 years ago), had a major impact on inland areas of Victoria, and particularly the study area.

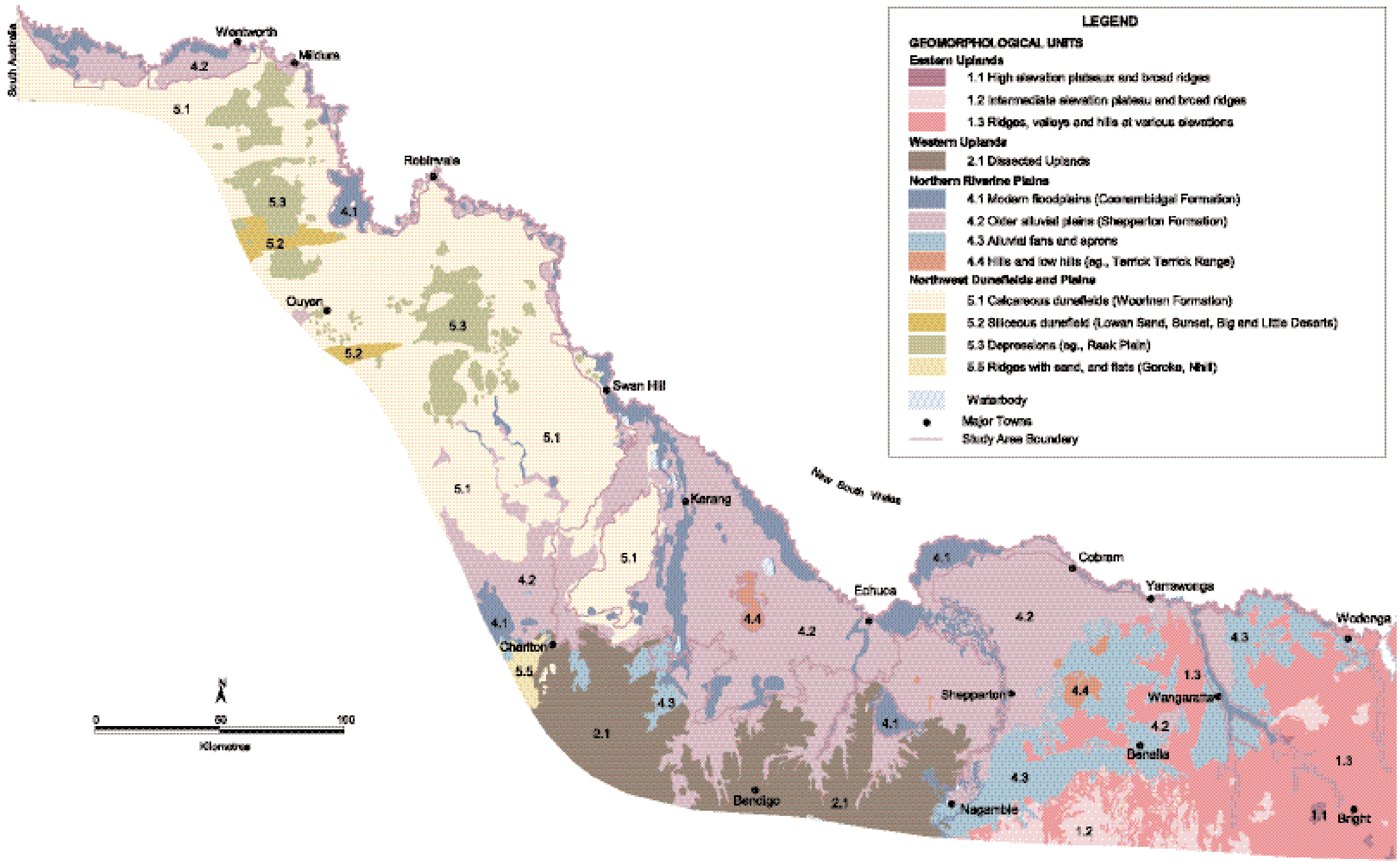
The River Red Gum Forests study area lies in a flat or gently undulating landscape, on the extensive Northern Riverine Plains, that extend inland through New South Wales (NSW). The North West Dunefields and Plains are of relevance in the northwestern part of the study area. Some hilly areas occur in the Eastern and Western Uplands along the southern and eastern edges of the study area.

Geomorphological features of importance in the study area are the lunette-fringed lakes and entrenched meander belts of the river system. Lunettes are crescent-shaped dunes formed by wind-blown (aeolian) movement of sand and clays from dry lake-floors. The larger the lake, the greater the dune source area and hence the largest lunettes form on the down-wind side of many of the biggest lakes across the Northern Riverine Plains during dry climatic phases. In some places the changing climate has left only the lake floor and lunette as evidence of formerly much more extensive bodies of water (Lake Kanyapella, Lake Bungunnia and Hattah Mega-lake—described below). Source-bordering dunes are formed in a similar manner to lunettes and often occur on the northeastern side of large point-bars (see Box 3.1, Figure 3.1) in the major rivers that were deflated and transported locally by aeolian or wind-blown processes during dry climatic phases. These wind-blown deposits are important cultural sites and may contain Aboriginal artefacts or burials such as those at the Willandra Lakes World Heritage Area (Lake Mungo) in NSW.

The present-day river system of the Northern Riverine Plains is the remnant of an older, more extensive system initiated in the Eocene 55–35 Ma (Macumber 1978). Major landforms include streams that leave the major rivers and re-join again downstream (anastomosing anabranches) forming large islands (Gunbower, Lindsay, Wallpolla and Mulcra Islands), large complex wetland and billabong systems (Hattah lakes, Barmah–Moira lakes and forest), and river meanders embedded in larger wavelength meanders inherited from ancient faster flowing streams (see Box 3.1).

Older surfaces, such as where bevelling cuts across changes in bedrock, or where distinctive weathering horizons are preserved, are of significant geomorphological interest. Many are related to the regional sedimentary record, particularly the erosion of uplands and major unconformities within sedimentary sequences.

Map 3.1 Geomorphological Units in and adjoining the study area.

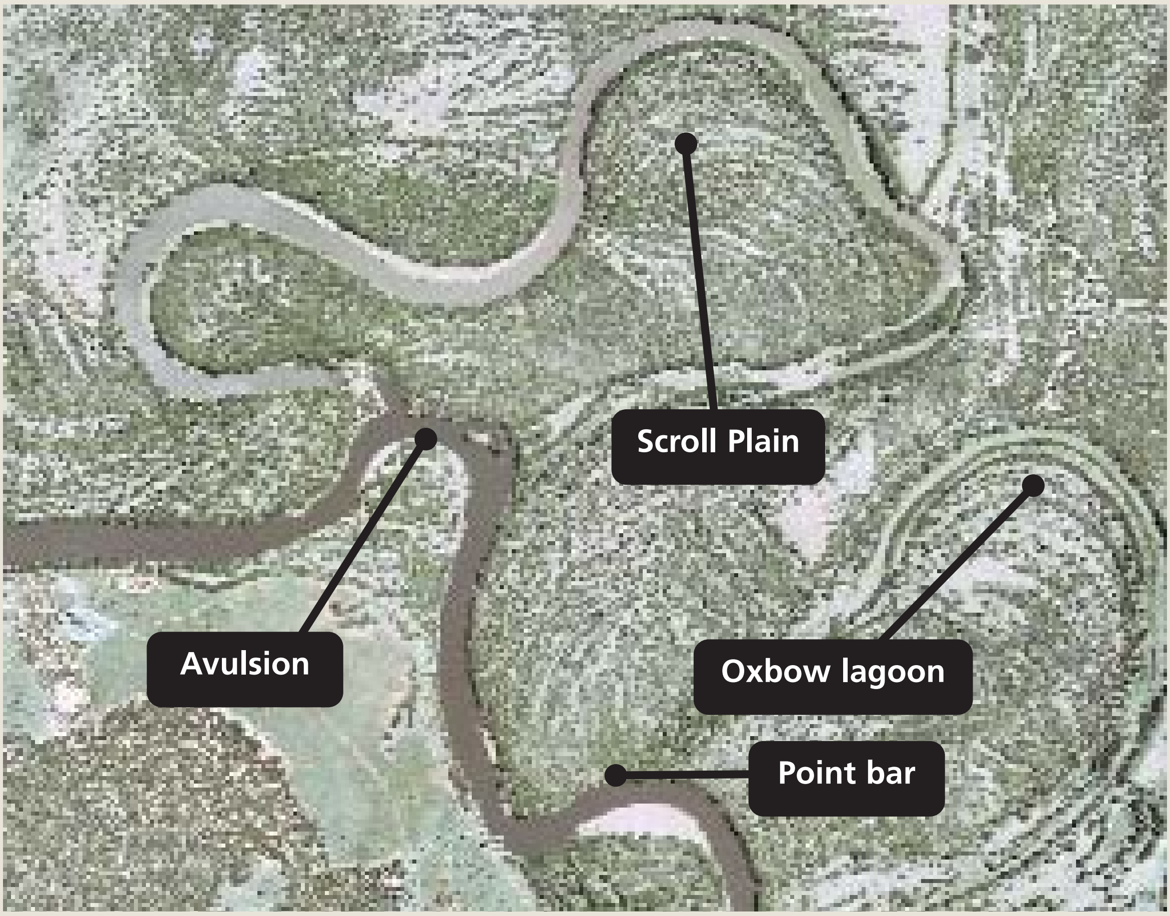


Box 3.1 River Meanders

Rivers rarely maintain a straight route, particularly on floodplains. Often a series of bends and loops known as meanders snake across the landscape, reflecting the way in which resistance to flow is minimised and energy spread evenly along the river course (see Figure 3.1). As water rushes past the outer part of a bend, sediment is eroded from the riverbank. With the slower flow concentrated around the inner side of each bend, coarse sediment accumulates and forms an area of shallow water and sandy beaches or point bars. Through this process incremental channel migration occurs and a new floodplain is created by lateral accretion. Channels bend further with migration until the narrow neck of land between one bend and the next is breached (avulsion). A new shorter flow path is created, and the old channel is abandoned to evolve into an oxbow lagoon or billabong. The size of meanders depends upon the underlying geology and the changing speed and volume of water flow. The rate and direction of channel migration, and the degree of floodplain inundation, are affected by tectonic as well as fluvial or river processes.

Compared with other parts of the world, a relatively small proportion of Australia's rivers are meandering, and the meanders of the River Murray are well developed and relatively unaltered by European settlement. Within the study area no single area of floodplain is representative of the whole Victorian Murray. Rather, some areas demonstrate the effect of local tectonic activity (Barmah forest), some suggest the influence of regional tectonism, and others may not be affected by tectonism at all (Gunbower Island, Yarrawonga reach). Some floodplains appear to show rapid oblique channel migration, the traces of which are not masked by flood deposits, and the result is clearly-marked 'scroll plains' such as those of Lindsay Island. In others, the old channels are semi-parallel to the present channel, and migration is slow enough that the present channel crosscuts the palaeochannels (Kings Billabong near Red Cliffs). Other floodplains such as Belsar Island near Robinvale may have more layers of flood sediments, covering any traces of previous channel migration.

Figure 3.1 Air photo showing meander channel features of the River Murray floodplain, Retail Bend and Murray-Kulkyne Park (see Figure 3.2 for location).



The River Red Gum Forests study area, by design, encompasses particular biogeographic regions which mostly carry river red gum or associated vegetation types. Because biological features are strongly correlated with geomorphological systems, the study area mostly encompasses the Northern Riverine Plains geomorphological region (Map 3.1). Only small areas of other regions—the North West Dunefields and Plains, the Eastern Uplands and Western Uplands occur the study area (and Rees 2000; see Rowan 1990).

Northern Riverine Plains

The Northern Riverine Plain is an extensive alluvial plain associated with the Murray River and its tributaries, which extends north from the Western and Eastern Uplands of the Great Dividing Range to the River Murray. It can be divided into an upland fringing slope with low residual hills, a plain crossed by palaeochannels and modern rivers such as the Loddon, Avoca and Campaspe, and the major alluvial terrace and floodplain-infilled troughs of the Goulburn and Murray rivers. Concentrations of lake and lunette systems, such as the Kerang Lakes, Avoca Marshes and Kow Swamp, occur intermittently across its surface.

Much of the plain is made up of Quaternary alluvial deposits of clay, silt sand and gravel (Shepparton and Coonambidgal Formations), forming broad fans extending and widening northwards from the uplands edge. The sediments were laid down in a fluvial system of floodplains and river channels, and in scattered shallow lakes and wind-blown dunes. The deposits extend from upland valleys such as the Loddon and Ovens and coalesce into an almost continuous mantle across the study area. Leveed channels of several ages are present, sometimes forming ridges above the general elevation of the plains, and may have source-bordering dunes. Higher terraces and aprons of uncertain age occur along the southern edge adjoining the uplands. In places, low rocky ridges of older basement rocks, such as the Terrick Terrick hills, rise above the plains.

Features of floodplain evolution and development can be categorised as modern streams, prior streams, ancestral rivers and lakes and lunettes (e.g. Bowler et al. 1978; Pels 1964; Rutherfurd 1990). Modern streams are the channels and swamps of the present-day river system (described in more detail under 'River Murray Evolution', below), with generally narrow channels and well-defined levee banks and floodplains. Some, such as the Campaspe, have alluvial terraces. Lakes and swamps lie in cut-off meanders or avulsion channels across the floodplains.

Prior streams are the traces of older rivers characterised as low ridges of silt and sand—former natural levee banks—that lie adjacent to shallow, meandering depressions of the former river channels. Often these channels are perched higher than the present floodplain and may be a great distance from present rivers. Typically, prior streams do not carry surface water, except in high flow conditions, and both channels and levees are broken where they have been partly eroded by later events.

Ancestral rivers are old, abandoned channels that lack levee banks, are incised into the surface of the plain, and are partly filled with alluvium. They are associated with and often crossed by the modern rivers and may act as floodways during high water flow. Many are wider than those of the present-day rivers, have coarse sand and gravel, and have much larger meanders, indicating they formed at times of much greater river discharge. Modern rivers often form a meander within the larger meander pattern of these ancestral rivers.

Lakes on the riverine plain have formed in three ways, as cut-off meanders and abandoned channels, deflation (wind-eroded) hollows, and as tectonic depressions. Many of these lakes are composite and fed by groundwater. Associated with shallow lakes are lunettes, crescent-shaped dunes composed of clay, silt and fine sand typically along the eastern shoreline. Some are single, but many form complex systems that record the gradual decrease in the size of the adjoining lake (e.g. palaeo-Lake Kanyapella, see Box 3.2). Most of the lunette sediment consists of clay and fine sand blown from the lake floor during dry conditions.

The alluvial terraces and floodplains of the modern rivers (Coonambidgal Formation—see Map 3.1) often have source-bordering dunes on the northeastern sides of channels, formed from fine sand deposited by the same river in times of greater flow. Several former courses of the major rivers, such as the Murray and Goulburn, are marked by extensive meander belts and occur in shallow depressions incised below the plains. These features indicate several phases of channel and dune activity, with many dunes forming along the Murray River during the last major dry glacial period. River channels with wide sandy point bars persisted into the Holocene, but formation of dunes along the river ceased as the climate warmed.

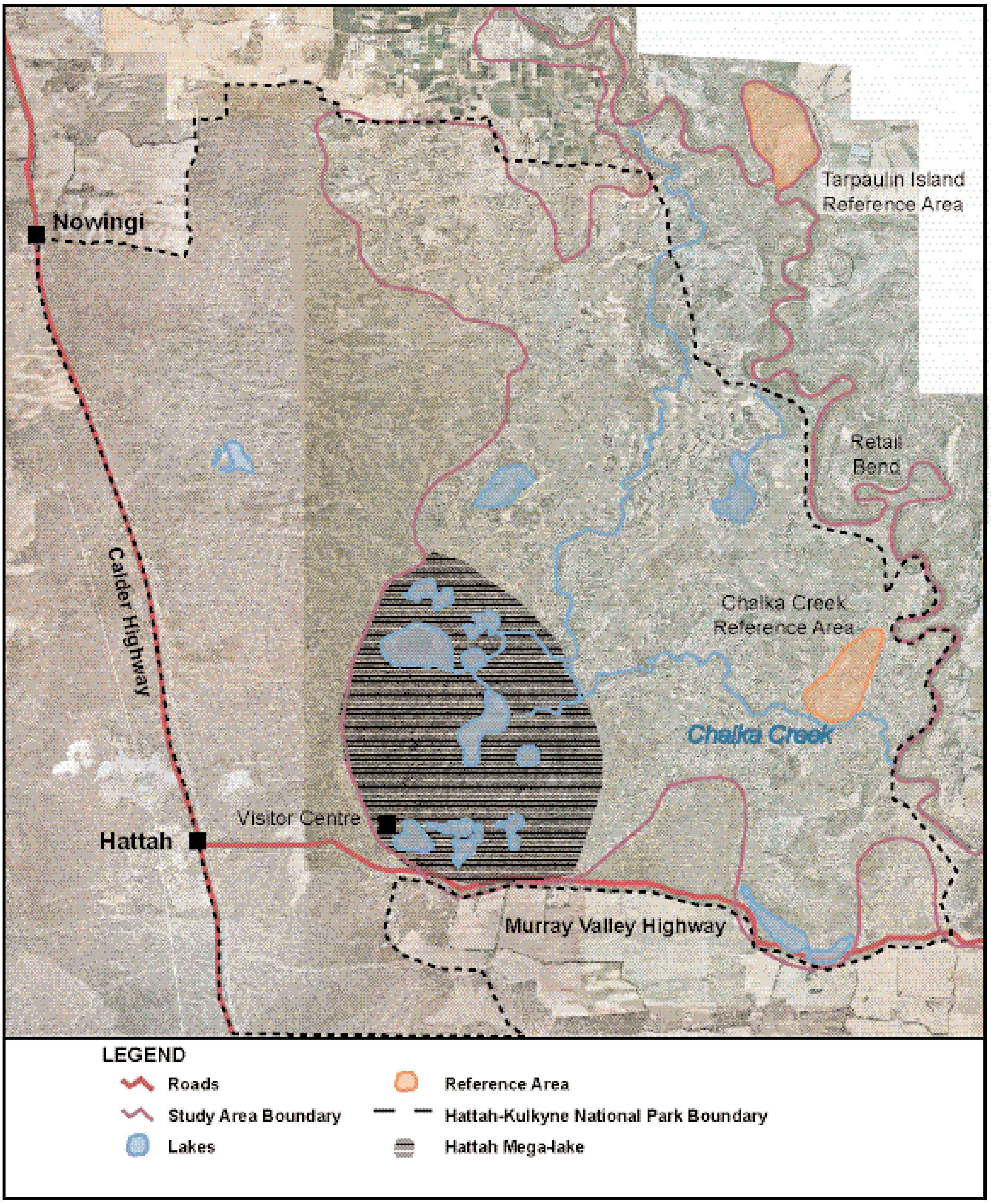
The final episode of river deposition after the glacial and periglacial conditions is present along the length of the River Murray and its tributaries. The current channel of the Murray River may be only a few hundred years old in many places. Some areas on the riverine plain, such as between Tragowel and Pine Grove, have only rare channels and no source-bordering dunes. Much of the central and eastern parts of the plain are overlain by a shallow mantle of calcareous wind-blown deposits (or parna) comprising silt and clay aggregates.

Near Echuca, movement along the Cadell Fault dammed the River Murray to produce palaeo-Lake Kanyapella around 30,000 years ago (see Box 3.2 Bowler 1978; Cupper & White 2003; Page et al. 1991; Rutherfurd & Kenyon 2005). Other faults (such as the Echuca South Fault) cross the alluvial deposits and alter the earlier leveed stream channels, allowing a chronological sequence of channels to be mapped (see Rutherfurd & Kenyon 2005). However some previously postulated 'faults' e.g. Leaghur Fault, are now regarded as erosional features, as evidence for displacement or movement cannot be found.

Hattah Lakes is the most extensive lake system along the River Murray, where a series of about 21 interconnected lakes and wetlands formed in a depression at the easternmost limit of the Sunset Country dunefields (Figure 3.2). The lakes are surrounded by longitudinal dunes of the Woorinen Formation and sub-parabolic dunes of the Lowan Sands. Water is supplied to the lakes by flooding from Chalka Creek:—an anabranch of the River Murray. Several of these lakes lie on the floor of the pre-existing Hattah 'Mega-lake' (in the order of 50 square km in size), which is bordered to the east by a large lunette (Kotsonis et al. 1999; Macumber 1978). The large size of the palaeo-lake, combined with high river discharge in the past, suggests that it contained freshwater, and developed during the pre-glacial wetter climates with significantly more surface water in the Murray Basin. Hattah Mega-lake is entrenched at a topographic level similar to the upper river terrace in this area, and probably developed from an old meander cut-off on this terrace.

Sub-parabolic dunes completely cover the high level terrace at Hattah Lakes and partially cover the Hattah Mega-lake floor, indicating that dune encroachment occurred at similar times to lunette formation and after the drying-out of the lake. The presence of source-bordering dunes and sub-parabolic dunes on the low level terrace suggests a high level of wind activity during deposition of this terrace. The present fluvial regime lacks source-bordering dunes and truncates sandy dunes on older terraces, indicating that dune mobility had ceased when this river system became active about 15,000 years ago. Within the Hattah Mega-lake, this reduction in aeolian activity was accompanied by a

Figure 3.2 Air Photo of the Hattah lakes complex.



change from saline lakes and clay lunette formation to freshwater conditions, as recorded by the presence of freshwater fauna in local midden deposits. Dating of the Northern Riverine Plain landforms has unravelled much of the Late Quaternary climatic history and processes in this region.

Downstream of Hattah the remaining area of the Northern Riverine Plains is represented as an entrenched and more constrained river system containing diverse landforms including anabranches that form large islands such as Lindsay, Wallpolla and Mulcra Islands, as well as meander channels, billabongs, levees and low dunes, with larger overflow lakes and lunettes abutting the semi-arid Mallee region. The area consists of three main geomorphological components: the riverine floodplain (subject to periodic flooding and encompassing numerous oxbow lakes, ephemeral wetlands and active meander belts); broad, flat alluvial plains (infrequently flooded); and alluvial rises or elevated terrace areas that were built up during more arid periods by wind-blown material from the surrounding areas. To the south and flanking the floodplains, lie the North West Dunefields and Plains.

North West Dunefields and Plains

The North West Dunefields and Plains extend north from the edge of the Western Uplands to the margin of the Northern Riverine Plain. In the study area, it occurs only in small peripheral patches west and north of Kerang (Map 3.1). This geomorphological region consists largely of dry, sandy, gently undulating plains with extensive siliceous and calcareous dunefields, becoming more subdued towards the south. Beneath the plains is a low relief bedrock surface, only rarely rising above the plains as low granitic hills (such as at Wycheproof). Rivers in the region, such as the Avoca and Wimmera, rise in the Western Uplands to the south, lose water by evaporation and infiltration as they flow northwards, and do not reach the Murray. Elsewhere across much of the North West Dunefields and Plains there is almost no run-off, except locally after heavy rain. The rivers are linear and relatively fixed, showing little evidence of migration, and are flanked by floodplain and terrace deposits of Pleistocene and Holocene age. Low-lying areas contain saline lake complexes, or freshwater lakes fed by the rivers (e.g. Raak Plain, Avoca Marshes). Clay plains, cemented in places by calcrete, underlie large parts of the dunefields, and salt lakes in the north of the region. Beneath the dune and lake sediments are the curvilinear coastal ridges of the Pliocene Parilla Sands.

There were several separate phases of dune activity comprising siliceous and calcareous dune complexes. A siliceous (Lowan Sand) dunefield (Sunset Country) lies to the south and west of the riverine plain in northwest Victoria and contains both linear and parabolic dunes. The parabolic dunes are often large, with sharp crests, and interspersed with wide sandplains and smaller, often smooth-crested, dunes of variable orientation. The linear dunes are closely-spaced, low and smooth-crested, with narrow, sandy swales. Dunes of both types are oriented east-west to northeast-southwest, parallel to the present dominant wind directions.

The calcareous dunefield forms a large area of the Mallee extending discontinuously from Nhill northeast to the Northern Riverine Plain, and includes reddish quartz sands (Woorinen Formation). These dunes are vegetated, predominantly linear and oriented east-west, but are not uniformly distributed. In the west quartz sand and carbonate dominate, but in the east, where the dunes have migrated over the clay-rich riverine plain, up to 20 percent clay content is common.

These calcareous dunes and associated palaeosols reflect the alternation of cool and arid conditions with wetter soil forming conditions. The siliceous dunes of the Lowan Sand have a notable absence of clay and carbonate in contrast to the Woorinen Formation dunes.

Large, variably saline lake complexes occupy low areas, such as the Kerang Lakes and the Raak Plain adjoining the study area. These saline lakes are groundwater discharge basins or relict groundwater discharge features, where saline groundwater can emerge and, through intense evaporation, produce hypersaline brines. Sediment is deposited by aeolian input and precipitation from groundwater; typically lake floor sediments are dominated by gypsum.

The freshwater lakes differ from the saline lakes in that they contain fluvial or river sediment and have well-defined elliptical or rounded margins. The eastern sides of most of the lakes have low half-moon-shaped lunette dunes of sand and gypseous silt. Orientation of these lunettes indicates that westerly wind regimes were responsible for their formation, which are thought to have dominated during arid dune-building phases of the Pleistocene.

Eastern Uplands

The River Red Gum Forests study area extends along the King, Kiewa and Ovens rivers into small areas on the northern slopes of the Eastern Uplands (Map 3.1). The Eastern Uplands form part of the broader Great Dividing Range, and are the largest and highest upland areas of Victoria. The region can be divided into two broad areas: the gentler topography of the high plains and the deeply incised valleys of the northern and southern slopes, including some low plateaus.

The northern slopes of the Eastern Uplands consist of steep-sided branching river valleys with thick sediment, separated by high, narrow ridges with mostly young, stony gradational soils caused by the continual movement of weathered material down the slopes. River gradients within the dissected northern slopes are steep, particularly in the upper reaches, but gradually decrease as the valleys widen downstream and enter the study area. River direction is often determined by past geological activity, for example, the Kiewa River follows the north-northwest line of the Kiewa Fault. These northern rivers flow either across the Riverine Plains to join the Murray River (Goulburn, King and Ovens Rivers) or, east of Wodonga, into the Murray directly (Indi (or Upper Murray), Mitta Mitta and Kiewa Rivers).

The lower parts of the river valleys of the northern margin are partially filled with alluvium and have open U-shaped or sometimes angled cross-sections. The alluvial flats are often flooded during late winter and spring in areas where snowmelt contributes to streams. Well-developed alluvial fan aprons have been deposited by ephemeral streams draining the sides of some of the major valleys. The large, older fans may be cut by subsequent erosion and new fans deposited in the gullies; as many as four 'nested fans' occur in some locations. Paired river terraces are common, and typically several sets can be identified.

Western Uplands

The Western Uplands extend from Kilmore Gap north of Melbourne westwards to near the Victorian-South Australian border. A small area of the Western Uplands occurs in the southern part of the study area near Wedderburn (Map 3.1). The region is low, with an average elevation of about 300 m, which divides drainage areas. The Loddon, Campaspe and Avoca Rivers flow north from these uplands towards the Murray River. The major valleys, terraces and floodplains of the Avoca and Loddon rivers are features of the Western Uplands' northern margin. Between the main valleys, the slopes of ridges and hills are often deeply weathered and mantled by colluvium and alluvium, with fresh to saline springs.

From the northern edges of the Western Uplands two palaeosurfaces extend northwards beneath the Northern Riverine Plain. The Karoonda Surface occurs on the uplands fringe but mostly overlies the Parilla Sands in the Murray Basin, as well as partly underlying the Blanchetown Clay. The Mologa Surface is a highly weathered, low-relief palaeosurface that overlies the upper parts of the Renmark Group and Murray Group within the Murray Basin—see chapter 2 for more details of the formations on which the palaeosurfaces lie.

GEOMORPHOLOGICAL UNITS AND LAND SYSTEMS

In this section, the detailed geomorphological units within each of the four geomorphic regions of the study area are described, before land systems are briefly summarised in the following section.

Geomorphological Units

In total, eight geomorphological units are found in the study area (Table 3.1).

Table 3.1 Geomorphological Units within and adjoining the study area.

Region	Unit	Brief Description	Map symbol
Eastern Uplands	High Elevation Plateaux and Broad Ridges	Subalpine terrain of low relief; source area of major streams and rivers—outside the study area	1.1
	Intermediate Elevation Plateaux and Broad Ridges	Montane terrain of low relief—outside the study area	1.2
	Ridges, Valleys and Hills at Various Elevations	Highly dissected terrain as well as outlying terrain	1.3
Western Uplands	Dissected Uplands	Generally subdued terrain in contact with the plains and dunefields	2.1
Northern Riverine Plains	Modern Floodplains	Present floodplain (Murray valley)	4.1
	Older Alluvial Plains	Shepparton Formation representing the older floodplain extent	4.2
	Alluvial Fans and Aprons	Associated with the erosion of the Uplands and the major river systems	4.3
	Hills and Low Hills	Inliers such as the Dookie Hills and the Terrick Terrick Range	4.4
North West Dunefields and Plains	Calcareous Dunefields	Predominantly linear dunes with various proportions of associated plain or swales	5.1
	Siliceous Dunefields	Adjoining study area only	5.2
	Depressions	Small area north of Swan Hill within study area; larger areas adjoining study area (Raak Plain)	5.3
	Ridges with Sand, and Flats	Adjoining study area only	5.5

Note : Map symbol numbers correspond with those in Map 3.1 and in the text on the following pages.

Northern Riverine Plains Units

The major groupings within Northern Riverine Plains are Modern Floodplains, Older Alluvial Plains, Alluvial Fans and Aprons, and Hills and Low Hills.

Modern Floodplains (4.1) are dominated by the major streams that often have a meander belt below the current plain level, such as those along the Murray, Ovens and Goulburn Rivers. Areas of inundation away from modern channels occur at Gunbower forest, Barmah forest, the Hattah lakes area, Lindsay and Wallpolla islands, Dingee Swamp and the Loddon River fan. There are also young lakes and basins with lunettes such as Kow Swamp, Lake Cooper, Lake Kanyapella depression and Lake Tutchewop.

Older Alluvial Plains (4.2) cover much of the study area, and comprise the extensive elevated plains away from the modern floodplains. This grouping includes plains with leveed channels (prior streams) such as those at Tatura and Naneella, as well as plains with non-leveed channels at Tragowel and Pine Grove. Lakes and depressions with lunettes, such as Lake Mokoan (originally Winton Swamp), are also associated with the Older Alluvial Plains.

At present there is no detailed information below the land systems scale available for significant areas of this group. Future mapping will incorporate work undertaken for irrigation potential in the 1960s and 1970s by the then Department of Agriculture. Unlike the current land systems coverage, the revised scheme will differentiate prior stream and non-prior stream areas, and related cover such as soil associations.

Alluvial Fans and Aprons (4.3) are associated with the elevated areas or uplands as well as the major streams which have deposited material upon leaving the uplands. These areas are quite extensive abutting the study area, but only small areas of low fans carry river red gum or associated vegetation communities. Alluvial fans have formed over much of the middle Broken River catchment (outside the study area) which is bound by the Strathbogie Ranges and the Warby Range, and in parts of the lower Loddon River.

Hills and Low Hills (4.4) such as the inliers of the Terrick Terrick hills and the Dookie hills, interrupt the predominantly flat alluvial plains landscape. Erosion of these hills has provided a source for deposition of coarse-grained material such as gravel and sands, and hence local variations in environment or habitat.

North West Dunefields and Plains Units

The North West Dunefields and Plains includes what was formerly known as the Mallee Dunefields (Rowan 1990) and consists of aeolian or wind-blown dunefields (calcareous and siliceous), basins or depressions, plains and ridge and flat terrain. The revised scheme (based on work by Rowan (1990), particularly that undertaken for the LCC (1987) Mallee Area Review) standardises this geomorphological division to a three tiers system that is used for the remainder of Victoria. The main groupings within the study area are minor occurrences of Calcareous Dunefields, Siliceous Dunefields, and Depressions. The three other major divisions of this geomorphic region occur outside the study area.

Calcareous Dunefields (5.1) consist of aeolian dunefields with various proportions of dune, plains and minor depressions. The dunes decrease in frequency as they approach the River Murray alluvial floodplains. These areas are utilised extensively for cropping due to the moderate to high nutrient status of the soils.

Siliceous Dunefields (5.2) occur in distinct belts alternating from east to west between parabolic and linear dunes. These areas are characterised by low nutrient soils unsuitable for cropping, and have therefore been retained mostly as large tracts of native vegetation on public land that form the large desert parks of the Mallee, including the Sunset, Big Desert and Little Desert National Parks.

Natural depressions or shallow basins (5.3) have formed generally as groundwater discharge areas, which are saline and often gypseous. A notable example is the Raak Depression located west of Hattah, just outside the study area. A small area of this geomorphic division occurs within the study area, to the northwest of Swan Hill. Lunettes associated with these depressions, provide an indication of the past extents of lakes under climatic conditions different to those today.

Eastern Uplands Units

The Eastern Uplands comprises the elevated landscape east of the Kilmore Gap and contain major alluvial valleys such as the Kiewa, Ovens, King, Goulburn, Broken and Murray Rivers that flow out into the Northern Riverine Plain. The area covered by this geomorphological region within the study area is comparatively small, and consists of valleys extending into the uplands. These outliers of the more extensive area of uplands consist of either Palaeozoic sediments or Palaeozoic granites, generally of subdued terrain.

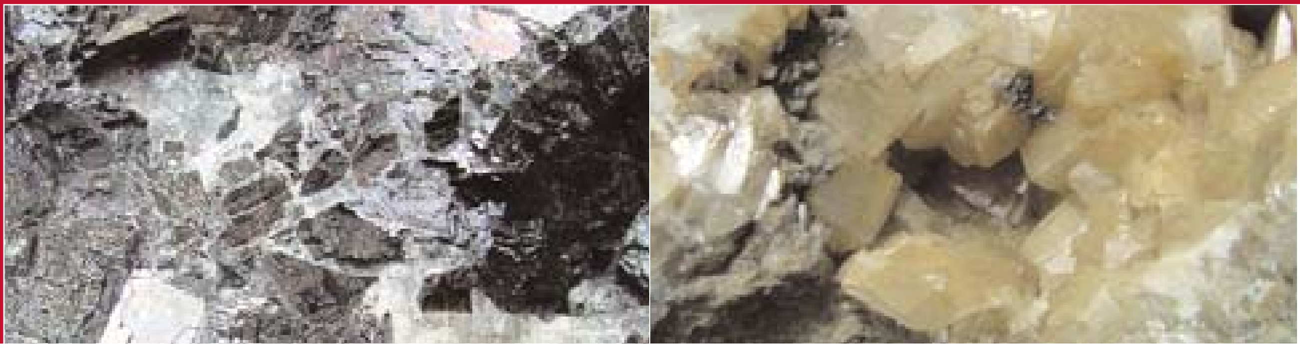
Western Uplands Units

The Western Uplands are elevated regions (generally formed of hard rock) west of the Kilmore Gap. These uplands are generally more dissected and lower than the Eastern Uplands, as well as having a drier climate. The Loddon, Campaspe, Avoca and Wimmera rivers are the main waterways flowing north out of the Western Uplands and towards the Murray River floodplain.

This geomorphological region comprises a comparatively small portion of the study area, consisting of extended valleys into the uplands and as well as outlying units predominantly to the north of Bendigo and Wedderburn. The major divisions within this unit are largely defined by underlying rock lithology which in turn defines hardness and therefore elevation in eroded landscapes. A very small part of the Dissected Uplands (2.1) unit is included within the study area.

Land Systems

Compared to geomorphological units, land systems describe a more detailed level of land information within the geomorphological framework. Land system mapping is used to characterise land in terms of its capabilities, limitation and management requirements, particularly in the context of agriculture use. In addition, prior to the advent of detailed vegetation mapping (e.g. at the ecological vegetation class or EVC level—see chapter 5 Biodiversity), the LCC used land systems as the basis for



recommending representative areas for particular public land uses (typically reference areas and conservation reserves).

Individual land systems have been allocated a key to provide a systematic nomenclature at the statewide level. The land systems set compiled by Rowan (1990) which has been updated (Rees 2000) provides a key for land system description based on geomorphological divisions, landform, surface lithology, geological age, climate (rainfall) and a unit designation. The land systems key is provided in Table 3.2.

As shown in Table 3.2, each land system has a unique range of land components. For example, 4.1 FfQ4-1 indicates that the land system occurs in the Modern Floodplain unit of the Northern Riverine Plains (4.1); it is a Floodplain landform (F), with a fine textured sediment lithology (f) of Quaternary age (Q), has an annual average rainfall of 400-500mm (4) and is the first designate of this type (1). The tables associated with these statewide land system entries also indicate broad soil and vegetation types as well as a simple assessment of land degradation susceptibilities (Rowan 1990).

A table of the land systems covering the largest extent within the River Red Gum Forests study area is provided below (Table 3.3). Those land systems that comprise a small area have been grouped under broader categories for simplicity. Map 3.2 is an example of a land systems map for an area near Swan Hill. In the northwestern part of this area the interaction of the North West Dunefields and Plains and Northern Riverine Plain may be observed. The modern floodplain occupies the entire floodplain compared to other areas in the southeastern corner of the map where the older floodplain extends laterally and occupies a more elevated or higher level of the landscape.

Table 3.2 Land Systems Key.

Landform		Lithology		Lithological Age		Climate—Av. Annual Rainfall (mm)	
F	Present Floodplain	c	Unconsolidated (coarse)	P	Palaeozoic	2	200-300
P	Plain above flood level	f	Unconsolidated (fine)	M	Mesozoic	3	300-400
D	Dunes	z	Unconsolidated (fine, saline)	C	Cainozoic, undfferentiated	4	400-500
R	Rise	g	Granite and gneiss	T	Cainozoic; Tertiary	5	500-600
L	Low hill	l	Limestone/calcrete (calcareous)	Q	Cainozoic; Quaternary	6	600-700
H	Hill	v	Acid volcanics			7	>700 (temperate)
M	Mountain	b	Basic volcanics			8	>700 (montane)
S	Depression/ Swamp/ lunette complex	m	Metamorphic rocks			9	>700 (sub/alpine)
C	Coastal Complex	s	Sedimentary				

Source: Rees (2000)

Map 3.2 Land Systems for an area near Swan Hill.

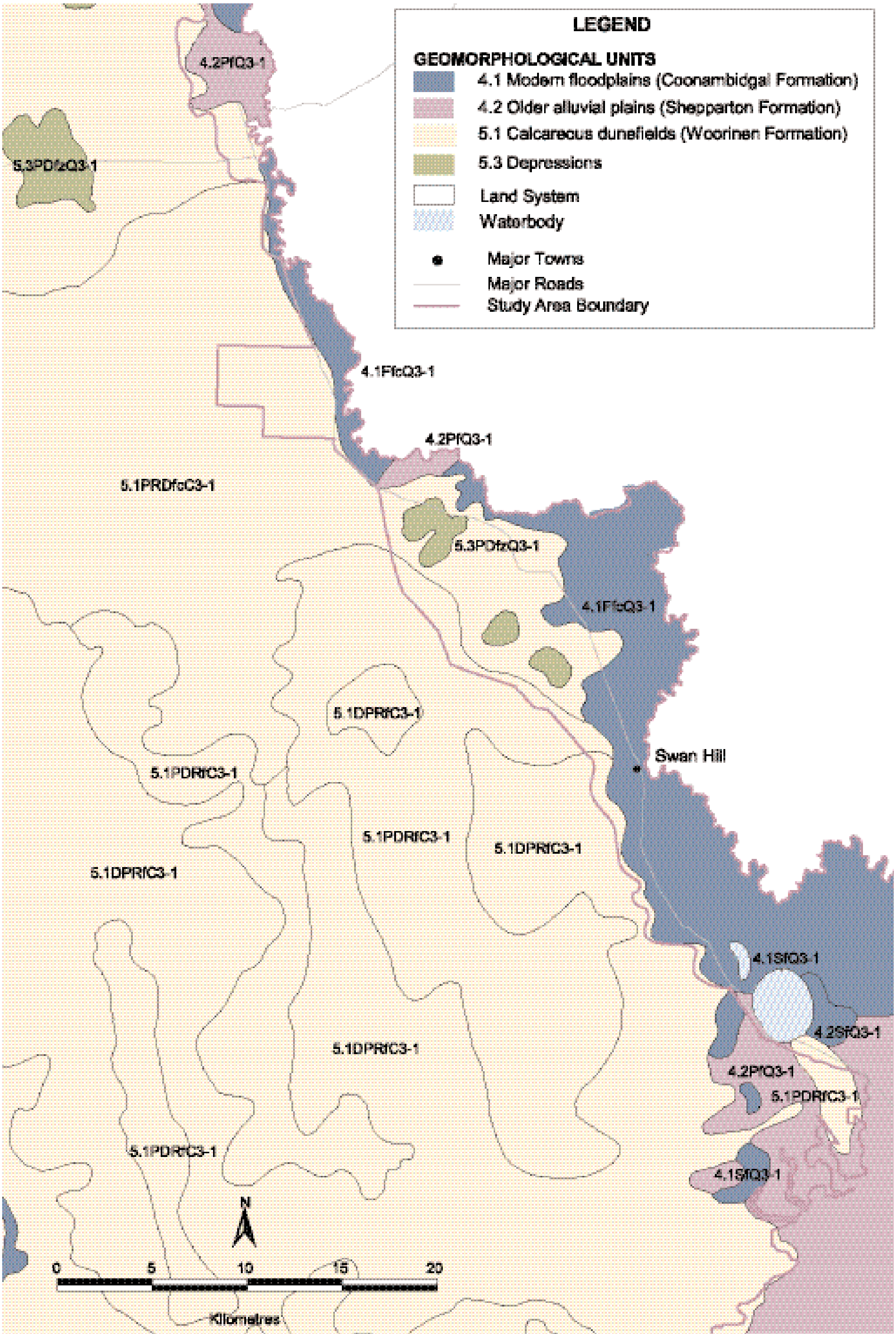


Table 3.3 Land systems in the study area.

Region	Land system
Eastern Uplands	1.1HgmP7-3
	1.1HsP7-5
	1.1HsP7-6
	1.1HsP8-5
	1.1LsP5-1
	1.1MsP8-5
	1.1PfQ6-1
	1.1PfQ8-1
	1.1PgP7-4
	1.1RbT7-2
	1.1RsP7-7
	1.3FfcQ7-2
	1.3HgP7-3
	1.3RgP7-4
	1.3RsP7-6
Western Uplands	2.1LmsP3-1
	2.1PfQ3-1
	2.1PfT4-7
Northern Riverine Plains	4.1DPcfQ2-1
	4.1FDcfQ2-1
	4.1FSfQ3-1
	4.1FSfcQ4-1
	4.1FfcQ2-1
	4.1FfcQ3-1
	4.1FfcQ4-1
	4.1FfcQ5-1
	4.1FfcQ6-1
	4.1PfQ2-1
	4.1PfQ3-1
	4.1PfQ3-3
	4.1PfQ4-1
	4.1SfQ2-1
	4.1SfQ3-1
	4.1FSfQ4-1
	4.2FfcQ3-1
	4.2PDfcQ2-1
	4.2PfQ2-1
	4.2PfQ3-1
	4.2PfQ3-2
	4.2PfQ3-3
	4.2PfQ4-1
	4.2PfQ4-2
	4.2PfQ4-5
	4.2PfQ4-6
	4.2PfQ5-3
	4.2PfQ5-4
	4.2PfQ5-5
	4.2PfQ6-5
	4.2PfQ7-2
	4.2PfcQ4-1
	4.2PfcQ5-1
	4.2SfQ2-1
	4.2SfQ3-1
	4.3PfQ3-4
	4.3PfQ4-8
	4.3PfQ4-9
	4.3PfQ6-3
	4.4LfbP4-1
	4.4LgP3-1
	4.4RsP4-2
	4.4RsP4-5
North West Dunefields and Plains	5.1DPRcfC2-1
	5.1DPRcfC3-1
	5.1DPRfC3-1
	5.1DPRfcC2-1
	5.1DPRfcC3-1
	5.1DPcfQ2-1
	5.1FSfQ3-1
	5.1PDRfC3-1
	5.1PDfcQ2-1
	5.1RPDfcC2-1
	5.1PRDfcC3-1
	5.1PfQ3-1
	5.3PDfzQ3-1

EVOLUTION OF THE MURRAY RIVER

Across the floodplains, evidence of older streams and channels suggest that much more water flowed in the past than the present day. The Murray River itself occupies a channel of varying age and character. Some sections are relatively recent, being constructed on recent floodplain and stream sediments, and having a typically straight and narrow character (e.g. through the Barmah–Millewa forest; see Figure 3.3). Sections within the ancestral river have meanders with large wavelengths and a convoluted and often tortured path to the sea (Figure 3.4). This river is both ancient— with origins over the last 50 million years— and relatively modern (Macumber 1978).

Much research has been undertaken on the geomorphology and hydrological processes that have shaped the Murray River (e.g. Bowler & Magee 1978; Currey & Dole 1978; Macumber 1978; Pels 1964).

The greatest influence on the river character has been the capture of the main channel by large tributaries (i.e. Goulburn and Ovens Rivers) and movements of cross-cutting faults such as the Cadell Fault extending between Deniliquin and Echuca (see Figure 3.3 and Box 3.2). Currey and Dole (1978) divided the Murray into five geomorphic tracts from its source to the Victorian border as shown in Figure 3.4. Rutherfurd (1990) built on Currey and Dole's model, describing the current path of the river and the key elements and adding the South Australian Gorge and Swamp tracts.

The preservation of these complex ancient streams is an important geomorphological feature of this region. They have persisted largely because of a lack of tectonic activity in southeastern Australia over the last 30 million years. Climate has also played a significant role, with limited weathering or erosion over the last few million years.

Box 3.2 Barmah Area Geomorphology

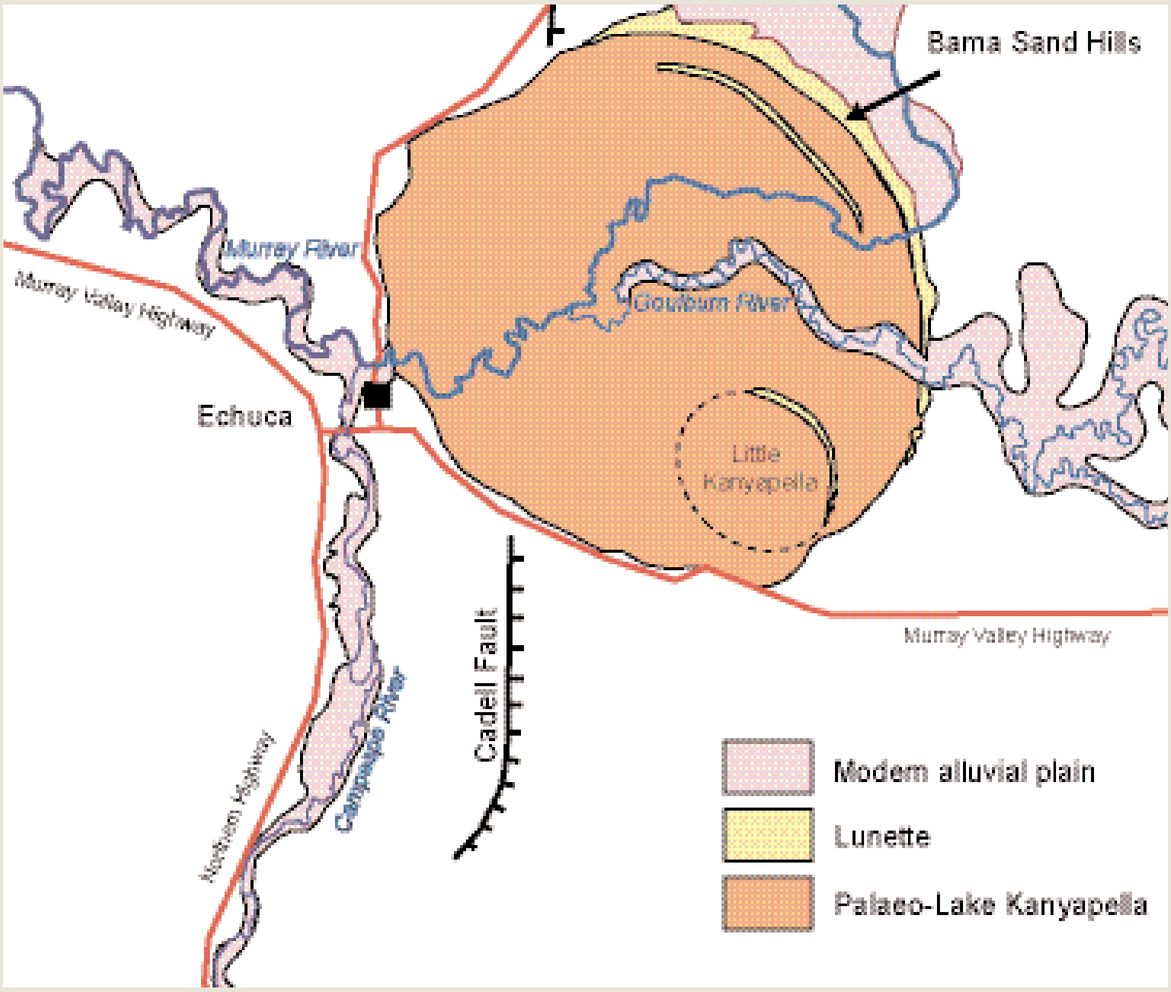
The Barmah-Millewa river red gum forests are unique in the Australian landscape. This broadly triangular floodplain forest has developed as a result of the interaction of ancient river drainage patterns and palaeo-levees, and the rise of the Cadell Fault Block (Figure 3.3).

Today we observe a narrow channel of the River Murray at the Barmah Choke, cutting through sediments of older river and dune deposits. These dunes rise up to 25 m above the flat floodplain and provide evidence of once extensive lakes formed by the damming of the river system. The largest of these is Bama Sandhill formed on the eastern and northeastern edge of Lake Kanyapella. This landform is now cross-cut by the Cadell Fault, and both the Murray and Goulburn Rivers. Other palaeo-lakes with lunettes are Little Kanyapella and Barmah Lake-Bucks Sandhill, forming part of the associated lunette created as the lake dried periodically.

Movements on the Cadell Fault have probably occurred several times during the evolution of the riverine plain. Dating of channel sediments suggest that the first movement was more than 30-35,000 years ago (Bowler 1978; Page et al. 1991; Rutherfurd & Kenyon 2005).

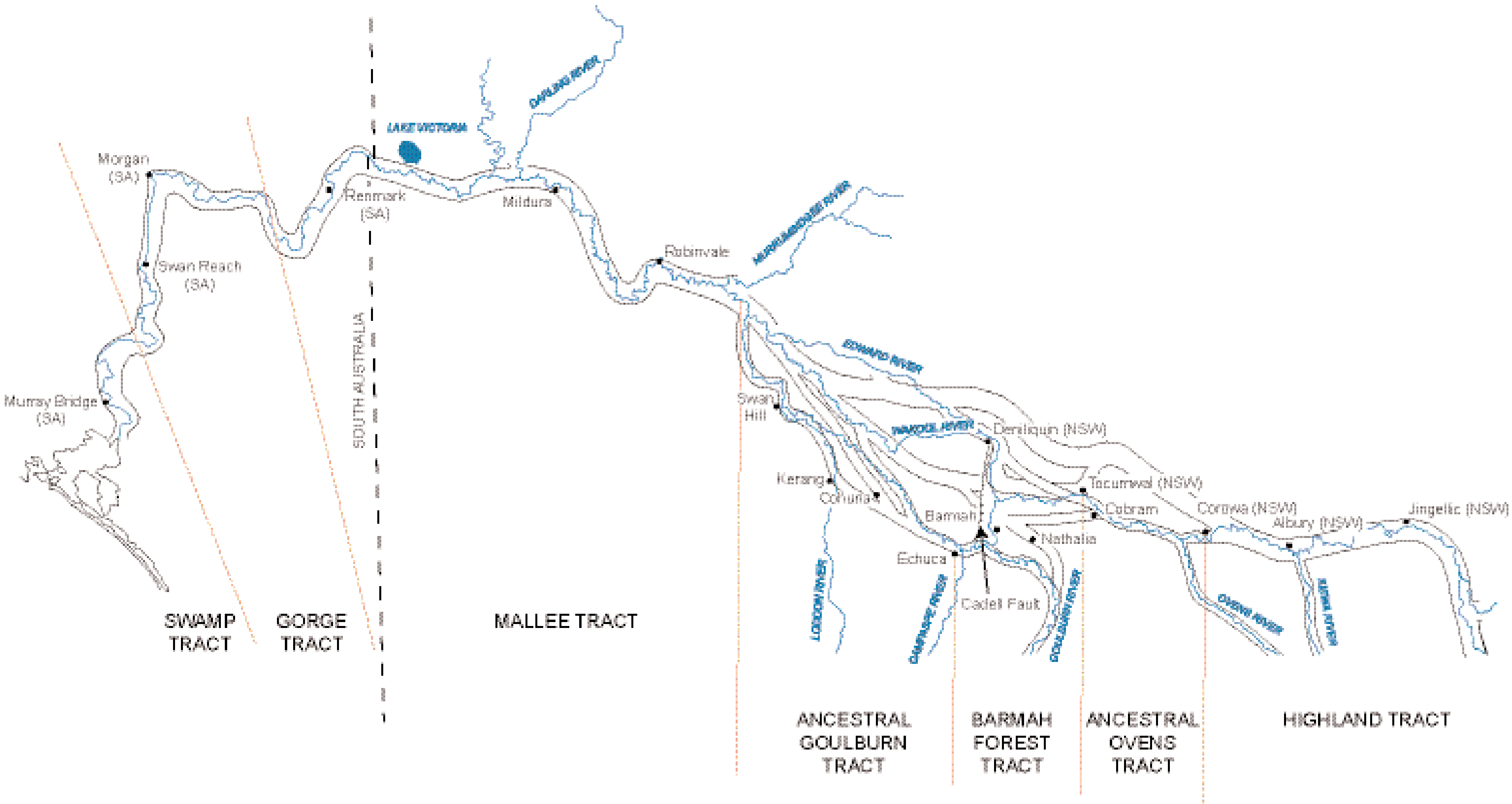
In the past the main channel of the River Murray has occupied various alternate courses including Bullatale Creek, Gulpa Creek, Green Gully and the Edward River, and entered the existing channel through the Mallee at Wakool Junction. It was not until perhaps 8000 years ago that the Goulburn captured the main Murray flow when the lunette bordering Lake Kanyapella was breached. This event is geologically very recent and overlaps with the presence of Indigenous people in the area. Traditional stories of a great flood and the breaching of the lunette may reflect this geological event (Atkinson 2005). As a consequence of this unusual hydrological arrangement between the two rivers, the Murray in this region acts as a tributary of the Goulburn and in times of high flow, the Goulburn will back up water in the Murray and cause flow to run 'upstream'.

Figure 3.3 Map of Palaeo-Lake Kanyapella and Cadell Fault near Barmah

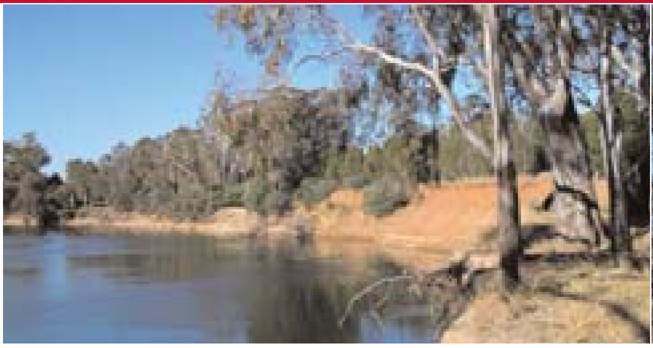


Source: modified after Rutherfurd and Kenyon (2005); Barberias (1983)

Figure 3.4 Geomorphological tracts of the River Murray.



Source: modified after Currey and Dole (1978); Rutherfurd (1990)



4 Climate and Hydrological Systems

Australia has the most highly variable climate of any continent. This chapter provides an overview of climatic and hydrological systems in the study area, wildfire occurrence and predicted climate changes as global warming continues into the 21st Century.

CLIMATE

Victoria's climate varies from the hot, dry inland plain of the Mallee region in the northwest to the alpine snowfields of the Great Divide in the northeast. The Mallee typically has the hottest summer temperatures in the state and annual median rainfall is below 300 mm. By contrast, the Alps or Eastern Highlands have the lowest summer temperatures in the state and annual median rainfall in excess of 1900 mm in some areas. This difference in climate is strongly reflected in the vegetation with sparse, stunted mallee scrub in the northwest, through to irrigated plains in central Victoria and towering mountain forests in the northeast.

Australia can be divided into six major climatic regions or Köppen classification groups based on temperature and rainfall, as indicated by native vegetation (Stern et al. 2000; Bureau of Meterology 2006). Two regions overlap with the study area: 'temperate' and 'grassland (formerly dry)' (Map 4.1). These classifications may be subdivided into classes characterised by seasonal temperature or rainfall patterns. The subdivisions largely reflect variation in rainfall between northern Australia (with winter drought), southern Australia (with summer drought) and central areas that are persistently dry.

'Grassland' occurs throughout much of northern Victoria extending east of Echuca through to South Australia (SA). Rainfall defines this zone, with a clear summer drought. The wettest winter month typically has more than three times the total rainfall of the driest summer month. Within the 'Temperate' area, the dry season is not as strong and the main distinction between classes is based upon the mean maximum temperatures of the warmest month. Hot summer areas with mean maximum temperatures of more than 22ºC occur at the lowest altitudes in the west of the study region. Warm summer (18-22ºC) and mild summer (less than 18ºC with three months of more than 10ºC) areas occur towards the east as the Riverine Plains rise into the Eastern Highlands (Map 4.1)

The entire study area is dominated by wet winter and dry summer rainfall patterns. However, there are markedly different mean annual rainfall totals across study area from east to west (see Table 4.1). Many visitors are attracted to the study area by comparatively pleasant winter daytime temperature. The availability of surface water and hours of daylight also make the area productive for irrigated agriculture.

The ecosystems of the study area, like many in Australia, have developed under highly variable rainfall conditions and are adapted to cycles of periodic wet and dry, including the extended dry conditions we call drought. Weaker than normal monsoon in the north and below average rainfall, water shortages and drought over eastern Australia are associated with El Niño. Its counterpart, La Niña, is often responsible for above average rainfall over much of Australia, especially the eastern states and an earlier than normal start to the northern monsoon season.

The strength of El Niño is partly measured by the Southern Oscillation Index (SOI) which describes surface atmospheric pressure changes between the eastern and western Pacific Ocean (at Tahiti and Darwin). Widespread rain and flooding in Australia often occurs when the SOI shows the high positive values typical of La Niña. During El Niño opposing conditions prevail, with the SOI showing moderate to strongly negative values. This measure, in conjunction with sea-surface temperatures, is the basis for long-range climate predictions. Research during the past decade reveals the SOI's influence across much of the planet and it is important for long term planning in both natural resource management and agriculture (Australian Academy of Science 2002).

CLIMATE CHANGE

Human activities have significantly altered the Earth's atmosphere over the last 200 years. Increasing greenhouse gas concentrations have already warmed the atmosphere, a trend which is expected to continue (Intergovernmental Panel on Climate Change 2001; Whetton et al. 2002; Pittock 2003; NRMMC 2004; Hennessy et al. 2006b). Australia is particularly vulnerable to climate change because of our variable climate, arid landscape and demand for limited water resources (Intergovernmental Panel on Climate Change 2001).

Recent research on climate change trends and impacts in Australia is detailed in the comprehensive volume published by the Australian Greenhouse Office (AGO): Climate Change: An Australian Guide to the Science and Impacts (Pittock 2003). This report found that the average temperature in Australia has risen by 0.7ºC over the last century. The report predicts that most of Australia may warm by between 0.4 to 2.0ºC by 2030 and between 1.0 to 6.0ºC by 2070, with slightly less warming near the coast. A warming of 1ºC would threaten the survival of some species in the Australian alpine regions and in southwest of Western Australia (Pittock 2003).

Map 4.1 Climatic classification of Victoria using a modified Köppen classification scheme.

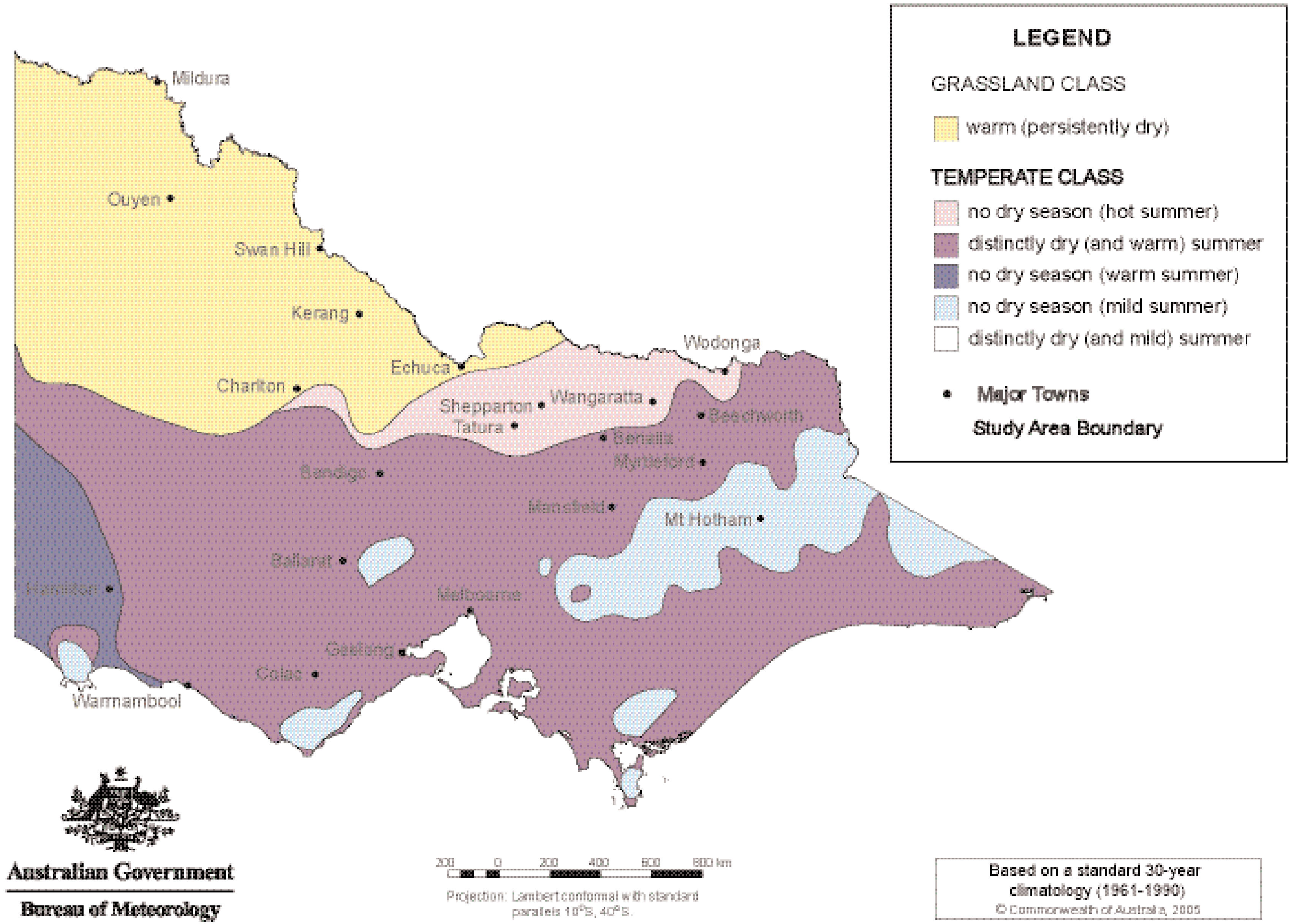


Table 4.1 Meteorological data for major towns within and near the study area.

Location	Elevation (masl)	Mean annual daily max. temp. (°C)	Mean annual daily min. temp (°C)	Mean annual rainfall (mm)	Mean annual # of clear days
Mildura	50	23.7	10.3	289	131
Swan Hill	70	23.0	9.7	349	127
Echuca	96	22.2	9.4	428	93
Kerang	78	22.8	9.4	373	125
Bendigo	208	20.7	7.6	502	99
Tatura	114	21.2	8.3	493	110
Benalla	170	22.0	8.7	670	125
Wangaratta	150	21.9	8.8	637	113
Wodonga	152	22.1	8.9	715	125
Myrtleford	223	21.7	6.6	905	103
Mt Hotham	1750	9.5	2.3	1979	53
Melbourne	31	19.8	10.1	653	49

Notes: Data for Swan Hill, Wangaratta, Wodonga, Myrtleford, and Mt Hotham have been collected over various historic periods. Data from Melbourne and Mount Hotham have been included for comparison.

Source: Bureau of Meteorology, data last modified 16/8/2004

The report also found that rainfall has increased over the last 50 years over northeastern Australia, but decreased in the southwest of Western Australia and in much of southeastern Australia, especially in winter. There were near-record low water levels in much of southeastern Australia's water storages in 2002-03, and little improvement since. There is a substantial risk that this pattern will continue for several decades. Droughts have become hotter and more severe, and this trend is expected to continue; tropical cyclones have become more intense and frequent; and heavy rainfall incidents have become more frequent in many parts of Australia. Increased greenhouse gas concentrations and ozone depletion may both be contributing to a strengthening of the atmospheric winds over Antarctica, dragging rain away from Australia and into the Southern Ocean (Pittock 2003).

The AGO presents a general picture of the trends and potential impacts of climate change in Australia but significant knowledge gaps still exist. However, observations clearly demonstrate that the climate is already changing.

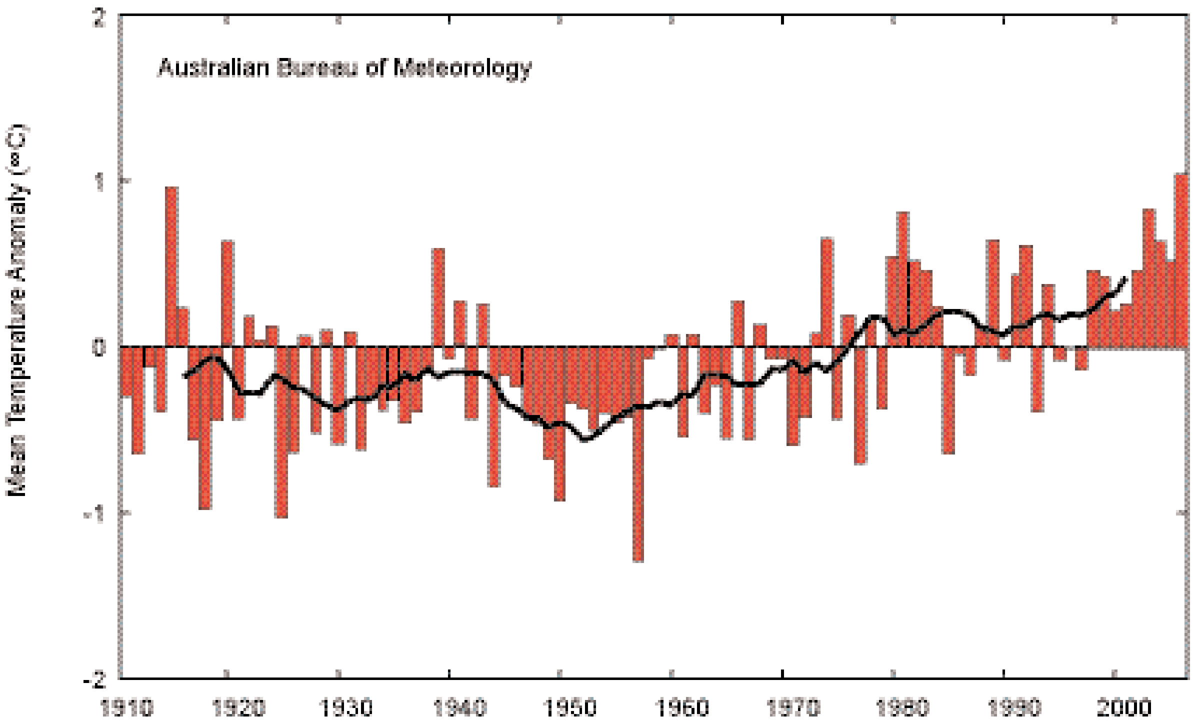
Projections of Victoria's Future Climate

The Victorian Government commissioned CSIRO to undertake high-resolution regional climate change projections for Victoria in 2002 (Whetton et al. 2002). The projections are based on the results of climate modelling in which the effect of increased levels of greenhouse gases in the atmosphere are simulated. The range of regional climate change projections allows for uncertainty in future greenhouse gases increases, and for differences between the simulated climate change of various climate models. These projections to 2070 were reviewed in 2004.

In each decade since 1950, Victoria's average maximum temperature has increased 0.11ºC and average minimum temperature has increased by 0.07ºC. When compared to national trends, Victoria's maximum temperature appears to be changing at a faster rate, and our minimum temperature at a slower rate (Whetton et al. 2002). Whetton et al. (2002) predict that Victoria is likely to be 0.7 to 5.0º C warmer than it was in 1990 with the frequency of extreme maximum temperatures expected to increase, with up to three times more hot days in some areas of the state. The frequency of frosts is also likely to decrease, with much of the state likely to become frost-free at the higher levels of projected temperature increases.

This pattern of increasing temperatures is also apparent within the Murray-Darling Basin (see Figure 4.1).

Figure 4.1 Annual anomalies (based on 1961-1990 averages) of mean temperature in the Murray-Darling Basin.



Source: Bureau of Meteorology (2006)

Notes: The black line shows the 11-year moving average.

Extreme rainfall events have increased in Victoria over the past century, and evidence exists of severe droughts during strong El Niño years in northern and southern Victoria with an increasing tendency for more frequent El Niño conditions over the past decade. Whetton et al. (Whetton et al. 2002) predicts that rainfall is likely to decrease, although there could be increases in some areas. Extreme daily rainfall events may become more intense and more frequent in many regions. Projected changes in annual rainfall range from +10 to -25 percent in most southern regions and +10 to -40 percent in most northern regions of Victoria. Warmer conditions will increase evaporation which, combined with reduced rainfall, is likely to increase moisture stress and wildfire risk.

Summaries of predicted climate change and impacts for catchment management regions provide a detailed discussion of the available information and likely results of climate change (DSEa, b, c, d). Some tangible examples compare current climate with predicted 2070 climate with a moderate greenhouse scenario of 2°degree C warming and a 10 to 20 percent decrease in annual rainfall. Under these conditions in 2070, Wangaratta would have the current climate of Dubbo (New South Wales—NSW), while Bendigo would be more like the current climate of Echuca. Mildura would be expected to be more like Menindee (NSW), while Shepparton is expected to be more like the current climate of Condobolin (NSW).

Water Resources

These predicted climate changes are likely to make Victoria's water resources increasingly vulnerable. Increased temperatures and evaporation rates will reduce water supply, affecting agriculture and biodiversity in parts of Australia. Demand for water is likely to increase with warmer temperatures and increased evaporation, although his may be offset by increases in seasonal rainfall patterns. Conservation measures, behaviour change and alternative supplies may also minimise these impacts.

Climate change may reduce and increase variance in rainfall, reducing river flows and run-off (e.g. Jones et al. 2002; Whetton et al. 2002; van Dijk et al. 2006). Preliminary results indicate that average annual run-off for Victoria's surface water management areas will reduce with climate change. In broad terms, the stream flow across the Murray-Darling Basin may be reduced by 5 percent in 20 years (1100 GL) and up to 15 percent in 50 years (van Dijk et al. 2006). In Victoria, a decline in rainfall is predicted to decrease run-off between 0 to 45 percent in 29 Victorian catchments (Jones & Durack 2005). Systems such as the upper Murray River could have up to 20 percent less run-off by 2030 and greater than 50 percent reductions by 2070. Such losses far exceed any savings currently required to provide for environmental water (see chapter 15) which have proved difficult to achieve under current circumstances.

Our need to use water more efficiently is likely to be reinforced by climate change. However, the predicted change and variability of climate is outside the range of previous experience, even when the highly variable climate of Australia is considered, necessitating new strategies, especially those related to the long-term sustainability of industries and resources (Pittock 2003). These strategies must to be informed by an understanding of natural and human systems, but also need to be location and sector-specific.

In addition, water quality may change. The number and types of organisms, water temperature, carbon dioxide concentration, transportation of water sediment and chemicals, and volume of water flow are all likely to affect water quality. Decreases in stream flow, reduced underground water and increased salinity are critical issues for water supply and management as well as natural resource management more broadly.

Within the study area, the variable climate and low rainfall in many areas, combined with increasing pressure on reduced water resources under climate change scenarios, will present considerable challenges for natural resource managers.

Forest Productivity

Future forest productivity depends in part on balancing the benefits of increased atmospheric carbon dioxide concentrations and the patterns of change in rainfall and temperature. For example, a doubling of carbon dioxide with a warming of 3ºC and no significant changes in rainfall would encourage tree growth in much of southern Australia, particularly in wheat belt and semi-arid regions. However, these benefits are likely to be offset by higher evaporation rates, fewer nutrients, increased pest and wildfire risk (Hennessy et al. 2006b). Rainfall is also likely to decrease and become more erratic, further impacting on growth rates.

In the floodplain forests of the study area, flood regime—rather than rainfall—is the major water-related determinant of tree health. The frequency, duration and extent of floods in the study area have generally decreased significantly because of human water use (see chapter 15). Reduced flooding has stressed and killed red gum and black box trees and reduced growth rates, thus reducing long term productivity for wood products and nectar production in many areas (see further discussion in chapters 5, 13 and 14). In short, the predicted adverse impacts of climate change on floodplain forest health are likely to more than counterbalance any predicted favourable effects.

Natural Environment and Landscapes

In the past, non-climatic pressures from human settlement have dominated environmental change in Victoria. In the future natural resources and biodiversity will be strongly affected by climate change (Intergovernmental Panel on Climate Change 2001). Ecosystems and species will respond to changing climate conditions, but at the same time have to cope with climate-induced changes in land use, and pests and diseases, particularly invasions by exotic species. These combined effects will become more severe, and ecosystems and species may not be able to adapt quickly enough to survive.

Climate change already affects Victoria's plants and animals, but further research is needed to identify the precise effects of climate change on biodiversity (see chapter 5 Biodiversity and Newell et al. 2001). Many of Victoria's ecosystems and species may have a limited ability to adapt to climate change (Brereton et al. 1995). Species restricted to small areas, or unable to quickly relocate to changed shifting climatic zones—assuming that all climatic zones will still exist somewhere—are particularly susceptible. The most susceptible include threatened species, those that occur in small patches of remnant vegetation, significantly modified or fragmented landscapes, or those invaded by exotic plants or animals. Reducing habitat fragmentation and protecting biolinks, refuges, and important habitats will be critical for the survival of some species (Brereton et al. 1995; Dunlop et al. 2003; Pittock 2003; NRMMC 2004; Thomas et al. 2004).

Summary

Public land provides an important refuge where native species can adapt, relocate and disperse in response to climate change. As part of the long-term planning for sustainable use of public land, habitat links be particularly important to facilitate migration and adaptation of species under changing climate. However, strategies to mitigate the effects of climate change on both the environment and the economy cannot rely on maintaining the status quo—more capacity, flexibility and conservatism must be built into existing systems. Climate change strongly reinforces the importance of incorporating long-term costs and benefits into decisions involving apparently pressing short-term considerations.

Having said this, there is limited capacity for VEAC to structure future public land use to accommodate the entire range of predicted impacts of climate change. Much of the response to mitigate or adapt to the projected future climate is required on a much larger scale (such as reducing greenhouse gas production), although actions will need to be location and sector-specific (such as farm or plantation forestry to sequester carbon). The full range of co-benefits and conflicts can be difficult to anticipate and to resolve (Pittock 2003), however, some are explored further in chapter 19 Issues.

WILDFIRE

Fire is a ubiquitous part of the Australian landscape. Australia's hot, dry and particularly variable climate makes it the most fire-prone continent. Many plants and animals have evolved with a dependence on the rejuvenation and succession provided by bushfire, or wildfire as it has become known more recently. For example, hakeas, banksias and acacias, have hard seed coatings or capsules, which only germinate under conditions associated with fire (Gill et al. 1981; Smith 1992b, a).

Eucalypts have developed markedly different mechanisms to cope with different fire regimes. For example, mountain ash (see Appendix 4 for scientific names of all plants mentioned in the text) grows in high-elevation, cool, moist forests that normally protect it from all but the rare, catastrophic fires it requires every hundred years or so in order to regenerate. Other eucalypts that occur in dry, fire-prone environments, such as messmate have a thick protective bark layer that insulates the interior of the tree from the heat of an intense fire (Smith 1992b).

Changes in Australia's flora correlate with major shifts in climatic conditions and the increased occurrence of fire in the landscape over thousands and even millions of years. Research finds a rapid increase in the amount of charcoal in lake or swamp deposits during the major dry periods of the last 130,000 years (Singh et al. 1981). These changes occurred as the frequency of fire increased, and fire-adapted species became dominant. Many fire-adapted species are highly combustible and accumulate high fuel loads. Indeed some species such as the hairpin banksia are entirely consumed by fire and regeneration is stimulated through a large number of seeds shed onto the ash bed after the fire passes (Smith 1992b).

Aboriginal people are known to have used fire as a land management tool, creating a new flush of vegetation growth in a mosaic of small probably cool burns and across parts of the Australian landscape. This technique is often referred to as 'firestick farming'. While knowledge of traditional burning practices of local Aboriginal people is not well documented for the Murray floodplain area, it is believed that regular, low intensity burning occurred throughout the floodplain forest, perhaps as often as every five years (Atkinson & Berryman 1983; DCE 1992). High intensity wildfires were probably uncommon prior to European settlement at which time traditional Aboriginal burning practices largely ceased in the study area (Curr 1883; DCE 1992).

Fire management on public land in Victoria is the responsibility of the Department of Sustainability and Environment (DSE). This responsibility includes control of wildfire, prevention of unplanned fire and the intentional use of fire for specific ecological and safety purposes. Fire protection plans are prepared for all Victoria's parks and forests. These plans are prepared in consultation with the community and follow the Code of Practice for Fire Management on Public Land (Department of Conservation and Natural Resources 1995). This document provides for a review to be undertaken within ten years and DSE has recently undertaken a public comment and consultation process to develop the revised document due for completion in 2006 (DSE in prep). Fire management is described in chapter 9.

On average 620 wildfires occur in Victoria's parks and forests each year, mostly during summer. Approximately two-thirds of all fires are caused by people, either accidentally or deliberately (DSE 2004e). The remaining fires are largely caused by lightning. Devastating wildfires following drought occurred in Victoria in January 1939 (Black Friday, resulting in 71 deaths), February 1983 (Ash Wednesday, resulting in 75 deaths) and 2003 (alpine fires, with one life lost in flash floods) (Wareing & Flinn 2003). The area burnt in Victoria by these fires is estimated to be 1.5 to 2 million ha, 210,000 ha and 1.1 million ha respectively (Wareing & Flinn 2003). By far the largest fires recorded in Victoria were those known as 'Black Thursday' (6 February 1851) in which approximately 5 million hectares or nearly one quarter of what is now Victoria was burnt. Areas affected include Portland, Plenty Ranges, Westernport, the Wimmera and Dandenong districts. Approximately 12 lives, one million sheep and thousands of cattle were lost. None of these major fires occurred within the River Red Gum Forest study area. Large wildfires occurred in 1944 near Benalla and 1952 near Wodonga (Paine 1982), but did not significantly involve river red gum forests.

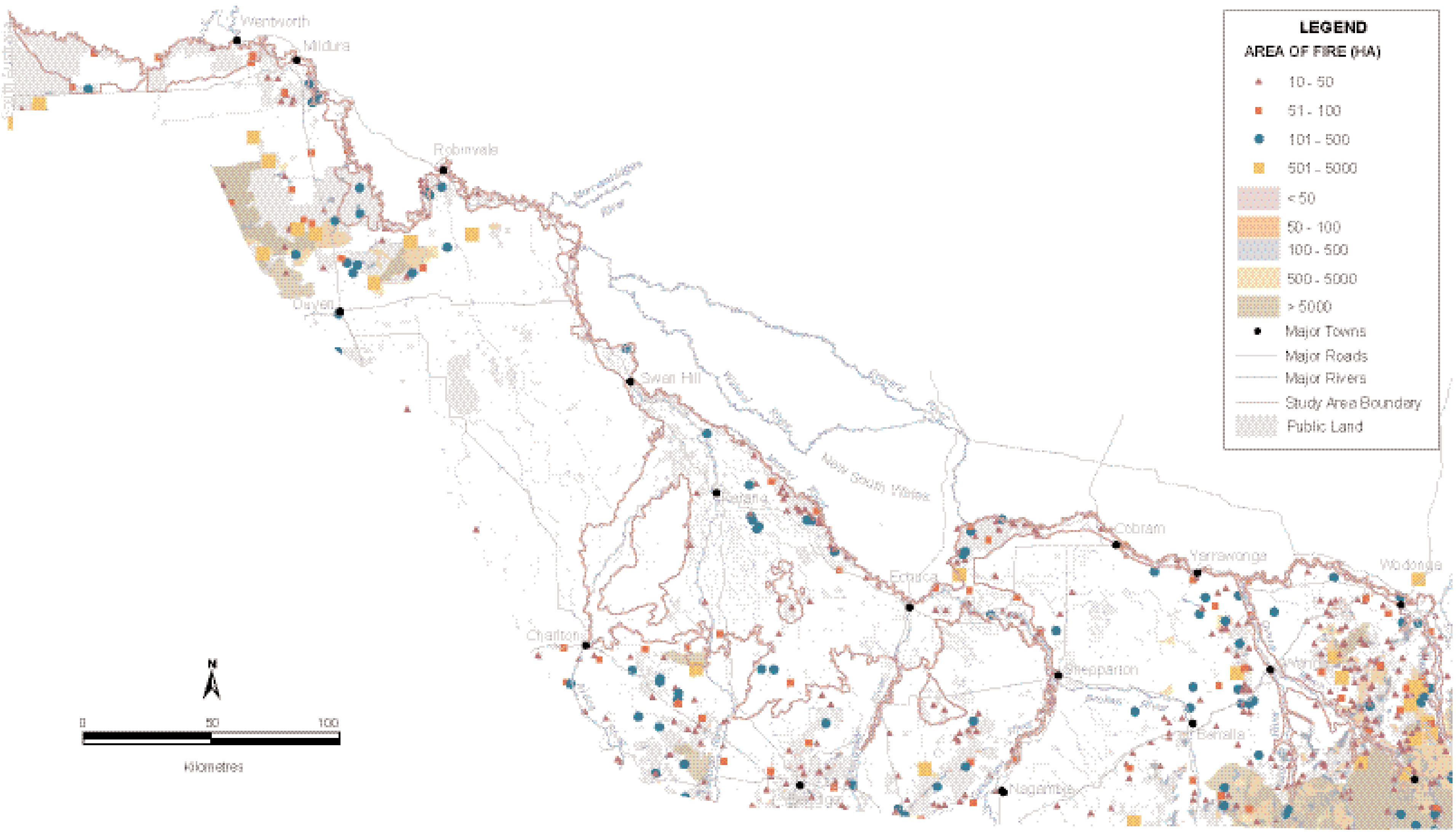
To date there have been few major wildfires, within river red gum floodplain forests, and those that have occurred are of limited extent (Map 4.2). For example, in the Barmah forest (both state forest and state park) there were 112 fires from 1983-84 to 2003-04, which burnt a total area of 302.5 ha (Eyles 2004). Of these fires, 80 burnt less than five hectares each, with the largest single fire in this period about 50 ha in extent. Ten fires burnt 10 ha or more, and 21 fires burnt five ha or more each. Excluding the largest fire, the average fire extent was 2.3 ha. The source and agent of these fires are shown in Table 4.2.

Table 4.2 Source and agents for 112 wildfires recorded in Barmah forest from 1983 to 2004

Sources	No.	% of fires	Agents	No.	% of fires
Lightning	12	10.7	Recreationists	70	62.5
Cigarette / Match	10	8.9	Lightning	12	10.7
Campfire / BBQ	60	53.6	Children	5	4.5
Deliberate	7	6.3	Malicious	1	0.9
			Employee – other	3	2.7
			Employee – DSE	1	0.9
Other	8	7.1	Other	3	2.7
Unknown	15	13.4	Unknown	17	15.1
Total	**112**			**112**	

Source: Eyles (2004)

Map 4.2 Wildfire occurrence in the River Red Gum Forests study area.



Source: DSE (2006b)

Recreational users, particularly campers, account for half of the fires in river red gum forests, through escaped campfires, BBQs and discarded cigarettes or matches (Table 4.2) (DCE 1992a). Land managers report that recent public education encouraging clearings around campfires and ensuring that they are extinguished has helped to reduce the numbers of escaped fires. Forests NSW has established a seasonal ban on solid fuel fires in state forests in the Riverina Region of southwest NSW along the Murray River. For further discussion of fire management on public land see chapter 9.

Hennessy et al. (2006a) reported an increase in wildfire risk for southeastern Australia under projected hotter and drier climatic conditions. Key findings for land management agencies are that the number of days on which conditions for prescribed burns are favourable will be reduced and higher fire risk will be experienced in spring, summer and autumn. Additionally, inland areas are at greatest risk for increases in wildfire occurrences.

HYDROLOGY

This section describes the River Murray catchment and its hydrology (the way in which water moves around the atmosphere, land and water systems through the water cycle). This section is closely linked to chapter 3 Geomorphology, chapter 5 Biodiversity and chapter 15 Water Use and Environmental Flows.

The River Red Gum Forests study area is in the vast Murray-Darling Basin (see Map 4.3). While the River Murray and its water fall within the jurisdiction of NSW, ecologically and economically the river supports human and natural activities on adjacent Victorian public land. Any investigation of public land along the River Murray in Victoria must consider the hydrology of the river and its relationship with the river red gum forests and associated ecosystems and landscape.

Overview of the Murray-Darling Basin

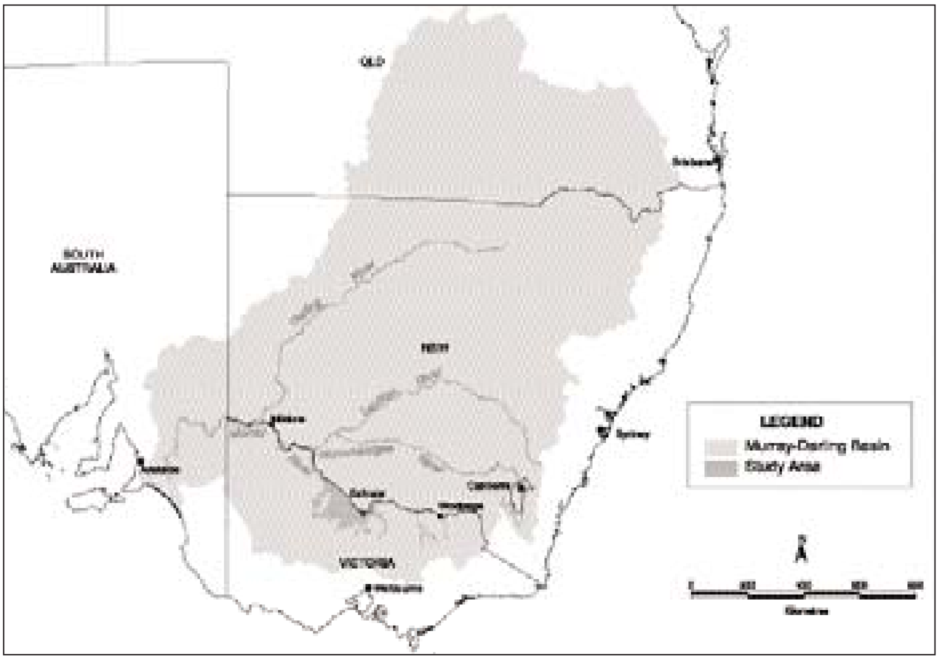
The Murray-Darling Basin covers approximately 1.1 million square km (14 percent of Australia) and is one of the largest catchments in the world. Some 86 percent of the basin contributes virtually no run-off to the river system except during rare extensive flood periods. The major rivers that flow through NSW and into the River Murray are the Darling (with headwaters in Queensland), Lachlan and Murrumbidgee (see Map 4.3 for location of these rivers within the basin). In terms of its length, the River Murray is one of the largest rivers in the world extending over 2000 km (MDBC 2005b).

The rate of flow in the River Murray is highly variable with flow rates oscillating along the length of the river, across seasons and between years. This high variability relates to the River Murray's uniqueness in terms of its size, shape, topography, geology and climate. It also is a major reason for the range of ecosystems found along the river (see chapter 5). Compared with other rivers, the River Murray's flow is relatively low. The entire Murray-Darling Basin is one of the driest basins in the world. For example, every square kilometre of the Amazon River's catchment averages 75 times more water flow than the Murray-Darling river system. To put this into perspective, the average annual flow of the Murray-Darling system would pass through the Amazon River in less than a day.

Because of the river's length and low flow rate it takes about four weeks for the water flow to travel the 1580 km from Hume Dam to the SA border, when flow is below bank-full. A flood-wave with over-bank flow takes about two weeks longer to travel the same distance, a total of approximately six weeks.

The River Murray is, by world standards, one of the most stable rivers of its size. The river's planform (the shape of the river as seen from the air or satellite image) has remained relatively unchanged since the 1860s when the river was first surveyed. However, as described in chapter 3 this has not always been the case as the river has changed channels extensively over thousands of years and geological time (Gippel & Blackham 2002).

Map 4.3 Location of the study area within the Murray-Darling Basin.



Natural Hydrology of the River Murray

Factors Influencing Surface Water Run-off

Around 84 percent of precipitation is either evaporated or taken up by plants and returned to the atmosphere as water vapour in a process known as transpiration. Approximately 1 percent of precipitation infiltrates the soil and reaches the groundwater, while the remaining 15 percent of precipitation reaches waterways via surface water run-off to be discharged into streams, rivers and lakes. Surface water run-off is a crucial aspect of the hydrology of the River Murray, as it determines flow volume and velocity and hence water availability for vegetation and human use.

Surface water run-off is influenced by vegetation cover, topography, climate and soil type.

Tree canopies are highly effective at intercepting rainfall and therefore, the point and time of impact of the rain reaching the ground. Other vegetation types also perform this function but, because of their smaller surface area, are not as effective at intercepting rainfall. The upper catchment areas of the River Murray have extensive tree cover, reducing immediate run-off and leading to more constant discharge and stream flow—vegetation reduces immediate peaks in surface water run-off after rain, and promotes more gradual dispersal over a longer period, allowing rainfall to permeate the soil. This increases base flows of streams because of higher and more constant ground water seepage. Vegetation also reduces soil erosion caused by surface water run-off and filters sediments, nutrients and other 'pollutants' (MDBC 2001). Deep rooted vegetation moves water through the water cycle by tapping into the groundwater table and, through evaporation and transpiration, keeps groundwater tables low (reducing soil salinity in some areas).

Steep terrain causes faster surface water run off and reduces the likelihood of water sinking into the soil. Water that does infiltrates the soil from surface run-off flows down slopes, eventually reaching streams and rivers. The more gradually the water reaches a river the less likely it is to flood. Topography also determines the energy of river flows and the form of rivers. For the Murray River, with a relatively flat topography except in the headwaters, any surface water run-off is relatively slow.

Climatic factors, particularly temperature, wind and humidity, influence evaporation and transpiration rates, which in turn influence the amount of surface water available and run-off potential. In the study area, the variable climate causes large variations in evaporation and transpiration rates. For example, in the western part of the study area high temperatures, relatively strong, dry winds and low humidity conditions cause high evaporation and transpiration rates. This results in almost no surface water run-off to the River Murray (see below) in this area. Rainfall intensity and duration also influence surface water run-off, with heavier and longer rainfalls increasing run-off.

Soil type also influences run-off. There are a range of soil types in the study area but most of the study area (such as the Chowilla floodplain (SA) and Barmah forest) is covered by clay type soils of varying thickness. In the Barmah forest, surface clays vary from 8 to 20 m deep over a short distance and can reach up to 30 m. On the Chowilla Floodplain, the clay layer is less than 5m deep.

Clay soils are impervious to water leading to rapid surface water run-off and low infiltration. However, when dry, most clays develop deep cracks (around 25 mm wide and up to 2 m deep), allowing water, organic material and animals to enter the soil. Floodwaters enter these cracks leading to deep soil recharge. When the clay soils of the floodplain are not fully dried out or where cracking has not occurred deep soil recharge is reduced. As clay soils become wet they expand, become saturated, close off surface cracks and become impervious to further water. Infiltration into these cracks therefore occurs for a relatively short period at the start of a flood (MDBC 2001).

Recharging of the sub-surface areas of the floodplain is unlikely if the soils are highly unstable clays. This is the case on the Chowilla Floodplain, where 32 days continuous flooding caused saturation only in the top 20-30 cm although soil water increased down to 70 cm. Impenetrable swelling clays are also found in the Barmah forest. Recharge from the surface may be localised if the surface layer is discontinuous and punctured by another soil type. In the Barmah forest, one flood penetrated to 5 m and another comparable flood to only 1 m (MDBC 2001).

Surface water run-off across the study area varies seasonally and annually with variations in weather. Summer and autumn are usually characterised by little if any surface water run-off, winter and spring have high natural stream flows and water levels in wetlands. Flooding of rivers, particularly in the east may also occur naturally in summer when tropical rain depressions move unusually far south (Parliament of Victoria Environment and Natural Resources Committee 2001).

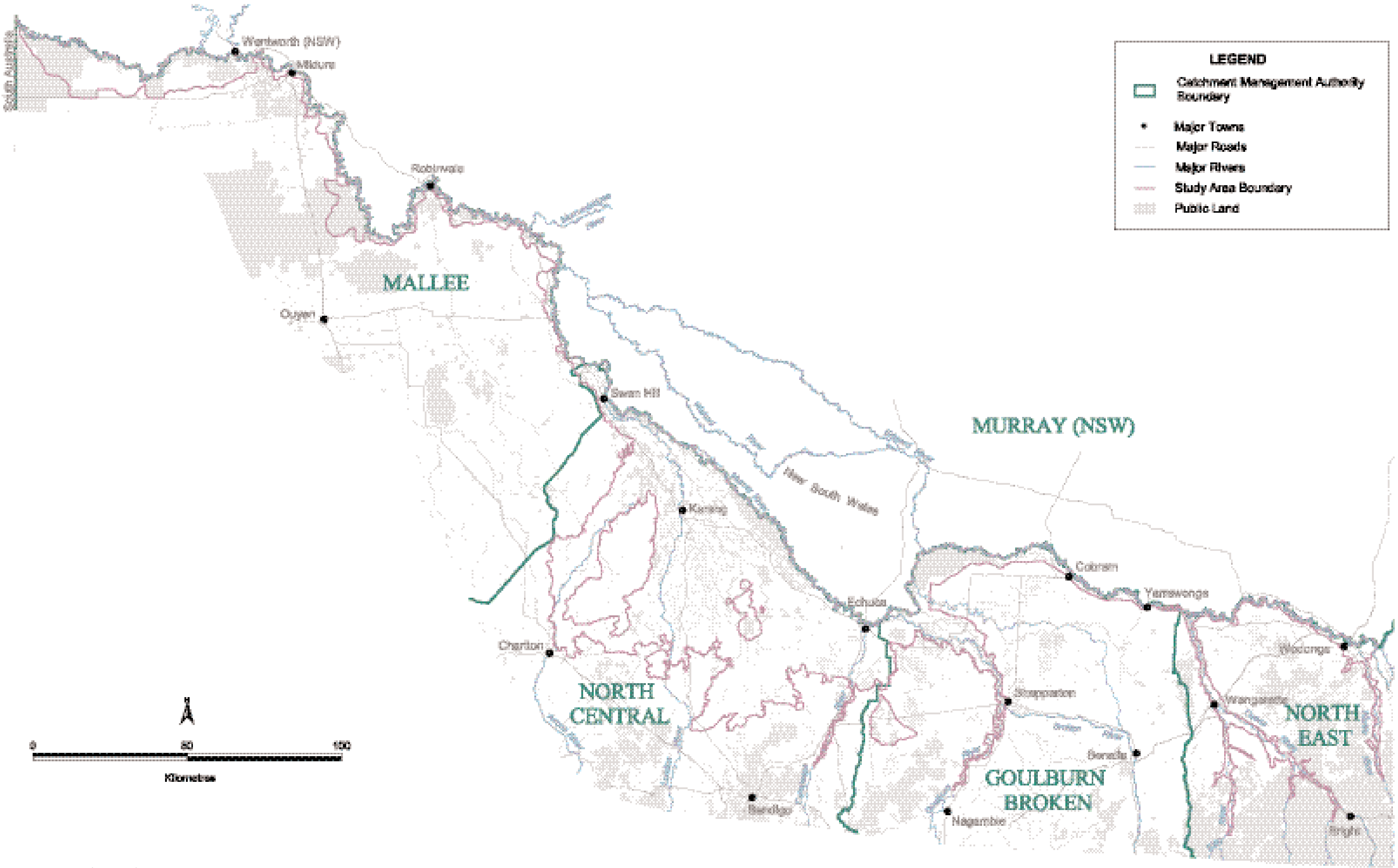
Victorian Catchments Flowing to the River Murray

The headwaters of the River Murray begin in northeastern Victoria on the border with NSW. At Dartmouth Dam, the River is 486 m above sea level and falls to 35 m above sea level at Mildura. From its headwaters above Dartmouth, the River flows north, west and south for 2530 kms before entering the Indian Ocean near Goolwa (SA). Most of the water in the River, however, comes from the first 500 of these kilometres—for the last 2000 km, surface water run-off from the land surrounding the Murray contributes relatively little to river flows (Mackay & Eastburn 1990).

In Victoria precipitation and flows in waterways vary considerably from catchment to catchment in both total volume and amount of variation over time. This variation is evident across the four main catchment regions in the River Red Gum Forests study area. As described in the preceding climate section, precipitation is generally higher and more reliable in the north east region of the study area and declines further westward.

There are four major catchments (North East, Goulburn Broken, North Central and Mallee) in Victoria associated with the River Red Gum Forests study area. The rivers in these catchments are shorter than the Darling and Murrumbidgee Rivers but contribute far more run-off into the River Murray (see Table 4.3). The location of major Victorian tributaries and the four catchments is shown in Map 4.4.

Map 4.4 Victorian Catchment Regions of the River Murray.



Source: DSE (2006a)

The **North East** catchment region includes the Ovens, King, Kiewa, Mitta Mitta and Upper Murray rivers and covers approximately 1.9 million hectares. Although this is only 2 percent of the Murray-Darling Basin, the region contributes 38 percent of the total water to the system (NECMA 2004). All these rivers enter the River Murray upstream of Yarrawonga.

As its name suggests, the **Goulburn Broken** catchment region includes the Goulburn and Broken Rivers. The Goulburn River is Victoria's largest river basin covering an area of 1.6 million hectares (7.1 percent of the State). The Goulburn River is approximately 570 km long and has a mean annual water discharge of 3040 GL. The Broken River (a tributary of the Goulburn) basin covers 772,386 ha (3.4 percent of Victoria), including the Broken Creek catchment that includes the de-commissioned Lake Mokoan. Over half of the annual stream flow occurs between July and September, with a mean annual flow of 325 GL (GBCMA 2003).

The Goulburn and Broken River basins together cover approximately 2.4 million hectares (10.5 percent of Victoria and 2 percent of the Murray-Darling Basin). Combined, the river basins generate around 11 percent of the basin's water resources and flow into the River Murray upstream of Echuca. These rivers provide large volumes of water to the River Murray during floods, thereby avoiding the physical constraint imposed by the Barmah Choke—see below.

Combined, the North East and Goulburn Broken catchment regions contribute 49-50 percent of the Murray Daring Basin's overall water resources.

The North Central catchment region contains the Loddon, Campaspe and part of the Avoca River basins. The Campaspe River with an approximate annual flow volume of 315 GL and the Loddon River with 263 GL flow directly into the River Murray. In contrast, the Avoca River discharges into the Avoca marshes and Lake Boga near Swan Hill (NCCMA 2003).

The Mallee catchment region contains three main basins, the Mallee Basin covers 2,802,688 ha, the Avoca Basin covers 1,235,246 ha and the Wimmera River Basin covers 2,401,130 ha (Mallee Catchment Management Authority 2003). Rainfall is relatively variable in this catchment region. Compared with the Goulburn Broken and North East catchment regions, the Mallee catchment contributes little if any run-off into the River Murray system, reflecting its semi-arid climate.

Flood Regimes

Under natural (pre-European river regulation) flood conditions, around half the surface water run-off from the catchments of the Murray-Darling Basin reached the sea. River flows varied considerably across the system in volume and between years. Before river regulation around 11,300 GL of water flowed down the River Murray to its mouth in South Australia during a typical year and varied from approximately 2500 GL during a dry year to 40,000 GL in a very wet year. This variation is a key feature of the flooding and flow regime of the River Murray.

Under current water regulation conditions (see chapter 15), flow is reduced to about 3000 GL in a typical year,

or 27 percent of flow under natural conditions (Murray-Darling Basin Commission 2002). The extraction of this amount of water from the River Murray system has adversely affected many species in the study area, most significantly in wetlands and river red gum forests. It has also significantly affected water quality and salinity (see chapters 5 and 15). However, the extracted water supports important agriculture around the study area (see chapters 8, 13 and 15).

For flooding to occur across the River Murray floodplains, river flow must breach the channels and flow over the river bank onto the surrounding landscapes. Flooding enables some tributaries such as the Lachlan which normally terminates in marshes, to reach the Murray River. Remaining surface water in floodplains and wetlands eventually permeates through the soil to recharge ground water systems. Prior to river regulation the natural flood regime of the River Murray could be divided into three types, large-scale floods, mid-range floods and low flow conditions (Gippel & Blackham 2002).

Large-scale floods generally occurred once every 20 to 100 years. These floods extended from the River Murray channel and out over the vast floodplains (see Map 4.5 for distribution of a 1 in 100 year flood). These floods were crucial for connecting wetlands, swamps and marshes along with the broader floodplain to the main river systems and for transferring energy and nutrients between the river and floodplains. They were also crucial for flushing the entire river system. Large-scale floods lasted for 2 to 6 months, depending on rainfall and snow in the upper catchment. Large floods on the Murray usually coincided with large-scale floods on Victorian rivers such as the Ovens, Broken, Goulburn, Kiewa and King.

Table 4.3 Stream flow in major Victorian rivers associated with the study area.

Catchment region	River	Length (km)	Average annual stream flow (GL)	Maximum annual stream flow		Minimum annual discharge	
				(GL)	Year	(GL)	Year
North East	Ovens	227	1110	2880	1956	195	1982
North East	Kiewa	184	665	1450	1974	193	1967
Goulburn / Broken	Goulburn	563	1680	5930	1974	228	1972
Goulburn / Broken	Broken	192	236	1130	1917	4610	1943
North Central	Campaspe	245	203	886	1974	2830	1902
North Central	Loddon	392	186	461	1974	36,200	1967
Mallee	Avoca	269	47	129	1973	3480	1982

Source: Cochrane et al. (1999) and DSE(2006i)

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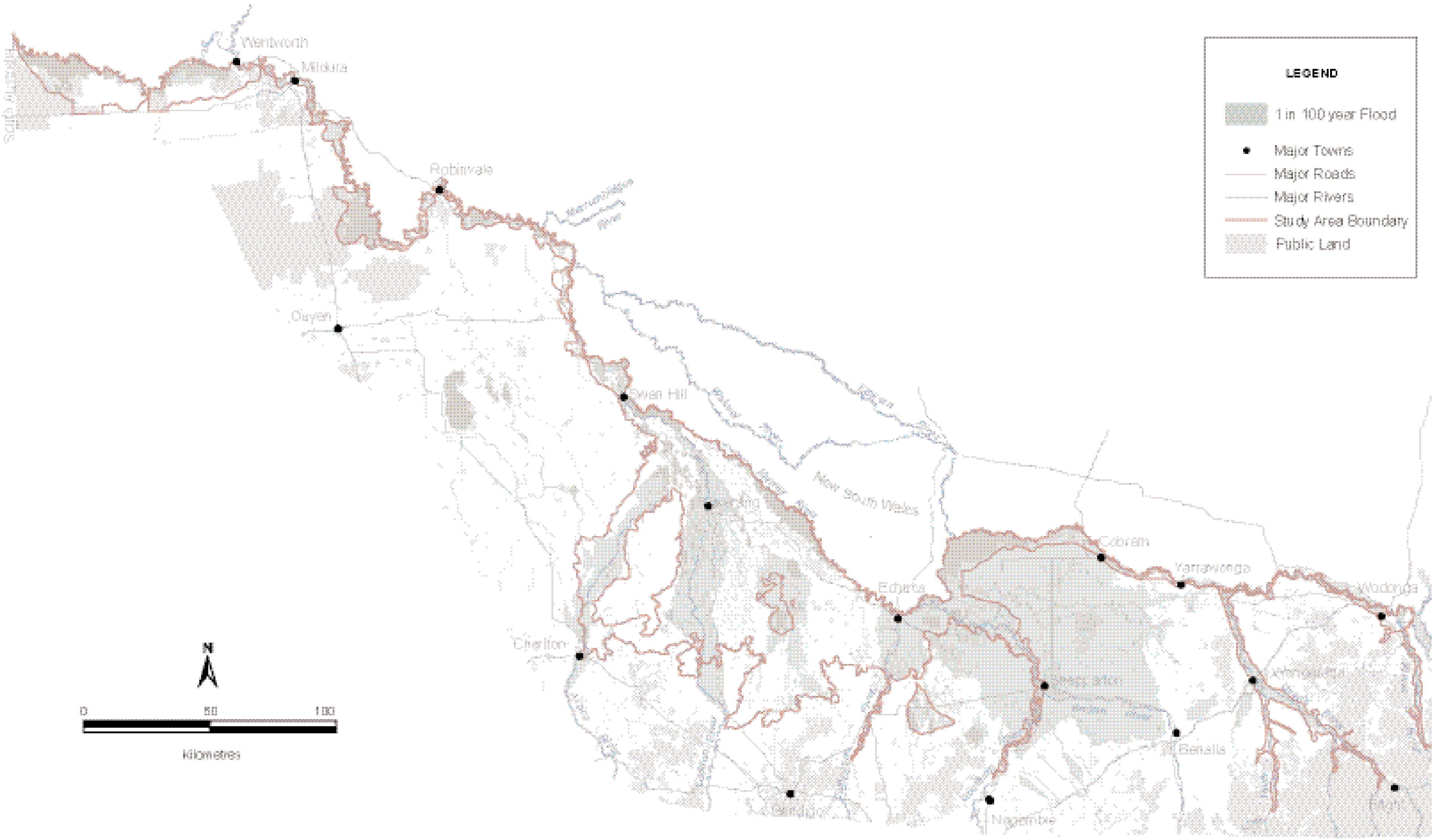
Map 4.5 Distribution pattern of a 1 in 100 year flood.



Source: Department of Sustainability and Environment Corporate Geospatial Data Library, 2006

Large flood events occurred in 1917, 1956 and 1973. According to Gippel and Blackham. (2002), peak flows recur every 20 years or more and their frequency has remained relatively unchanged with river regulation. Major floods are usually preceded by heavy rain that fills storages and reduces demand for water diversion. With the huge volume of run-off, dam storage capacity is reached, forcing large volumes of water to be released out of the storages (Gippel & Blackham 2002). However, such floods may become less likely in the future, due to climate change reducing rainfall and run-off.

Mid-range floods occurred approximately once every 2 to 10 years and were usually of shorter duration than the large floods (one to six months). Monthly flows at the SA border exceeded 1000 GL and occurred in 45 percent of months (Gippel & Blackham 2002). Such flooding regimes are crucial for the sustainability of the various ecosystems found within the study area.

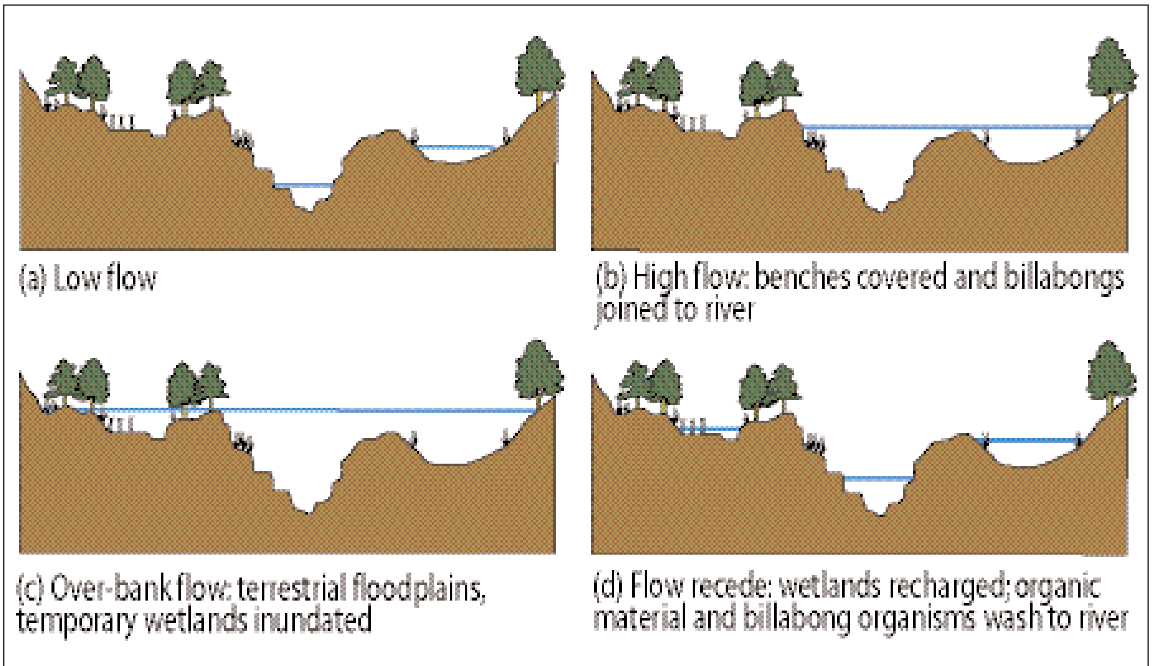
Today, with regulation these floods are only expected to occur in 15 percent of months, with mid-range floods lasting only one to three months. Studies by Thoms et al. (2000, cited in MDBC 2005b) indicate that these types of floods occur much less frequently now than they did prior to river regulation. Floods that once occurred every second year now occur every 6 to 8 years, while floods that once occurred every 10 years now occur every 25 to 30 years. This change in flow regime through river regulation reduces the frequency of flooding of wetlands, riparian vegetation and floodplains, with dramatic consequences for species and ecosystems that may be able to survive some reduced flooding but not to this extent (see chapters 5 and 14).

The third type of flow regime is low flows, which includes periods of no flow and even—in extreme droughts—drying of much of the river bed so that the River was reduced to a chain of often saline ponds. Today, with river regulation and the demand for a reliable water supply by downstream water users such events are highly unlikely to occur in the future. Now, there is nearly always some flow in the River other than at the most downstream reaches in SA where regulation is thought to have increased the frequency and degree of low flows.

The flow regime prior to regulation was also characterised by seasonality of flooding. For example, flooding usually occurred from July (winter) to November (late spring). Reduced flows occurred during the drier seasons from December (summer) to May (late autumn). The seasonality of natural flooding also influenced water temperatures. Cold water flowed during late winter–late spring particularly with the melting of snow. Warmer water flowed in summer–late autumn when there was less water and higher land surface temperatures.

The river red gum forests and associated ecosystems have adapted to these conditions of seasonal flow variability, temperature variations, drought, and wet and dry cycles to form the rich biodiversity of the river red gum forests we see today. Figure 4.2 illustrates the relationship between the river's flow regimes and its anabranches, billabongs, lakes and ecological communities—particularly the lateral flow of water under flood conditions across the broader floodplain. Today, the natural variation of the River between floods and low flows has largely been eliminated, resulting in the degradation of large areas of river red gum forests and their associated ecosystems. Environmental flows (see chapter 15) are designed to address these ecological concerns.

Figure 4.2 Relationship between flow regimes of the river and ecological communities.



Source: MDBC (2002)

Groundwater

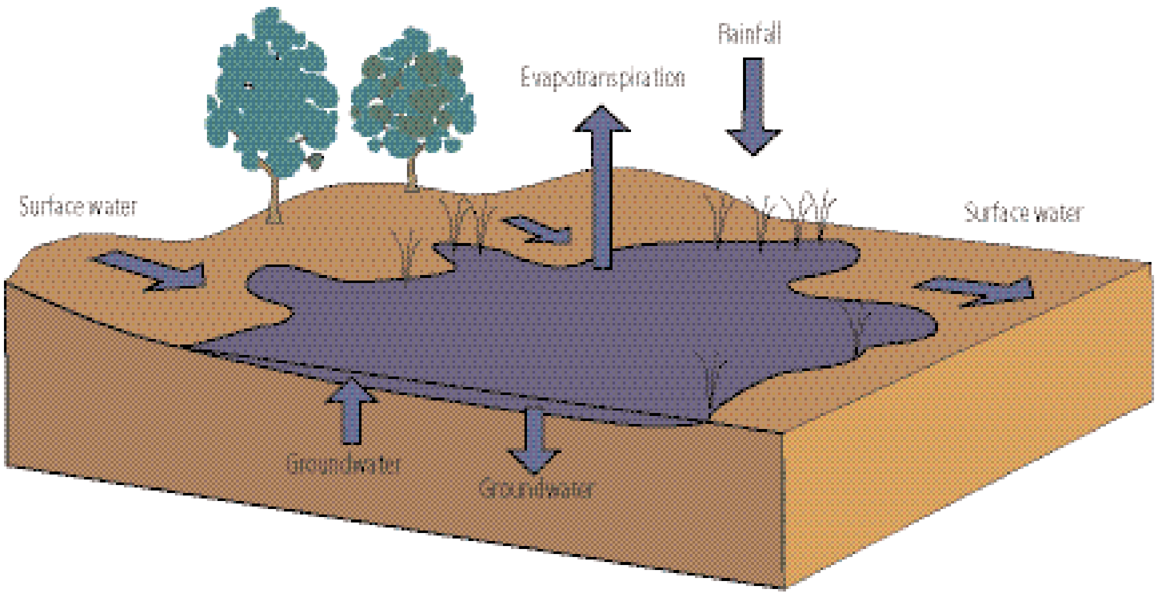
Hydrology also relates to the movement of water through ground systems and the interaction and interchange between surface and groundwater systems. Groundwater is water stored in the saturated zone (or aquifer) below the land surface. This water may be held in layers of soil or underlying porous materials such as gravel or porous rock. Where there is an impermeable layer both below and above the aquifer, it is known as "confined". An unconfined aquifer has no impermeable layer above the aquifer. A water table occurs where all the openings in rocks and the soils close to the surface are saturated with water.

The level of the water table or pressure in an aquifer is dependent on equilibrium between recharge and discharge, which is influenced by the amount of surface water in the upper catchment areas and floodplains. Aquifers, therefore, are dependent on the amount of water entering from rainfall recharge and watercourse seepage (Parliament of Victoria Environment and Natural Resources Committee 2001).

Extraction of groundwater increases outflows. If there is no increased water input, extraction will lower the water table or pressure in the aquifer and reduce the lateral flow of groundwater into waterways and wetlands. This is particularly important for the River Murray with its semi-arid environment because reduced lateral flow of groundwater provides less water during drought for river flow and in wetlands, billabongs and lakes (for example, see Figure 4.3).

Lower groundwater also affects deep-rooted plants, which may not be able to reach the groundwater during periods of droughts. Examples of this are stressed or dying river red gums downstream of Cohuna due to the changed water table and flood regimes.

Figure 4.3 Groundwater movements and wetland hydrology.



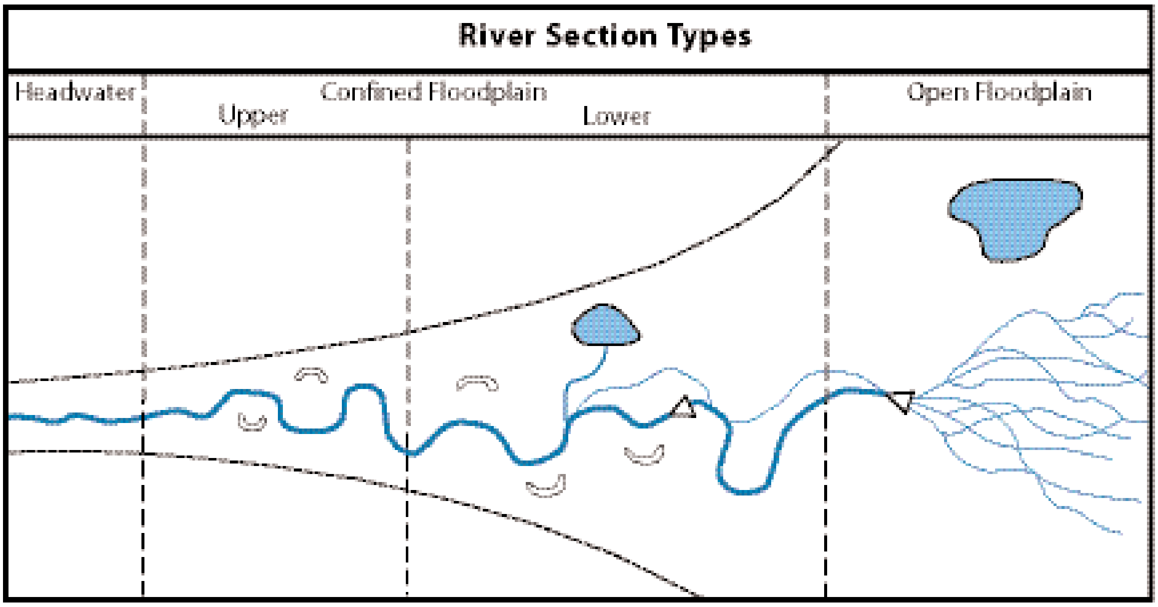
Source: MDBC (2001)

There are four main groundwater aquifers found within the Murray-Darling Basin relevant to the River Red Gum Forests Investigation, as follows.

- The Renmark Group aquifer, located around the central western area of the Murray-Darling Basin, is relatively saline. The water pressure in this aquifer results in groundwater leaking upward into the overlying sediments.
- The Murray Group aquifer lies to the south of the River Murray and flows in a north-north-westerly direction from the recharge areas of the southern Wimmera toward a discharge point along the River Murray. Groundwater in this aquifer is relatively fresh.
- The Pliocene Sands aquifer is in the central area of the River Murray. This aquifer has a complex ground water exchange process. Around the basin margins, where the aquifer is unconfined, the water leaks down to the aquifer from streams and rivers. Where the aquifer is confined, recharge is through downwards leakage from rainfall and by lateral transmission from the adjacent formations. At the eastern end of the aquifer the groundwater is relatively fresh. Towards the west the groundwater becomes more saline.
- The Shepparton Formation aquifer is found in Victoria and southern NSW. This aquifer has a complex local flow regime due mainly to the permeability of the materials forming the aquifer. This aquifer lies below the irrigation areas of the Goulburn Valley and receives recharge through irrigation leakage (Mackay & Eastburn 1990).

These regional aquifers recharge through two processes. The deeper confined aquifers have recharge zones generally around the Murray Basin margins and, more importantly, where the major rivers enter the plains from

Figure 4.4 Different sections types associated with the River Murray and the various features found within each section.



Source: MDBC (2001)

the uplands. The shallower unconfined aquifers receive water from large-scale rainfall over the surface.

Discharge from the deeper aquifers leaks up through confining layers to the watertable. Discharge from the watertable aquifer leaks into the lower reaches of the River Murray and its tributaries as well as by evaporation through capillary action up through the soil profile (Mackay & Eastburn 1990). Flows out of these aquifers into the River Murray are often the only additional water to the river as it flows west.

The River Murray and its Floodplains

The hydrology of the River Murray varies considerably across different sections of the river. The following description focuses on the hydrology of the headwater (upper catchment area) and floodplain sections. Each of the sections is shown in Figure 4.4, as are other sections of the river.

Headwaters

The hydrology of the headwaters of the River Murray (equivalent to the upland section in Figure 4.4) is largely shaped by the mountainous topography, relatively high rainfall during winter/spring and the confined nature of the river channels. The headwaters are mainly located within the North East catchment region of Victoria. River channels are small and narrow, with channel width often being less than 10 times the channel depth. The river banks associated with these channels are usually vertical rather than sloping in nature.

In its headwaters the River Murray channel and form is relatively straight but as it flows from the headwaters to the floodplains, such as below Hume Dam, meandering patterns begin to emerge (as described in chapter 3). Channel slope and gradient is greater reflecting the higher, more mountainous topography than that of the floodplains and stream flow is consequently more direct and rapid (MDBC 2001).

River Murray headwater channels are associated with bedrock outcrops and ancient sedimentary deposits (see chapters 2 and 3). These channels are often temporary or ephemeral with flow into the headwater section being maintained by groundwater drainage from the upper catchment areas well after rain and surface water run-off have ceased. As a result, river flow rarely drops below a relatively high base level except during periods of severe drought.

There are distinct seasonal variations in run-off and flow in the headwaters. Late winter to mid spring rainfall is greater along with spring snow melts. In contrast, during late spring through to early autumn, rainfall is low and there is little surface run-off. Some streams cease to flow.

A number of land-use activities in the River Murray headwaters affect river flow and condition, particularly extensive land clearing. Reduced vegetation cover increases immediate run-off of surface water; less surface water infiltrates the soil, resulting ultimately in less groundwater discharge into streams and rivers. In combination, greater surface water run-off and vegetation clearing not only increases soil erosion, but also increases stream sediment as the filtering and soil-binding benefits of deep-rooted vegetation are lost. Sediment in the entire River Murray has been estimated to have doubled from 0.5 million tonnes a year to 1.0 million tonnes a year (MDBC 2001). Broad scale plantation forestry in the headwater section, is also believed to change the hydrological balance, intercepting groundwater discharge into streams.

Floodplains

The floodplains of the River Murray (corresponding to the upper and lower lowland sections in Figure 4.4) emerge as the river flows from the headwaters into the flatter and drier landscape. Floodplain sediment is deposited by the meandering river over time (see chapters 3). This section of the River Murray extends from around Albury-Wodonga to Wakool Junction near Swan Hill. As Figure 4.4 illustrates, this relatively shallow and wide section of the river winds, meanders and branches. Like the headwaters the River Murray floodplain has its own unique hydrology. Flow and flood patterns are greatly influenced by the low slope and gradient of the river bed and the associated floodplain areas.

There is more water in the river on floodplains and the fast turbulent streams of the headwaters are absent. The water is significantly warmer than in upper catchment because of higher air temperatures and direct solar radiation. When both flow and water turbulence is low the water may stratify, with warmer water lying on the surface and cooler layers lying closer to the river bed.

Flow and flood vary greatly across seasons and across years in the floodplain section of the River Murray. This variability is due to variation in rain and snow falls in the upper catchments. High flow or flood levels most commonly occur during late winter through to late spring. Reduced flows are usually associated with summer and early autumn. While flood frequency varies depending upon upper catchment rainfall, flood duration is closely linked to both the volume of water causing the flood as well as subsequent rain or snow-fall. Once a flood commences, there needs to be sufficient and ongoing water available to maintain the volume of water over a long period of time.

Water movement onto the floodplain is influenced by the relatively unconfined and low river channels. This channel shape enables water to move laterally out of the main River Murray and onto the surrounding landscape, or to form anabranch channels (channels that leave and then re-join the main river). Anabranches are usually not the major waterway, but may be a major waterway during times of varying flow. Depending on the size of the river flow when they were formed, anabranches may have larger channels than the existing, principal river and hence still carry more water during large floods.

The largest anabranch system on the River Murray is the Edward-Wakool system, which leaves the Murray River at Picnic Point, flows through Millewa forest before rejoining the River Murray at Wakool Junction. Hydrologically, this system is significant because, in times of large floods, it receives most of the flow. For example, during 1975 flood, 55 percent of the total water passing through Tocumwal went through the Edward-Wakool system. The Edward-Wakool system is unique and has its genesis in tectonic movements which created the short, shallow and narrow reach known as the Barmah Choke (see chapter 3). The Choke is a natural constraint on river flow because of its small channel relative to the channel upstream and downstream. For example, the River Murray's channel capacity at Yarrawonga is 25,000 ML per day whereas at the Barmah Choke it is only around 8500 ML per day. During flood periods this natural constriction not only diverts a large percentage of flood water north, then west, into the Edward-Wakool anabranch system but it also acts like a partial dam, forcing water to back up onto the floodplain and inundating extensive forest and wetland areas. This natural constraint has important implications for management of water for irrigation purposes and environment outcomes (see chapters 15 and 19).

Floods, and flooding of the floodplain in particular, achieve both longitudinal and lateral connectivity between different sections of the river and between the river and its floodplains. Longitudinal connection (or flow and flood movement down the entire length of the river) allows energy, nutrients and dispersal of plants and animals along the entire length of the river. Lateral connectivity through flow and flood movements between the river and floodplain transfer energy and nutrients around the floodplain and into various ecosystems as well as replenishing energy (carbon) and nutrients levels within the main river channel.

Water movement on the open floodplain is greatly influenced by evaporation from both land and water surfaces. Where evaporations rates are high, for example around Swan Hill and during summer, any remaining surface water quickly evaporates with little remaining for soil infiltration. Available surface and ground water is affected by the amount of water taken up by vegetation and the amount of floodwater either being returned to the river from the floodplain or remaining within the floodplain itself. As described above, clay-based soils play a significant role in this process.

Remaining Sections of the River Murray

Other sections of the River Murray also have characteristic, unique hydrology.

The Mallee trench is a wide plain of marine origin crossed by the River Murray in a single, well-defined channel which cuts deeper into the surrounding semi-arid plain as it moves downstream. The Mallee trench is broadly defined by the Murravian Gulf, marking the extent to which the sea once encroached across the river valley. The Mallee trench extends from the Wakool Junction near Swan Hill for approximately 850 river kilometres down to Overland Corner (SA). There is little, if any, surface water run-off into the River Murray in this area, where the river is characterised by low stream slope, low energy relative to its length and tiny catchment area relative to the size of the whole basin (Mackay & Eastburn 1990).

The Murray Gorge is found in the South Australian section of the River Murray between Overland Corner and Mannum, a distance of about 280 km. In the Gorge, the River has cut down through hard limestone rock during a period of low sea level, forming steep cliffs along the river channel. The river bed intersects with the regional watertable, and salty groundwater enters the river through aquifers exposed in the cliff face (Mackay & Eastburn 1990). There is virtually no surface water run-off in this section.

The Lakes and Coorong section of the River Murray system consists of the terminal lakes Alexandrina and Albert which, together with the Coorong, once formed a huge estuarine system. Barrages now separate the lakes from the Coorong and retain fresh water in the Lakes.

Summary

The hydrology of the River Murray is characterised by:

- its low and relatively flat gradient and slope;
- the extremes in wet and dry cycles across seasons and across years and its relatively low water flow volumes compared with other major rivers;
- the importance of both longitudinal and lateral connectivity via water flows for energy and nutrient transfer across the entire system;
- the meandering planform and associated wetlands, billabongs, anabranches, lakes and marshes; and
- the unique semi-arid environment through which most of the river flows.

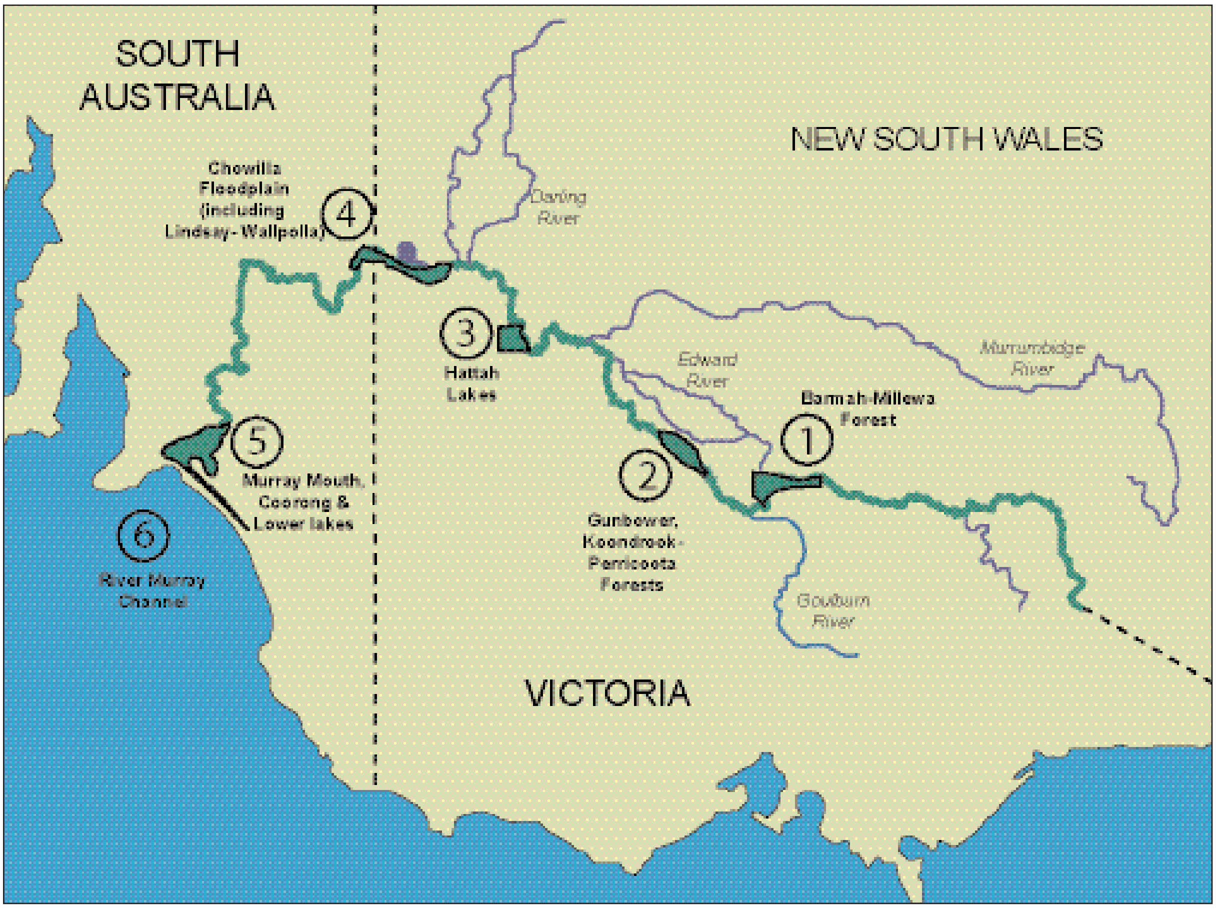
Significant Ecological Asset Sites

The broad overview of the hydrology of the River Murray presented above reveals wide variations across the different sections. Such variations are formally acknowledged through the work of the Murray-Darling Basin Commission in association with Victorian government agencies. Under the Commissions's *The Living Murray, First Steps* program, six unique and at risk significant ecological asset sites along the length of the River Murray have been identified. The sites are shown in Figure 4.5 and include:

- Barmah-Millewa Forest;
- Gunbower-Koondrook-Perricoota Forests;
- Chowilla Floodplain, Lindsay-Wallpolla;
- Lower Lakes, Murray Mouth and Coorong; and
- River Murray Channel.

Each of these sites has their own unique natural hydrology. Replication of these hydrological conditions to achieve environmental outcomes is the basis of their listing (see chapter 15 for discussion of environmental flows). All of these sites, except for the Lower Lakes, Murray Mouth and Coorong, are relevant to the River Red Gum Forests Investigation.

Figure 4.5 Location of significant ecological asset sites.



Source: MDBC (2005)

5 Biodiversity

Biodiversity is important for economic, social and spiritual well-being. This chapter describes the biodiversity of the study area and how we classify those assets across Victoria generally and within the study area specifically. It also describes the threats to biodiversity. The chapter addresses broad patterns of biodiversity, characteristic habitat and species, and the processes impacting on biodiversity.

Biodiversity means many things to different people but can be defined as "the natural variety of all life forms: the sum of all our native species of flora and fauna, plants, animals and micro-organisms, the genetic variation within them, their habitats, the genes they contain, and the ecosystems of which they are an integral part" (DNRE 1997c).

Maintaining, protecting and enhancing biodiversity have become important priorities for communities as well as local, state and Commonwealth governments. People value biodiversity for its own sake and appreciate the opportunity to experience it. Many believe that future generations should have the chance to see a Murray cod or a superb parrot, for instance (see Appendices 4 and 5 for the common and scientific names of species recorded in the study area). Some simply value the existence of biodiversity—taking comfort in the knowledge that it exists even if they cannot experience it themselves. Others believe that all life forms have an inherent right to exist. In addition to its own intrinsic value, biodiversity maintains the health of natural systems more broadly, such as healthy soil and waterways—the term "ecosystem services" has been coined to recognise this role.

BROAD PATTERNS OF BIODIVERSITY

The Murray-Darling Basin is the largest catchment in Australia (see chapter 4), and the river, along with the climate and geomorphology, are the most influential factors on biodiversity within the River Red Gum Forests study area. Important features are the wet–dry cycle and irregular natural flooding. Unlike other great river systems, such as the flooded forests of the Amazon, the timing, frequency, duration and extent of flooding in the Murray-Darling system is not predictable from year to year. Species in the area must adapt to survive for extended, unpredictable dry periods between flood events as rainfall is low and evaporation rates are high. This wet–dry cycle leads to a different suite of species than areas with permanent inundation. A recently filled wetland will initially attract filter-feeding birds but fish-eating birds will not arrive until later in the cycle when fish are more abundant.

The geographic extent of the study area explains the broad patterns of biodiversity. Arid-adapted species at the southern limit of their range are found in the north west. More cold-adapted, higher rainfall species such as mountain swamp gum are found in the upper reaches of the Kiewa and Ovens Rivers, in the foothills of the Alps. Grasslands extend from the Hay Plain, interrupted only by the River Murray and into Northern Victoria, to support a distinctive suite of species.

While the vegetation varies widely across the study area, it shares common features along the river's edge. The rivers are typically banded by open forest/woodland dominated by river red gum and various associated wetland plants. The understorey depends on the frequency, depth and duration of flooding (usually determined by the elevation above the river). For example, in frequently-flooded sites, summer-green grasses dominate the ground layer. In more elevated drier sites, the understorey includes woody shrubs and grasses adapted to drier conditions. In the semi-arid areas of the far north west of the study area, saltbush plains are extensive on the poorly drained, relict floodplain of the Murray River.

Even subtle changes in elevation change the vegetation. In Barmah forest, increases of only 10 to 20 cm in elevation see river red gums replaced by black box. In some higher areas, trapped floodwaters support vegetation similar to that found in lower lying areas, illustrating the complexities of the system.

Many changes have occurred to the vegetation, fauna and water regimes of the study area since European settlement. Some of these are discussed in this chapter.

Bioregional Context

Australia can be divided into broad geographic regions with similar biophysical characteristics (climate, soil and geomorphology) and consequently, similar vegetation. 'Bioregions' capture the ecological patterns of the landscape or seascape, providing a natural framework for recognising and responding to biodiversity values. Australian Bioregions are used to assess the status of native ecosystems, their protection in the national reserve system and to monitor and evaluate the Australian Government's current Natural Resource Management initiatives. Victorian Bioregions are the principal units for conservation planning and biodiversity management in the state (DNRE 1997c).

Australia is divided into 85 regions, and further into sub-regions, based on major geomorphic features (Environment Australia 2000). These are referred to as the IBRA Bioregions (Interim Biogeographical Regionalisation for Australia). The River Red Gum Forests study area is almost exclusively (97 percent) within the Riverina region, an ancient riverine plain that includes the Murray River and tributary floodplains.

In Victoria, the landscape is divided into 28 biogeographic regions called Bioregions, which correspond closely with the IBRA subregions. Four main Victorian Bioregions fall within the River Red Gum Forests study area: Victorian Riverina, Murray Fans, Murray Scroll Belt and Robinvale Plain along with a number of smaller sections of other bioregions (see Map B and Table 5.1).

The Victorian Riverina Bioregion is an ancient riverine floodplain of the Murray River and its tributaries (the Avoca, Loddon, Campaspe, Goulburn, Broken, Ovens, King and Kiewa Rivers), characterised by flat to gently undulating land. Some rivers, such as the Avoca, drain internally into a series of terminal lakes and wetlands. The Murray River itself intersects this bioregion only between the Ovens and Mitta Mitta Rivers, and for a few kilometres downstream of Echuca (Map B).

Table 5.1 Victorian bioregions intersecting the River Red Gum Forests study area.

Victorian Bioregion	Area falling within the study area (hectares)	Percent of Victorian extent of bioregion intersecting study area
Victorian Riverina	722,500	38
Murray Fans	289,385	66
Murray Scroll Belt	116,143	100
Robinvale Plain	64,185	100

Source: DSE (2006a).

Note: Because the study area boundary was not solely derived from Bioregional boundaries, small areas of other bioregions have also been included in the study area: Murray Mallee (16,541 ha within the study area), Northern Inland Slopes (2966 ha), Wimmera (1419 ha), Central Victorian Uplands (375 ha), Highlands Northern Fall (245 ha) and Goldfields (61 ha).

The majority of this bioregion is less than 160 m above sea level, especially within the study area.

The **Murray Fans Bioregion** (along the River Murray between the Ovens River and Boundary Bend—see Map B) contains alluvial fan-shaped deposits formed when hillside streams slow down and deposit a broadening fan of sediment on the plain (LCC 1989b). The resulting floodplain along the Murray River also includes terminal sections of the wide floodplains of the Avoca, Loddon, Campaspe and Goulburn Rivers. This bioregion is uniformly flat or gently undulating with elevation from 60 m to 120 m above sea level.

The 'core' floodplain landform of the Murray Fans Bioregion is typified on Gunbower Island and in Barmah Forest. This floodplain has numerous oxbows and meander scrolls, as well as many source-bordering dunes (typically supporting drier, highly-localised vegetation formations). Flanking the floodplain is a terrace of better-drained riverine plain, sometimes also including wind-blown dunes. Upstream of Echuca, the Kanyapella Basin forms a vast lake/lunette sequence, derived from wind-blown and alluvial sediments, and containing transient and permanent wetlands, fringed by wind-blown dunes (LCC 1983, 1987).

The Murray Fans Bioregion lies between the Murray River and the Victorian Riverina (to the east and south) and the mallee dunefields (the Murray Mallee and to a lesser extent the Lowan Mallee Bioregions to the west). The land systems and associated vegetation is similar to that of the adjoining Victorian Riverina Bioregion between Yarrawonga and Swan Hill. Consequently, the Murray Fans Bioregion shares important environmental issues with flanking bioregions, especially the Victorian Riverina. Salination of streams and wetlands is even more extreme in this bioregion because it is the end the state's major drainage systems.

Downstream of Swan Hill, where the Murray Mallee Bioregion abuts the Murray Fans, there is a greater contrast in geomorphology and vegetation. In this region, the floodplain and riverine plain components become more slender, being pressed between the Murray River and the mallee dunefield land systems of the Murray Mallee Bioregion.

The remaining two major Victorian Bioregions in the study area are created by floodplains intruding into the semi-arid Murray Mallee Bioregion. The **Robinvale Plains Bioregion** occupies a thin riverine floodplain along the Murray River from the Wakool River junction to a few kilometres upstream of the Murray and Darling River junction. The floodplain is generally less than 1–4 km from the river, except at Hattah-Kulkyne National Park where it extends up to 15 km inland, encompassing an extensive complex of wetlands. Robinvale Plains includes three different geomorphic components: low lying, periodically inundated floodplains of heavy grey clays (frequently overlain by shallow grey sandy surface soils); raised wind-blown dune hummocks with reddish-yellow sandy soils (most extensive in Hattah-Kulkyne National Park); and lunettes associated with the lakebeds and creek systems of Hattah-Kulkyne National Park.

Downstream of the Robinvale Plains, the **Murray Scroll Belt Bioregion** has a wider floodplain with meandering channels, billabongs, levees and low dunes, and larger overflow lakes and lunettes. This region continues downstream into South Australia. It is affected by summer floods and higher water salinity from the Darling River (NSW National Parks and Wildlife Service 2003). The Murray Scroll Belt Bioregion contains three primary geomorphic components: the riverine floodplain, (subject to periodic inundation and including oxbow lakes, ephemeral wetlands and active meander belts); broad, flat alluvial plains (rarely flooded); and alluvial rises (or elevated terraces of wind-blown material built up during more arid periods).

Ecosystems and Communities

An **ecosystem** is 'a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit' (Millennium

Ecosystem Assessment 2005). Species also interact with the non-living components of the environment including the soil, water and air. 'Ecosystem services' is a relatively new term used to describe the benefits, or 'services', we derive from these interactions, such as the production of goods, regeneration of services, stabilising services, life-fulfilling services (e.g. spiritual inspiration) or preservation of options (Lovett et al. 2004). For instance, nutrients, light and water are transformed by invertebrates, fungi and bacteria into fertile soils essential for agriculture.

There are many different types of ecosystem services (Ecosystems Services Project 2001), including:

- Pollination
- Insect pest control
- Regulation of climate
- Provision of shade and shelter
- Maintenance and regeneration of habitat
- Prevention of soil erosion
- Maintenance of soil fertility
- Maintenance of soil health
- Waste absorption and breakdown
- Maintenance and provision of genetic resources
- Fulfilment of people's cultural, spiritual and intellectual needs
- Water filtration
- Maintenance of healthy waterways
- Regulation of river flows and groundwater levels

Many more ecosystem services and their effects on humans, are described in the report of the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005). Ecosystem services underpin our social and economic health and threats to biodiversity also threaten associated ecosystem services and human well-being.

Ecological communities, or associations of plants and animals inhabiting, and interacting, within a common environment, are open and dynamic. Components of a community are interdependent. New species can enter the community, changing the pattern of occurrence and interaction within the community. Communities change naturally over time (for example, through ecological succession), however, communities may also be damaged when one or more of the component species declines or disappears, and/or when non-indigenous elements are added. Other species that may rely on the declining species may suffer a corresponding decline. Many communities are threatened and some are listed under the *Flora and Fauna Guarantee Act 1988* for protection. Table 5.2 lists the communities potentially in the study area that are listed under the *Flora and Fauna Guarantee Act 1988*.

Ecological Vegetation Classes (EVCs)

The diversity and complexity of vegetation communities requires a framework which can be used to simplify and identify common features. In Victoria, hierarchical Ecological Vegetation Classes (EVCs) have been developed over the past decade to classify vegetation into ecologically meaningful and useful units. EVCs are defined by a combination of floristics (major plant species), lifeform, position in the landscape, and an inferred fidelity to particular environments.

One hundred and sixty-nine EVCs have been identified in the River Red Gum Forests study area (Appendix 6), including many mosaics and complexes in which the primary EVCs are closely mixed. Many EVCs only occur in the study area on the periphery of much larger occurrences in adjoining bioregions, for example, various mallee EVCs. The vast majority of the natural vegetation in the study area can be defined within 34 EVCs (described in detail in Appendix 7), covering (1) the forests, woodlands and wetlands along the floodplains; (2) the grassy woodlands and grasslands on higher terraces (especially between the Avoca and Campaspe Rivers); and (3) saltbush plains (especially west of Mildura).

The distribution of vegetation types in the study area is shown in Map B. Because of the large number of EVCs, and the closely interwoven occurrence of EVCs in many areas (e.g. see the Barmah forest inset in Map B), it is not possible to discern individual EVCs over much of a map of this scale. Accordingly, EVCs of similar composition and environmental determinants have been grouped under the same colour in Map B.

Vegetation along the rivers has been extensively altered over 150 years of water regulation by levee banks, dams and weirs. Today, many flood-dependent EVCs such as Grassy Riverine Forest and Riverine Swampy Woodland are threatened by the lack of regular flooding and the consequent flushing of salt from the ground surface. As a result, grass species better adapted to drier conditions are now invading communities that once supported flood-dependent grasses. Some shrubs that are relatively tolerant of grazing and flooding are also invading previously regularly-flooded grassy woodlands and forests. Grazing has also had a major impact on the riverine vegetation, eliminating or reducing sensitive species, promoting weed invasion and altering the original vegetation.

Vegetation Condition

While EVC mapping describes the extent of vegetation, it does not provide information on the condition of the vegetation. Recently, the condition of extant native vegetation has been mapped at a broad scale across northern Victoria (ARIER et al. 2004). Vegetation condition was mapped in five classes from 'good' to 'poor' condition, incorporating factors such as vegetation type, geology, climate, tree density, fragmentation and land use based on Landsat satellite imagery. This mapping is useful for broad-scale conservation and management planning but not for small scale planning, such as individual properties.

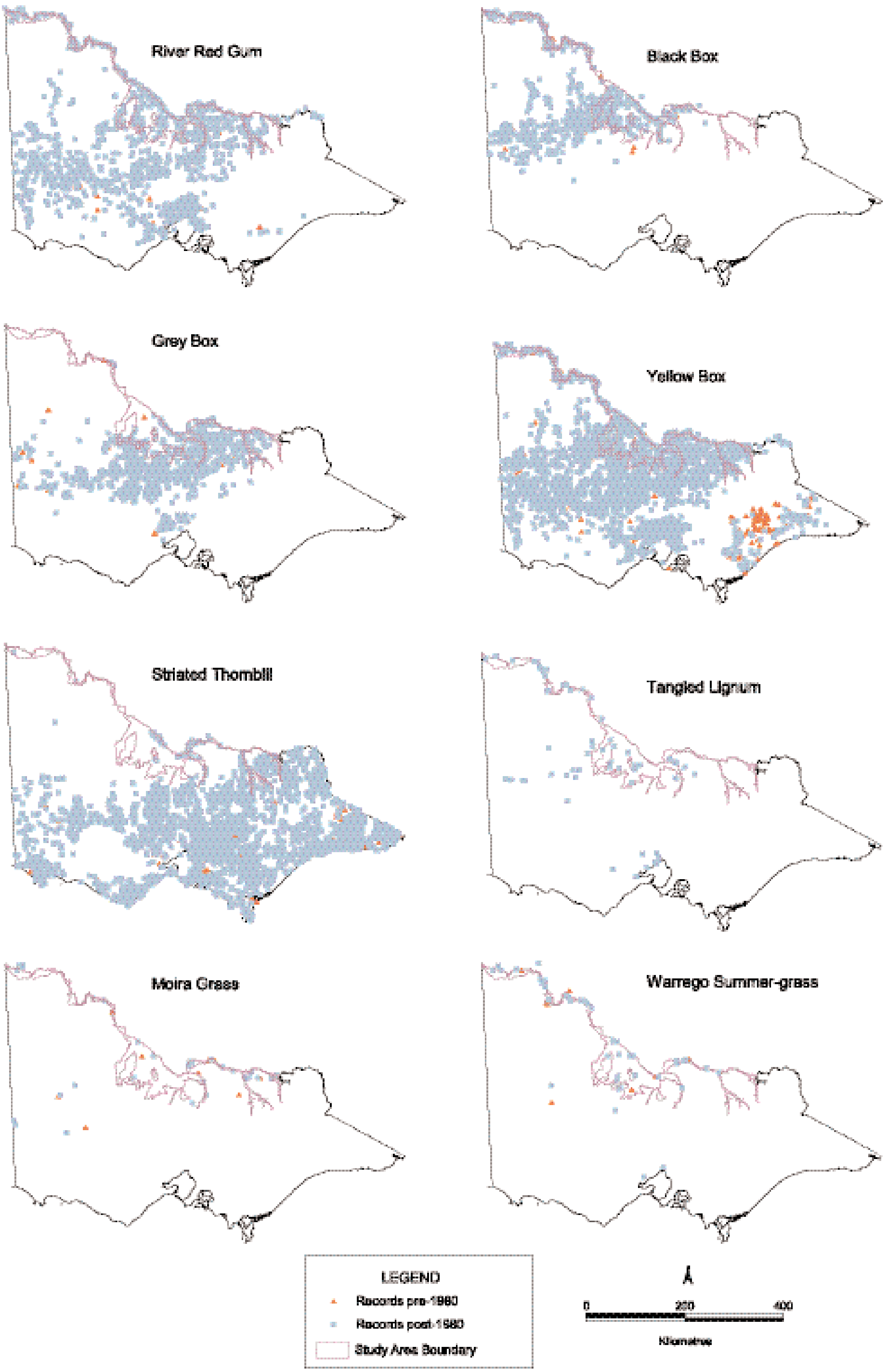
The results of this work for the study area (see Map 5.1) reveals that the vegetation is generally in best condition around Lindsay, Wallpolla and Mulcra Islands as well as Kings Billabong and Belsar Island. Native vegetation is generally in medium condition in Gunbower and Barmah forests, but mostly poor condition around the Kerang lakes and on floodplains upstream of Lake Mulwala.

Table 5.2 Communities in the River Red Gum Forests study area listed under the *Flora and Fauna Guarantee Act 1988.*

Community Name	Description
Victorian Temperate-woodland Bird Community	24 bird species (13 species individually listed) that are totally or largely restricted to temperate woodland habitat. Woodlands include box-ironbark, yellow box, cypress-pine and other woodlands. The fauna includes many species of nectar-feeders, ground-seed feeders, open-ground insect-eaters and hollow nesters.
Victorian Mallee Bird Community	20 bird species (8 species individually listed) that are characteristically and commonly found within mallee vegetation/habitats. Threatened by habitat loss, fragmentation and degradation. Also predation by foxes and cats. Large bushfires negatively impact some species.
Lowland Riverine Fish Community of the Southern Murray-Darling Basin	Occurs in the lowland reaches and associated floodplains of the Murray, Darling and Murrumbidgee rivers and their tributaries within Vic, NSW & SA. Includes 15 fin fish species, ten of which are individually listed.
Northern Plains Grassland Community	Distributed across the Northern Plain, primarily on alluvial sediments. Rainfall on average less than 430 mm. The community ranges from open to closed tussock grassland dominated by wallaby grasses, spear-grasses and spider grass, with some herblands or occasionally low chenopod shrubland.
Semi-arid Herbaceous Pine–Buloke Woodland Community	Entirely restricted to public land in northwestern Victoria, including Murray Sunset and Hattah-Kulkyne National Park. Slender callitris-pine in association with buloke. The ground layer is mostly herbaceous species with few shrubs. It is threatened by grazing, soil erosion and lack of regeneration.
Semi-arid Herbaceous Pine Woodland Community	Occurs in the Mallee region of northwestern Victoria. Overstorey dominated by slender callitris-pine and occasionally buloke. Shrubs are uncommon and the ground layer is dominated by herbaceous species. Threatened by clearing along roadsides and railways, fertiliser and weedicide drift, land clearance and overgrazing.
Semi-arid Northwest Plains Buloke Grassy Woodlands Community	Occurs at widespread sites across northwestern Victoria. Buloke as the dominant tree sometimes in association with black box and yellow gum. Gold-dust wattle is the dominant shrub and there are normally a number of grass species. Threatened by clearing along roadsides and railways, fertiliser and weedicide drift, land clearance and overgrazing.
*Semi-arid Shrubby Pine–Buloke Woodland Community**	Restricted to the Mallee region in northwestern Victoria where sites occur on public land of varying tenure. Slender cypress-pine usually with buloke. A distinctive shrub layer and herbaceous annuals. Primarily threatened by overgrazing (native and domestic).
*Grey Box–Buloke Grassy Woodland Community^*	The community was formerly distributed from Jilpanger southwest of Horsham to near Rutherglen. Shrub layer is generally lacking and the ground layer is dominated by grasses. Threatened by stock grazing, timber removal, mining and maintenance of firebreaks.

Notes: * may not be found within the study area
^ formerly found within the study area

Figure 5.1 The distribution of selected characteristic species in the River Red Gum Forests study area.



Source: Data from the Flora Information System and Atlas of Victorian Wildlife, curated by the Department of Sustainability and Environment

Figure 5.2 Hairy darling-pea on a ridge in river red gum/black box woodland on Mulcra Island, west of Mildura.

Species Diversity

This section summarises the flora and fauna species in the study area.

Plant species

Many plant species are found in the study area with records of over 88,000 2279 taxa (species, subspecies and variants – see Glossary), 167 of which are threatened or near-threatened (Appendix 4). Plant species on the floodplains of the study area are distributed according to the extent, duration and frequency of flooding. Other species, notably grassland species, have been highly depleted and now survive only in fragmented remnants.

The forests of the study area are dominated by the river red gum. Other common eucalypts include grey box, black box and yellow box (Figure 5.1 and below for detailed descriptions). Non-eucalypt trees include cypress-pines, sheoaks, wattles and the semi-parasitic ballarts. The main cypress-pine species are white cypress-pine in the east of the study area and slender cypress-pine in the west. Leafless ballart is found mostly downstream of Echuca, broom ballart is restricted in distribution and found near Hattah-Kulkyne and pale ballart is distributed along the length of the study area but is common in the Gunbower, Benwell and Guttrum forests.

Shrubs are not abundant on the floodplains of the study area, partially due to the long history of domestic stock grazing in these forests. However, they include many wattles (e.g. gold-dust and varnish wattles), over 30 salt bush species and a saltwort. Lignum, a tangled, almost leafless, green shrub (see below), is commonly found on the floodplains west of Tocumwal. There are also many species of herbs, grasses and sedges in the study area, including spear-, wallaby, and kangaroo grasses. The distribution of many grasses and sedges closely follow the watercourses, e.g. warrego summer-grass (Figure 5.1).

Introduced species, including weeds, are common and are discussed below under 'Processes Impacting on Biodiversity'.

Threatened Plants

As listed in column 'Vic' in Appendix 4, the River Red Gum Forests study area includes (or has included) populations of seven extinct plant taxa, 63 endangered plant taxa and 101 vulnerable plant taxa. A further 124 taxa are considered 'rare' and 81 are considered 'poorly known'. Sixty-three plant taxa in the study area are listed under the *Flora and Fauna Guarantee Act 1988*.

The threatened plants of the study area include:

- Trees, such as wilga, northern sandalwood, yarran wattle, weeping myall, swamp sheoak and buloke;
- Shrubs, such as emu-bushes (*Eremophila*), spurges (*Euphorbia*), salt paperbark and a variety of saltbushes (*Atriplex*, *Chenopodium*, *Maireana*);
- Herbs, such as darling-peas and Swainson-peas (*Swainsona*), scurf-peas (*Cullen*) and a wide variety of daisies (e.g. *Brachyscome, Leptorhynchos, Rhodanthe, Vittadinia*); and
- a variety of grasses belonging to the genera *Austrostipa*, *Aristida*, *Sporobolus*, *Eragrostis* and *Digitaria*, along with sedges of the genera *Cyperus* and *Eleocharis*.

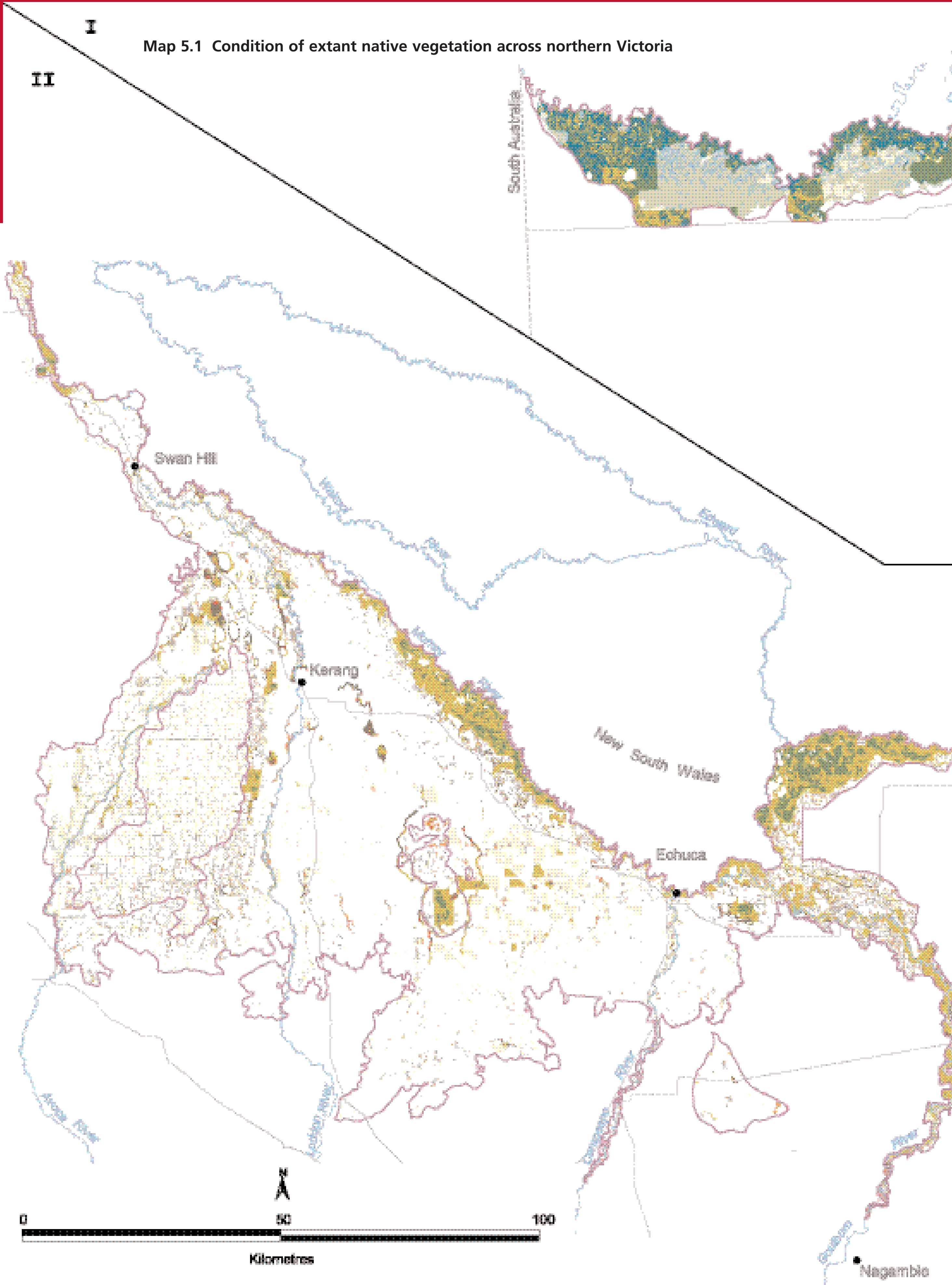
The biogeography of the study area is reflected in the relatively high representation of certain genera among the threatened plant taxa, such as *Swainsona* (see Figure 5.2), *Cullen*, *Sclerolaena* and *Ptilotus*, and in the relatively low representation of other groups, such as the orchids.

In habitat terms, many of the threatened plant taxa inhabit grasslands, grassy woodlands and wetlands rather than just river red gum forests. Figure 5.3 shows the very restricted distributions of some of these threatened species.

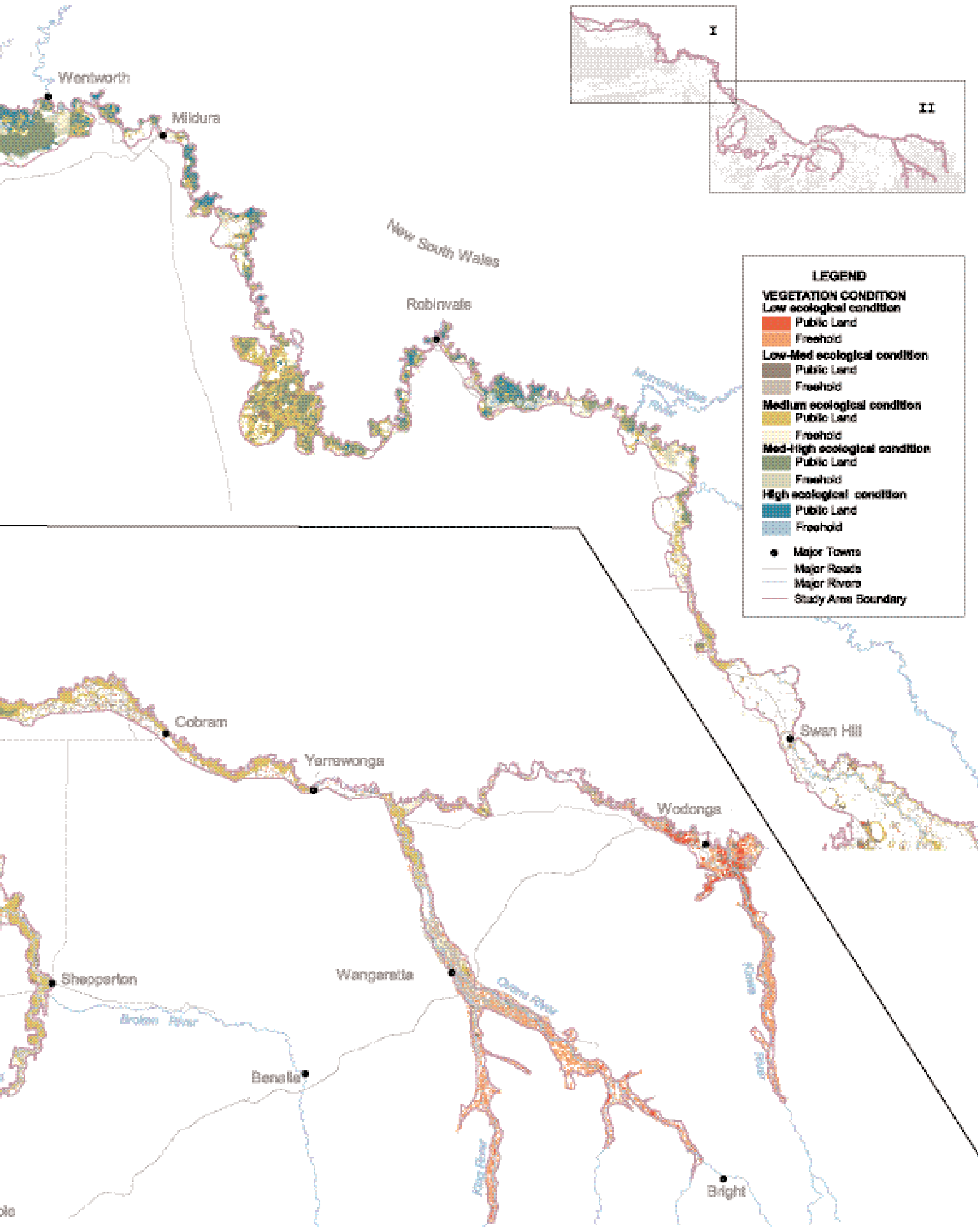
Figure 5.3 The distribution of selected threatened flora species in the River Red Gum Forests study area.

Source: Data from the Flora Information System, curated by the Department of Sustainability and Environment

Map 5.1 Condition of extant native vegetation across northern Victoria



Source: ARIER (2004)



I
II
LEGEND
VEGETATION CONDITION
Low ecological condition
Public Land
Freehold
Low-Med ecological condition
Public Land
Freehold
Medium ecological condition
Public Land
Freehold
Med-High ecological condition
Public Land
Freehold
High ecological condition
Public Land
Freehold
Major Towns
Major Roads
Major Rivers
Study Area Boundary
Wentworth
Mildura
New South Wales
Robinvale
Murrumbidgee River
Swan Hill
Cobram
Yarrawonga
Wodonga
Shepparton
Wangaratta
Ovens River
Broken River
Benalla
Kiewa River
King River
Bright

Table 5.3 The number of vertebrate animal species recorded in the River Red Gum Forests study area, by class.

Vertebrate group	Total no. of species	No. of introduced species
Mammals	62	13
Birds	326	11
Amphibians	21	0
Reptiles	76	0
Fish	33	8
Total	**518**	**32**

Source: DSE Atlas of Victorian Wildlife 2006

Fauna

There are over 150,000 records of 518 species of vertebrate fauna (Appendix 5 and Table 5.3), including 126 threatened taxa in the study area.

The 62 **mammal** species recorded in the study area range in size from the little forest bat (weighing less than 5 g) to the red kangaroo (with males weighing as much as 85 kg). The mammals inhabit a wide range of habitats but are mostly rarely seen, being either cryptic or most only active at night (e.g. possums, platypus and phascogales).

Bats are the largest group of native mammals in the study area, comprising nearly 40 percent of native mammal species—16 microbats and two species of megabats (or fruitbats, the grey-headed flying-fox and the little red flying-fox). Microbats use echolocation (emitting and receiving high-frequency sounds) to detect prey, predators and obstacles. The white-striped freetail bat emits these sounds within the range of human hearing and can often be heard by riverside campers.

The pig-footed bandicoot, eastern hare-wallaby, lesser stick-nest rat and an undescribed short-nosed bandicoot were once recorded in the study area but are now extinct. The eastern quoll, red-tailed phascogale, western barred bandicoot, brush-tailed bettong, rufous bettong and bridled nailtail wallaby were also recorded in the study area but are now extinct in Victoria. It is possible that the western quoll, kultarr, greater stick-nest rat, Bolam's mouse, desert mouse, and the now extinct white-footed rabbit-rat also occurred in the study area at the time of European settlement (Menkhorst 1995). A number of other threatened mammal species occur in the study area, including the squirrel glider (see Figure 5.4).

Birds are perhaps the most widely known of the vertebrate groups, probably because they are mostly active during the day, are relatively large-bodied and there are many species. Three hundred and twenty-six species of birds have been recorded in the study area, nearly twice the number of all other vertebrate species. The study area provides habitat for raptors, woodland birds, wading birds, migratory birds, colonially-breeding species and rare and threatened species. These include the nationally-threatened plains-wanderer (see Figure 5.4), Australian painted snipe, superb parrot and regent parrot. It also supports important Victorian populations of the red-chested button-quail, inland dotterel, intermediate egret, little bittern, freckled duck, ground cuckoo-shrike, and grey-crowned babbler.

Australia has bilateral agreements with Japan and China for the protection of migratory birds common to both countries (the JAMBA and CAMBA agreements). The study area includes 34 species listed in each or either of those agreements (Appendix 5). The agreements aim to protect migratory birds from take or trade, protect and conserve habitat, exchange information and build cooperative relationships between the countries and Australia.

Twenty-one species of **amphibians** have been recorded in the study area, including species with only a few records—Lesueur's frog, mallee spadefoot toad and giant bullfrog. Frog breeding is greatly influenced by water regimes. For many species the seasonality, frequency, duration and water temperature of flooding are important. In Barmah forest, the highest frog activity is not in the creek systems but in well-vegetated and actively flooding wetlands. Ponded wetlands without fresh flows show relatively little frog activity (Ward 2004). The importance of water regimes for frogs, in combination with a general decline in worldwide frog populations, makes frog species especially vulnerable within the study area. Some species previously recorded in the study area may no longer occur at those sites. For instance, the common spadefoot toad, Bibron's toadlet, and growling grass frog have not been recorded in Barmah forest for several years despite intensive survey efforts (Ward 2004), and the growling grass frog has also not been recorded in Gunbower forest for the last couple of years (Keith Ward pers. comm).

Seventy-six species of **reptiles** have been recorded in the study area. Although many (38 percent) of these have been recorded fewer than ten times, many common species may be under-reported, while there has been little survey effort for more cryptic species. For example, the common blue-tongued lizard (Figure 5.5) is probably common in the study area but has only been recorded 31 times. Over 80 percent of the Victorian records of five threatened reptiles are within the study area: curl snake, broad-shelled tortoise, eastern water skink, tessellated gecko and red-naped snake—illustrating the importance of the region for those species. Other threatened reptiles with populations in the study area include the hooded scaly-foot, Mueller's skink and carpet python (see Figure 5.4).

Figure 5.4 The distribution of selected threatened fauna species in the River Red Gum Forests study area.

Source: Data from the Atlas of Victorian Wildlife, curated by the Department of Sustainability and Environment

Figure 5.5 A common blue-tongued lizard in Myrtleford, Victoria.

Fish play a vital role in the ecology of rivers, streams, lakes and wetlands (Koehn 2002). They are present in each trophic level as detritivores, herbivores, omnivores and carnivores. Across their life cycles they provide food for many other species and contribute to water quality and nutrient cycling. Thirty-three species of fish have been recorded within the study area. Eight of these are introduced and, of the 21 native species, nine are threatened in Victoria (Appendix 5). Notable threatened fish include freshwater catfish, Murray hardyhead (see Figure 5.4), trout cod, Murray cod and silver perch.

Invertebrates are an important and diverse group, comprising more than 95 percent of the world's animal species. There are an estimated three and eleven million species of invertebrates worldwide. Invertebrates are involved in essential ecological functions such as pollination, herbivory, parasitism, predation, seed harvesting and dispersal, decomposition, scavenging, and soil turnover. All these functions contribute to a sustainable ecosystem.

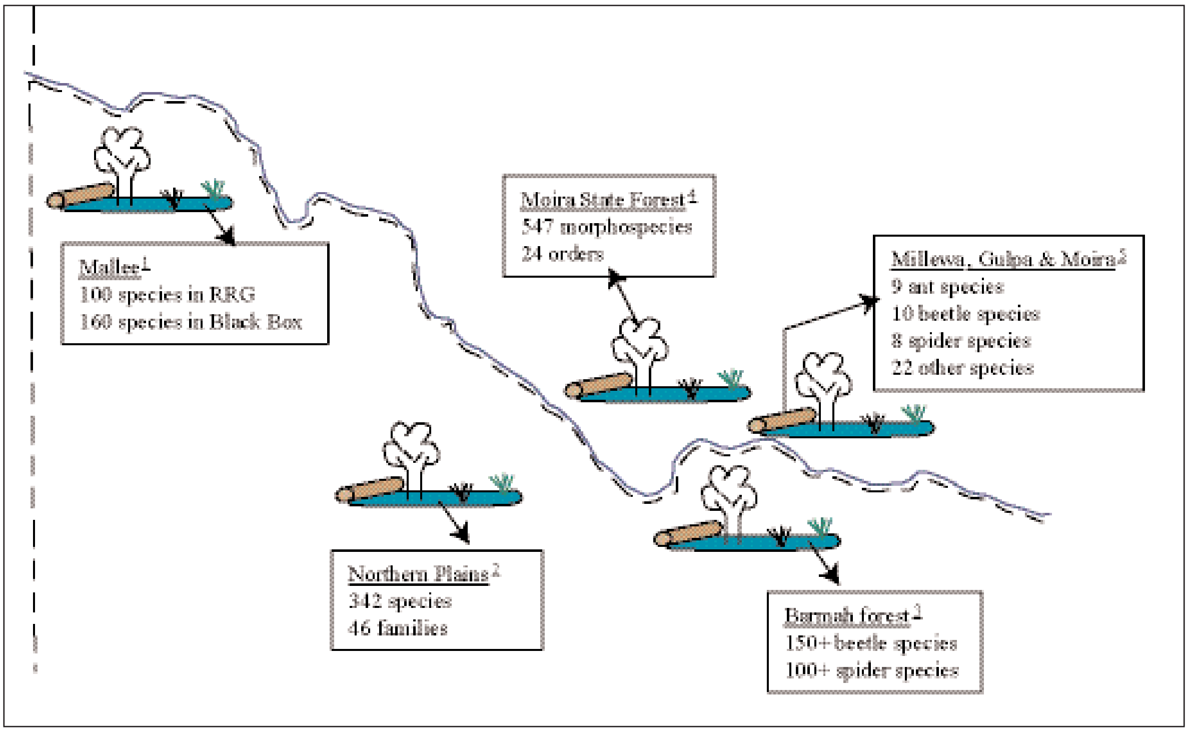
The invertebrate fauna of the study area varies with geography through the dry-sclerophyll forest, riparian zones, arid zones, as well as having a cosmopolitan element (Mac Nally et al. 2002a). Preliminary studies indicate that river red gums have a very rich invertebrate fauna that changes seasonally in composition and function (Yen et al. 2002). The few studies available on terrestrial invertebrates within river red gum ecosystems indicate that there is high invertebrate species richness at both individual tree and at ground-level, but the extent and variation across the study area is unknown. River red gum ecosystems in different locations may appear botanically similar, but differences in invertebrate fauna may be great.

Little is known about how invertebrate species interact with each other and with their environment, including within river red gum ecosystems. While there is a rich arboreal invertebrate fauna, especially herbivorous insects, with leaf damage and dieback being significant management issues (see below), there is limited information on the importance of river red gums as habitat for these arboreal invertebrate species.

Current information about arboreal, ground-dwelling and log-dwelling invertebrates is represented in Figure 5.6. Robertson et al (1989) collected a total of 100 species of ground dwelling invertebrates in river red gum forest sites and 160 species in black box forest with 52 of these species being found in both river red gum and black box forests (See [1], Figure 5.6). In a study of remnant river red gum and grey box forests on the northern plains near Echuca, a greater number of ground-dwelling invertebrate orders was found in river red gum compared with pasture (Yen et al. 1996) (See [2], Figure 5.6), however there were large seasonal differences in composition. In an examination of 4487 beetles from 342 species (representing 46 families) collected by Yen et al. (1996), Ward et al. (2002) found that summer sampling yielded most species, but winter yielded more specimens.

Flooding patterns also affect invertebrate abundance. Ballinger et al. (2005) examined ground-active terrestrial beetles and spiders before and after a managed flood in Barmah Forest (See [3], Figure 5.6).

Figure 5.6 Diagrammatic summary of the five studies of invertebrate diversity near the study area.



Source: Data from the Atlas of Victorian Wildlife, curated by the Department of Sustainability and Environment

[1]Robertson et al. (1989); [2]Yen et al. (1996); [3]Ward et al. (2002); [4]Ballinger et al. (2005); [5]Yen (2003)

Immediately following flooding, the abundance, species richness, and biomass of predatory carabid beetles (which like humid environments) was greatest at sites that had been flooded the longest (approximately 4 months). However another predator of aquatic invertebrates, the lycosid spiders were not affected by the duration of flooding. There was no difference in the number of beetles before flooding, but the differences observed after flooding remained for over two years. Increases in the abundance of large beetles, like these are likely to affect insectivorous vertebrates such as the yellow-footed antechinus.

To collect arboreal invertebrates, Yen et al. (2002) sprayed the canopy of two individual River Red Gum trees in the Moira State Forest (NSW) with insecticide, one in February and one in October (See [4], Figure 5.6). A total of 458 invertebrate species was collected from the canopy with only 90 species collected in both February and October. The canopy was dominated by Hemiptera (bugs), Diptera (flies), Hymenoptera (ants and wasps) and Araneae (spiders). A further 69 invertebrate species (mainly spiders) were collected by hand from beneath the bark of the two trees (9 in February and 52 in October 1999, with 8 species found in both months). The large number and diversity of invertebrate species on two individual trees suggests that the total number of invertebrate species in river red gum forests is large, particularly taking into account variation due to season, tree age and condition and local variation. Internal invertebrate species that feed within the leaf or stem such as leaf miners and gall formers, wood feeders, and associated parasitoids, were not collected in this study, but would further add to the total species tally.

A brief survey of 31 large river red gum logs (greater than 60 cm diameter) in the Millewa, Gulpa Island and Moira State Forests in NSW (Yen 2003) (See [5], Figure 5.6), found mainly timber feeders, Bostrichidae and Cerambycidae beetles and the termite *Coptotermes acinaciformis*. The few invertebrate species found may have been due to the nature of the timber and/or flooding regimes. River red gums decompose slowly on the ground and may take 175 years (Mackensen et al. 2003). The saproxylic (wood-feeding) fauna of river red gums seems to be poor compared with other forest types (Ballinger & Yen 2002; Yen 2003).

It is worth considering current and potential threats to the diverse river red gum invertebrate fauna despite the overall lack of detailed background. While some threats are obvious, such as clearing river red gum forests for pasture, horticulture or agriculture, many other threats may be more subtle. Threats that can be managed at the local level include fragmentation, habitat simplification (such as loss of coarse woody debris and plant litter by grazing, firewood collecting, trampling and vehicular access for recreation and inappropriate fire), and inappropriate use of chemicals and their effects on non-target groups. Information is required on the effects of these threatening processes on invertebrates filling different ecological roles, in different age structured forests in different areas under varying management regimes. Grazing is a major use in some of these forests, and its effects on the structure and functioning of the ground layer and its associated invertebrate fauna need to be documented. Habitat simplification through loss of coarse woody debris is also a matter of concern for terrestrial invertebrates.

Threatened Vertebrates

Based on conservation status information from the DSE Advisory List of Threatened Vertebrate Fauna in Victoria (2003a), the study area includes (or has included) populations of four 'extinct' vertebrate taxa, three 'regionally extinct' vertebrate taxa, 12 'critically endangered' vertebrate taxa, 28 'endangered' vertebrate taxa and 38 'vulnerable' vertebrate taxa. A taxon is considered 'regionally extinct' if it no longer occurs in Victoria, but remains extant in the wild in other parts of its former range. Eighty-two vertebrate taxa occurring in the River Red Gum study area are listed as threatened under the *Flora and Fauna Guarantee Act 1988*.

Nationally threatened species such as the critically endangered spiny rice-flower and endangered trout cod do not occur anywhere else in the world. Their native environments are highly modified and they face high levels of threats. Further research into these species is being undertaken to increase their numbers and reduce the threats to their survival (Figure 5.7).

Figure 5.7 Measures implemented to protect the nationally endangered trout cod in the Yarrawonga Regional Park.

CHARACTERISTIC HABITATS AND SPECIES

The geology (chapter 2), geomorphology and land systems (chapter 3), climate and hydrological systems (chapter 4) combine to provide the setting for the vegetation communities, resulting in different patterns of faunal and flora assemblages. This section describes those patterns within the study area.

The principal habitats within the study area are:

- floodplains and other wetlands (fresh and saline, ephemeral and 'permanent') including river red gum forests,
- rivers and streams,
- eucalypt woodlands on higher ground, dominated by grey box or yellow box,
- tussock grasslands,
- saltbush plains in the Murray Scroll Belt, and
- mallee, west of Mildura.

Floodplains and Other Wetlands

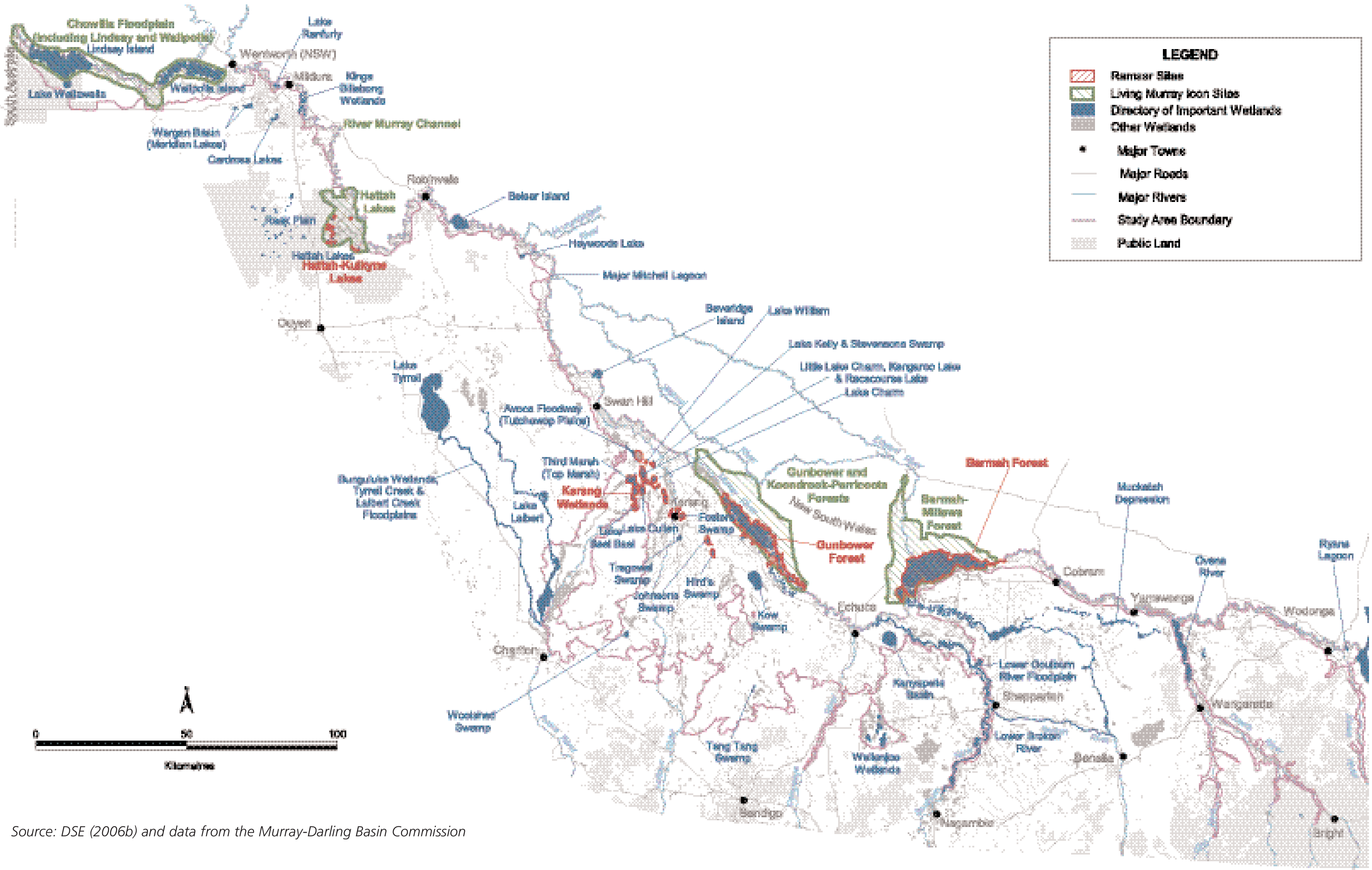
The floodplains of the study area are formed in part by the very low gradient of the Murray River between Lake Hume and the South Australian border. In these areas, natural flooding (described in detail in chapter 4) has played a major role in shaping the local flora and fauna.

Wetlands are an important feature of river red gum floodplains. They are formally defined as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres' (Ramsar Convention undated). In Victoria, there are approximately 16,700 non-flowing wetlands covering 538,943 hectares (DSE 2006b). The Directory of Important Wetlands in Australia (Environment Australia 2001) lists 159 Victorian wetland systems which are recognised as nationally important. Of these 42 are on public land in the study area (Map 5.2).

Box 5.1 Ramsar sites

Victoria is committed to the aims of the Ramsar Convention, namely the conservation and wise use of wetlands and the maintenance of the ecological character of those wetlands listed as of international importance under the Convention (Ramsar sites) (DNRE 1997c). Four of Victoria's 11 Ramsar sites are on public land in the study area: Gunbower Forest, Barmah Forest, Kerang Wetlands and Hattah-Kulkyne Lakes (see Map 5.2). These Ramsar sites are recognised for their high waterbird diversity and numbers, their representative ecosystems, their importance in maintaining regional biodiversity and for supporting threatened species. They also have many additional values, outlined in strategic management plans (DSE 2003b, b, d, 2004h).

Map 5.2 Wetlands in the River Red Gum Forests study area listed on the Directory of Important Wetlands, Ramsar sites and Living Murray Significant Ecological Assets.

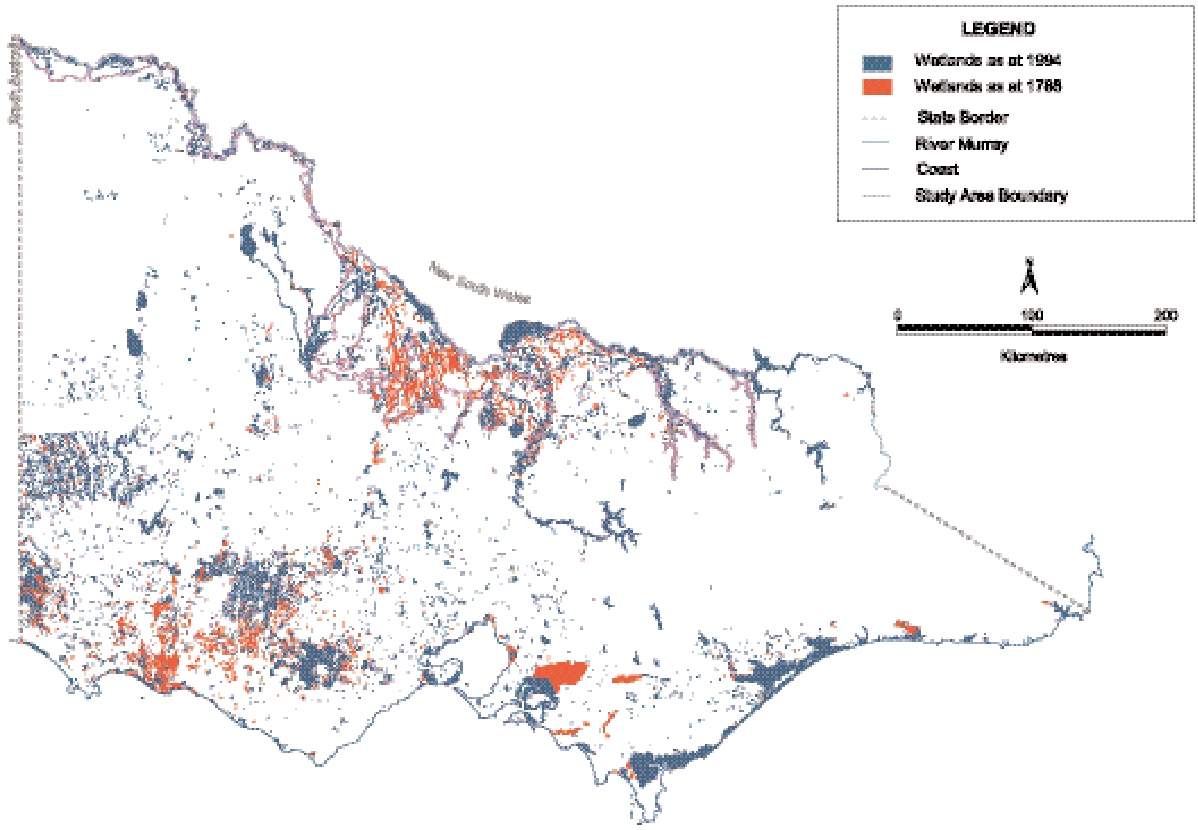


Source: DSE (2006b) and data from the Murray-Darling Basin Commission

Better-known wetlands in the study area include Barmah and Gunbower forests (and neighbouring NSW forests: Millewa and Koondrook-Perricoota), the Hattah-Kulkyne Lakes floodplain and Lindsay-Wallpolla Islands (and neighbouring Chowilla floodplain in NSW and SA). These are the largest near-natural areas of floodplain forest on the Murray River, and are recognised as significant ecological assets under The Living Murray program (see chapter 15). Wetlands inthe study area provide a range of significant ecosystem services including maintaining biodiversity, maintaining hydrological stability, retaining sediments, cycling of carbon and nutrients, regulating the local climate and purifying water. They generate economic products, such as timber and honey, as well as being important in the supply and regulation of water for human consumption and irrigated agriculture. Some are also used for livestock grazing.

The study area is one of the most significant regions for non-permanent freshwater wetlands in Victoria (Map 5.3)—public land in the study area supports almost half of the State's freshwater meadows, almost 30 percent of its shallow freshwater marshes and approximately 20 percent of its deep freshwater marshes and permanent open freshwater wetlands (Table 5.4). For these wetland types, between 23 percent and 35 percent of the area of wetlands lies on public land outside wetlands of international and national importance (Table 5.4).

Map 5.3 The depletion of Victorian wetlands between 1788 and 1994.

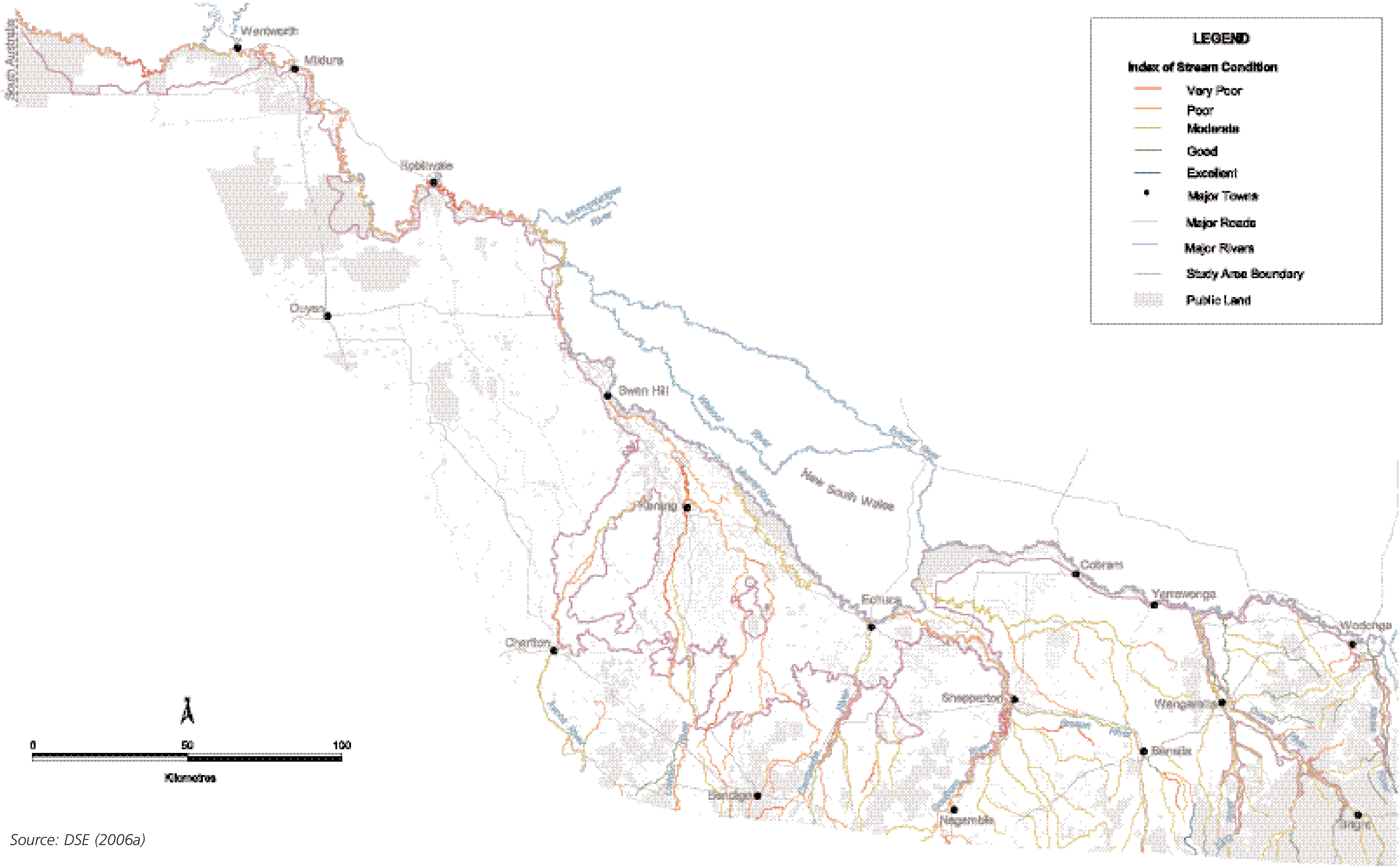


Source: DSE (2006b)

Since European settlement, freshwater meadows have been depleted in Victoria by a third, shallow freshwater marshes by almost 60 percent and deep freshwater marshes by almost 70 percent. In the River Red Gum Forests study area (on public and private land) depletion of these wetland categories has been 60 percent, 61 percent and 55 percent, respectively (Robertson & Fitzsimons 2005g) (Map 5.3). While these three categories have been depleted across the state, the area of permanent open freshwater wetlands has increased by 34 percent in the study area (Robertson & Fitzsimons 2005g) and 55 percent in Victoria, reflecting the building of, or conversion of other wetland types to permanent water storages.

Rivers and streams are one of the defining underlying elements of river red gum biodiversity. The condition of waterways is measured by the Index of Stream Condition (ISC) (see Map 5.4). The index measures the change from natural conditions and indicates the waterways' capacity to support a diverse biological community. The study area has 187 km of streams in 'good' ecological health (Table 5.5).

Map 5.4 The condition of waterways in the River Red Gum Forests study area, measured using the Index of Stream Condition.



Source: DSE (2006a)

Table 5.4 Extent of wetlands statewide and in the River Red Gum Forests study area, by wetland type.

Wetland category	Area in Victoria (ha)	Wetlands on public land in study area		Percent of area on public land in the study area outside Ramsar Sites and Nationally Important Wetlands
		Area (ha)	As a percent of area in Victoria	
Freshwater meadow	118,174	54,918	46	27
Shallow freshwater marsh	54,496	15,260	28	23
Deep freshwater marsh	54,664	9780	18	35
Permanent open freshwater	180,396	41,626	23	26
Semi-permanent saline	64,264	3312	5	64
Permanent saline	61,327	2222	4	20
Sewage pond	3793	171	5	96
Salt works	1829	not present	—	—
Total	**538,943**			

Source: DSE (2006b)

Significant plant species of the floodplains

Tree species diversity is low in riparian and floodplain forests compared with most forest types (Roberts & Marston 2000). Although there are more than 500 eucalypt species in Australia, only four occur widely in the study area: river red gum, black box, grey box and yellow box (Figure 5.1). **River red gums** (Figure 5.8) are the most widespread eucalypt in Australia (but do not occur naturally in Tasmania). They can grow to approximately 45 m, with height generally increasing as flood frequency and duration increases (Roberts & Marston 2000).

River red gums have a typically spreading form—subject to competition for light, water and nutrients. Large areas of river red gums on the fertile soils of the floodplains have been cleared for agriculture and the largest remaining river red gum forests are the Barmah-Millewa and Gunbower-Perricoota forests. The remaining river red gum forests and river red gum dominated EVCs cover approximately 130,900 ha (Appendix 6).

River red gum wood is hard and resistant to decay and termites, making it popular for uses, such as canoes, boomerangs, shields, waddies, sleepers, fencing timbers, house stumps, and wharf and bridge timbers (see chapters 6 and 14). River red gums are also good nectar producers and are important for the bee-keeping industry (see chapter 13).

Table 5.5 Summary of stream condition in the River Red Gum Forests study area.

Condition	Count	Length (km)
Excellent	0	0
Good	13	187
Moderate	71	1,339
Poor	83	1,709
Very poor	27	569
Unknown	8	36
Lakes	9	48

Source: DSE (2006b).

Note: Apart from the stretch between Piangil and the South Australian border, the Murray River is generally excluded from this table, being New South Wales waters.

Figure 5.8 Mature river red gum on Mulcra Island.

Seedling River Red Gums are vulnerable to both heat stress and immersion (either total immersion or water logging of the roots). Successful regeneration of river red gums thus relies on a complex interaction of a range of critical factors (Jacobs 1955; Dexter 1978), including:

- availability of an adequate seed supply;
- a suitable seed bed;
- an appropriate water regime, which includes:
  - > a flood event;
  - > an appropriate period and timing of flood recession (which depends partly evaporation, drainage and elevation);
  - > duration and depth of flooding in the season following germination;
  - > availability of moisture in the sub-soil;
  - > adequate summer rainfall;
- minimal grazing pressure (by native, domestic and feral vertebrates and invertebrates);
- low competition from overstorey trees and other vegetation; and
- establishment of the root system to access reliable groundwater supplies (after about two years).

A distinction needs to be drawn between germination of red gum seed and successful regeneration. With good seed crops, favourable weather and microenvironmental conditions, widespread germination of red gum seeds usually occurs. However, successful establishment of the seedlings requires coincidence of the factors set out above. In particular, spring floods with recession in early summer results in abundant germination but low soil moisture over summer may kill many of the seedlings.

Successful natural regeneration is therefore episodic and unpredictable, and the periods between regeneration events may be lengthy — up to 15 years or more — resulting in a series of even-aged stands. The decade 1870–80 brought a group of good flood years but surveys in Barmah forest indicate that, between 1880 and 1965, there were only six periods when flooding was suitable for extensive natural regeneration events: 1903–04; 1917–18; 1935–36; 1937–38; 1957–58 and 1961–63 (Dexter & Poynter 2005).

Altered water regimes are changing the patterns of regeneration. Summer flooding provides moisture for seedlings resulting in reduced mortality and stands of thick regrowth (Figure 5.9). River red gum regeneration at Barmah is such that it is displacing other vegetation (see Moira Grass, below), and at Kingston-on-Murray in South Australia it appears to be sufficient to replace old trees dying naturally (George et al. 2005) provided saplings survive into adulthood.

In nature, then, the structure of river red gum forests is largely determined by regeneration events but the presence of large old trees also has an impact. Over time, larger trees develop a 'zone of influence' within which they suppress and ultimately exclude smaller trees competing for water and nutrients in the soil (Opie 1969). Jacobs (1955) hypothesised that the central Murray river red gum forests prior to 1870–1880 were far more open than in the 1950s and comprised comparatively low numbers of large trees that had lived for 500 to 1000 years or more. Other observers, however, described areas of densely wooded forest. These diverse observations probably reflect the variability of the forests, including a range of ages (regrowth to old-growth), differing stand structure depending on distance from water and where the observer was located.

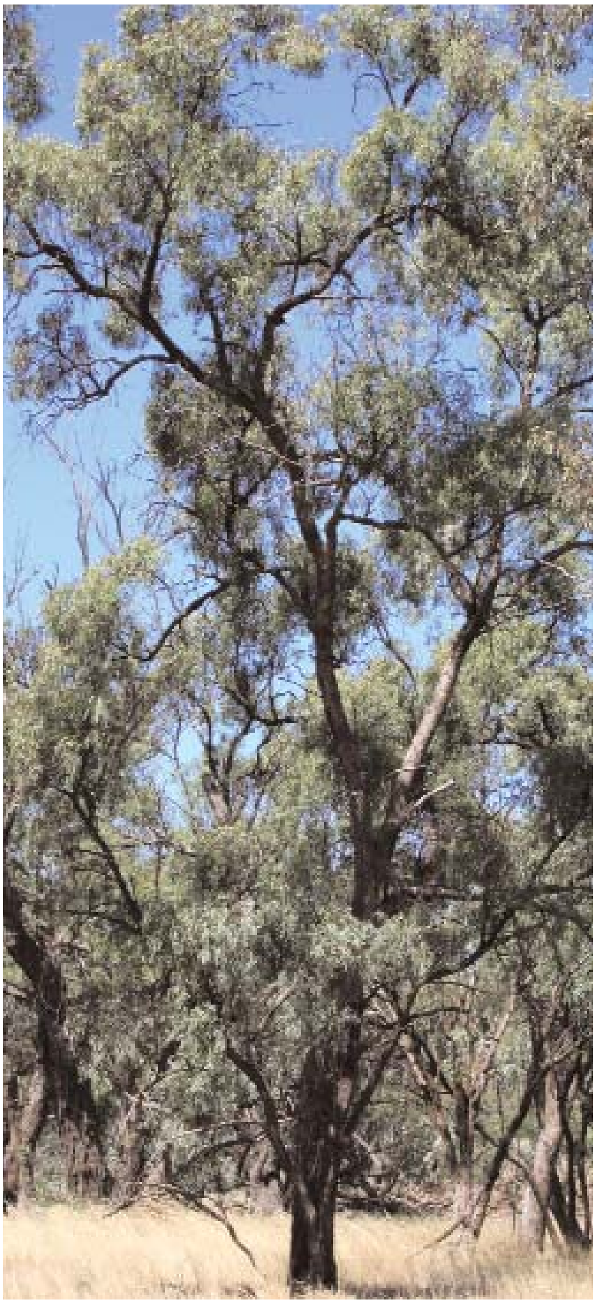
The ecology of adult river red gums, like that of seedlings, is very closely linked to water. Adult trees

Figure 5.9 Dense regrowth of river red gums on a dry lake bed in Hattah-Kulkyne National Park.

obtain water from groundwater, rain and flooding. The lowland floodplains have low rainfall and high evaporation, and growing conditions alternate between very dry and flooded (Roberts & Marston 2000). In extended dry conditions, some trees rely on ground water. The roots of river red gums at Barmah forest extend 10 m into the sub-soil to extract water in the sandy aquifers (Bacon et al. 1993b). They can also reduce water use by shedding leaves.

Nonetheless, particularly in more arid regions, most river red gums require periodic flooding and both the frequency and duration of flooding are important determinants of growth and condition (see Table 5.6). For example, Bacon et al. (1993a) found that short-term flooding of channels that occupied 15-20 percent of the forest floor temporarily improved tree moisture status and this increased tree growth rate in up to 70 percent of the forest. However, short duration floods may only result in short-term benefits. Soil water storage returned to pre-flood levels within 40 days of flood recession in Barmah forest (Bacon et al. 1993b).

Figure 5.11 Black box at Leaghur State Park.



Although river red gums require periodic flooding, they cannot survive permanent inundation. Roots require oxygen and become increasingly anoxic as the oxygen is depleted leading to stress in the tree. Prolonged inundation reduces growth and can kill trees (Jacobs 1955). How long it takes to stress trees depends partially on the soil, the tree species and growth stage and the flooding regime, but may be several years or more. In Barmah forest, river red gums have survived permanent flooding for two years (Bren 1987) but others died after four years (Chesterfield 1986).

Some river red gum forests are in poor condition due to either insufficient flooding, or near-permanent flooding (Figure 5.10). They are in especially poor condition downstream of Swan Hill where there has been no natural flooding for ten years and the climate is arid (Brett Lane & Associates Pty Ltd 2005). These forests have been given emergency watering (see chapter 15) to help them recovery. Earlier studies on river red gum condition also found that over 30 percent of river red gums and 35 percent of black box trees at sites downstream of Echuca and into South Australia were unhealthy (>40 percent of crown dead) or dead (Margules & Partners Pty Ltd et al. 1990). These measures of condition broadly correlate with the vegetation condition measures discussed earlier this chapter (Map 5.1). It should be noted that factors other than the water regimes, for example insect attack, disease and salinity, also affect the condition of the river red gums (see below).

Black box (Figure 5.11) is an inland species distributed in Victoria from Strathmerton in the east, along the Murray River to the South Australian border and south to around Horsham (Figure 5.1). Black box grows to approximately 20 m depending on flood frequency (Roberts & Marston 2000). In open habitat it has a short trunk and drooping form with some lower branches touching the ground. The leaves are narrow and a dull green colour and the bark is dark, rough and persistent to the small branches.

Black box trees were widely cleared for agriculture and their heavy, durable timber harvested for fencing and firewood. The largest remaining black box forests in Victoria are within the western part of the study area, e.g. Leaghur State Park and Hattah-Kulkyne National Park.

Black box trees are less tolerant of flooding but more tolerant of prolonged dry periods than river red gums and thus tend to occur higher on the floodplain than river red gum (Roberts & Marston 2000). This is evident in Barmah forest where increases of only 10–20 cm in elevation cause changes in eucalypt species. Black box are adapted to dry conditions through very low transpiration rates, small canopy leaf area and leaves hanging vertically to reduce water loss (Roberts & Marston 2000). Mature black box die after inundation for approximately 18 months (Roberts & Marston 2000). Black box often regenerate after flooding but seedlings grow slower if they are flooded for longer than a month.

Figure 5.12 Tangled lignum at Mulcra Island and close-up of flowers.

Figure 5.10 River red gum trees dying and in poor condition on Lindsay Island due to lack of water.

Table 5.6 The influence of flood regimes on rushlands, moira grass plains, river red gum forests and box forests and woodlands in Barmah-Millewa Forest.

Flood Regime[1]	Main Vegetation Type					
	Rushlands	Moira grass plains	River red gum forest			Black box forest[2]
			> 30m	21-30m	< 21m	
Ideal time	July–January	September–January	August–December			occasional short flood
Frequency						
natural average	every year	every year	9 years out of 10	7 years out of 10	4.5 years out of 10	1 year out of 10
minimum required	7.5 years out of 10	every year	7 years out of 10	5 years out of 10	3 years out of 10	none required
current	8 years out of 10	7 years out of 10	6 years out of 10	4.5 years out of 10	2.5 years out of 10	1 year out of 10
Duration						
natural average	10 months	8 months	5 months	3 months	1.2 months	1 month
minimum required	2 months	5 months	1 month	1 month	0.5 month	none required
current average	5 months	3 months	2 months	1.5 months	0.7 month	0.5 month

Sources: MDBC (1992; 2000), Ward (1991).

Notes:
1. The base parameter is that 80 percent of the forest is flooded for at least one month.
2. Includes Black Box Woodland and Open Woodland, which is usually briefly inundated in less than 30 percent of years. Yellow Box, Grey Box, Murray Cypress Pine Woodland and Open Woodland are seldom, if ever, flooded.

Many other species of the floodplains are specially adapted to the ecological conditions and water regimes. Two well-known floodplain plants are lignum and moira grass. Three species of lignum occur in the study area—tangled (see figure 5.1 and Figure 5.12), spiny and twiggy, although spiny lignum is rare in Victoria. They are typically green shrubs up to 12 m tall with entangled branches, but their form is highly dependent on flooding regimes. They mostly occur along rivers, streams and floodplains, often in association with black box. When flooded, lignum provides important nesting habitat for water birds. It is salt and drought-tolerant but will not survive permanent flooding (Roberts & Marston 2000).

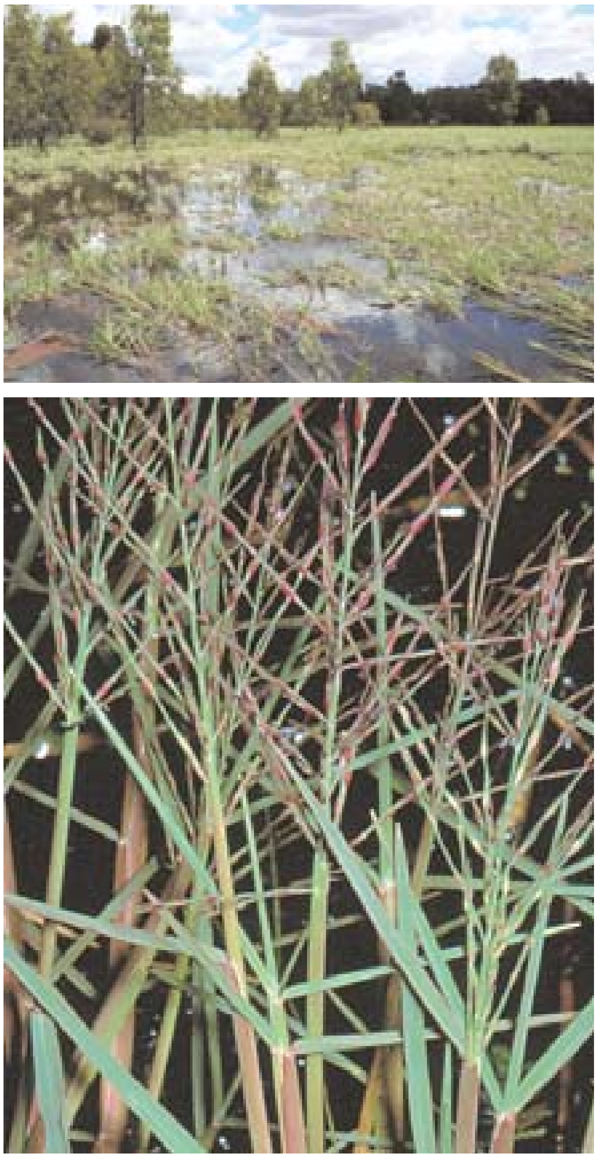
Moira grass (sometimes called spiny mud-grass, see Figure 5.1 and Figure 5.13) is an aquatic to semi-aquatic grass with pyramid-shaped flower heads up to 15 cm long. It forms a turf in dry conditions but can grow up to 1.5 m and form floating mats on open water during flooding (see Table 5.6 for flooding frequency and duration). Moira grass only grows after flooding. Growth rates of 10 mm per day in winter and 20 mm per day in late spring have been documented in Barmah forest (Ward 1991).

Changed water regimes are changing the distribution of Moira grass. In the past, the extended floods killed red gum seedlings but the absence of extended and frequent floods is now causing Moira grass plains to be invaded by river red gum thickets (Bren 2005). Unseasonal summer flooding increases the survival rates of seedlings, which would otherwise die from summer droughts. Reduced spring flooding means seedlings are not inundated for as long or as deep as previously (Bren 2005). Giant rush is also encroaching onto Moira grass areas. Moira grass plains have been reduced from about 4050 ha (13.5 percent) of Barmah Forest in 1930 to about 1650 ha (5.5 percent) in 1980 (Chesterfield 1986). In Barmah forest, a minimum flood duration of 5 months, receding before summer, is required for Moira grass to out-compete river red gum seedlings and milfoil (Ward 1991). Floods need to be approximately 0.5 m to completely submerge river red gum seedlings and prevent premature nodal rooting of Moira grass into the soil. This equates to a flow of approximately 1500 ML per day in the Gulf Creek (Ward 1991). Moira grass is a preferred species for cattle grazing and Roberts and Marston (2000) suggest that the distribution of Moira grass on the floodplain may be explained in part by past cattle stocking rates and practices.

Significant animal species of the floodplains

At a statewide level, riverine forests provide habitat for a wide diversity of vertebrate animals. The forests are important for the conservation of woodland birds, including many of those in the Woodland Bird Community listed as threatened under the *Flora and Fauna Guarantee Act 1988* (see Table 5.2). The mature riverine trees contain hollows which many mammals and birds need for shelter or breeding, including the threatened squirrel glider, superb parrot and regent parrot. These parrots, in particular, are unlikely to survive in Victoria without riverine forests. Fallen woody debris provides shelter for small mammals, ground foraging birds and many reptiles. During winter, many birds, such as the flame robin and pied currawong, migrate from the mountain forests to find food in the river red gum forests.

Figure 5.13 Moira grass in Barmah forest while flooded and close-up view.



Species usually found in higher rainfall areas such as the feathertail glider, sugar glider, koala and striated thornbill (see Figure 5.1) extend their distribution north-west along the mesic corridor provided by the river red gum forests of the Murray River floodplain. De Vis' banded snake, yellow rosella and barking marsh frog are entirely dependent on river red gum forest habitat in Victoria and the ecosystem provides a stronghold for many other species.

Numerous swamps and lakes in the Kerang and Swan Hill districts provide breeding, feeding and drought refuges for some 60 species of waterbird, including 15 waterfowl and 23 species of migratory shorebird. Flooding regimes are particularly important for the survival of egrets. Egrets generally breed in flooded forests but feed away from the nesting sites in more open wetlands. Egrets take longer than other water birds to commence breeding after flooding, and do not breed successfully unless their nesting sites are flooded for three to five months. This is thought to prevent terrestrial predators from accessing the nests.

Egrets generally only breed in living trees with at least half a metre of water beneath them. If the water recedes, the egrets will abandon the nest, even if the young are close to fledging. Following spring floods, the extensive river red gum forests of the Barmah and Gunbower areas provide the only Victorian breeding sites for colonies of great and intermediate egrets, and major breeding colonies of other herons, cormorants, ibis and darter.

The lack of adequate spring floods in recent decades has resulted in an almost complete lack of breeding by many colonial waterbirds, particularly intermediate and little egrets, which are classified as critically endangered in Victoria, and also the great egret, which is endangered. Little egrets bred in Gippsland in 1993, near Geelong in 1998-2004 and in Gunbower Forest in the early 1970s. Intermediate egrets are known to have bred at only two sites in Victoria: Ryans Lagoon (near Wodonga) in 1981 and Gunbower Forest in the early 1970s and one nest in 1993. Great egrets bred at many sites in the 1970s and 1980s but had not been recorded breeding in Victoria since 1993. There are probably fewer than 200 breeding pairs remaining. Increased environmental flows in 2005 under the Living Murray initiative (see chapter 15) resulted in great egrets breeding in Gunbower Forest and both great and intermediate egrets breeding in Barmah Forest.

The carpet python is another threatened species found within riverine forests. This species inhabits two distinct habitat types within Victoria: river red gum forests and associated black box woodlands along rivers and streams, and also rocky hills with Blakely's red gum. Increased predation and habitat clearing as well as decreased prey availability are thought to reduce carpet python populations (Allen et al. 2003). Carpet pythons are ambush predators which use fallen timber, ground cover and rocks to hide from potential prey and to shelter from predators. Removing this cover for firewood and landscaping, threatens the survival of carpet pythons. Carpet pythons are also sometimes killed by humans.

River red gums are a keystone eucalypt tree species for terrestrial invertebrates because of they provide both food and shelter, as well as leaf litter and coarse woody debris on the forest floor. Recent research indicates that flooding has significant food-chain implications for terrestrial invertebrates. Larger invertebrate predators, such as carabid beetles and lycosid spiders, increase in response to flooding thereby sustaining larger populations of insectivorous vertebrates that prey upon them.

Aquatic species are likely to be particularly sensitive to changes in the river system. The critically endangered silver perch, for example, spawns partly in response to rises in water level and temperature. Given the great changes in the region's hydrology since European settlement (see chapters 3 and 15), it is perhaps unsurprising that seven of the 21 native fish species recorded in the study area are threatened. Many of the study area's streams and rivers now provide the most important Victorian habitat for species such as the critically endangered trout cod and Murray hardyhead, and the endangered Murray cod (see box 5.2), freshwater catfish and Macquarie perch.

In addition, the Lowland Riverine Fish Community of the southern Murray-Darling Basin is listed under the *Flora and Fauna Guarantee Act 1988*. This community has 15 fin fish species: ten that are listed individually under that Act, and five that are not—golden perch, flat-headed galaxias, bony bream, flat-headed gudgeon and western carp gudgeon.

Eucalypt (Box) Woodland

Woodlands dominated by eucalypts other than river red gums and black box, particularly grey box and yellow box, also provide significant habitat for woodland birds, small mammals and reptiles. These woodlands provide similar kinds of ecological services as the river red gum forests, but have fewer wetlands and do not usually flood naturally. The dominant eucalypts are not adapted to periodic inundation and consequently have not declined with reduced flooding. However, Margules and Partners et al. (1990) estimate that approximately 33 percent of the floodplain vegetation along the River Murray has been cleared and much of this would have been box woodland (not necessarily all in the River Red Gum Forests study area).

Grey box has a wider distribution in the study area than black box, occurring from Wodonga in the east to Kerang in the northwest with an outlying population near Robinvale (see Figure 5.1). Grey Box is the dominant eucalypt on many roadsides in the Victorian Riverina Bioregion. Like black box and river red gum, grey box wood is strong and durable and widely used for products such as fence posts. It was widely cleared from its pre-European distribution and remains mostly on roadsides and as single paddock trees.

Yellow box is widely distributed across Victoria but is largely absent from the north and south west and alpine areas (see Figure 5.1). Yellow box wood has similar characteristics to grey box wood and the trees are also good honey producers, flowering from September to January.

Buloke is a leaf-less tree that grows to 5-15 m. It is distributed in north and west Victoria and is commonly found with grey box and slender cypress-pine. Approximately 97 percent of the original buloke woodland in Victoria has been removed (DNRE 1997b). Most remnant buloke trees occur as scattered trees, many in paddocks and along roadsides. This history has negatively affected many species that inhabit buloke woodlands, such as the grey-crowned babbler.

Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions have been listed as an endangered community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Remaining examples are threatened by continued clearing, weed invasion, fertiliser and herbicide drift and grazing by rabbits and stock. This community is poorly represented in conservation reserves throughout its range.

Large old tree sites

Large old trees are particularly important in both riverine forests and eucalypt woodlands. Large trees provide a more open forest structure, with a greater area and variety of foraging substrate for insectivorous fauna. They also provide abundant bark and fallen timber,

Box 5.2 Murray Cod

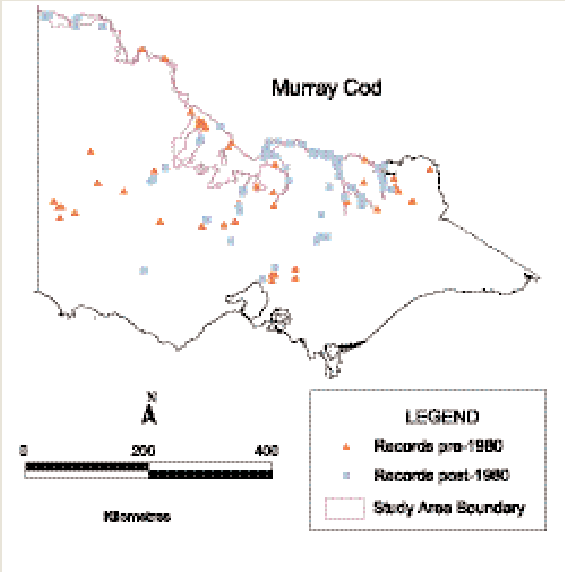
The Murray cod is Australia's largest freshwater fish (up to 113 kg)—a premier angling species—and generates considerable public interest because of its size, 'mystique' and excellent eating qualities (see Figure 5.14 and Figure 5.15). This interest elevates the Murray cod's importance from being merely a fish to being a significant part of Australian folklore and cultural heritage. Murray cod were naturally abundant and traditionally a major part of the diet for Aboriginal people in the area, as well as an important cultural icon. Early European settlers ate Murray cod and a substantial commercial fishery existed until the early 1900s. Since then, the species has declined dramatically and is now endangered in Victoria and listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Murray cod are an important component of the native fish communities of the Murray-Darling Basin and share many threats with other fish species.

Murray cod lay sticky eggs on hard surfaces like submerged wood, when temperatures rise over 15°C (Koehn & Harrington 2006). The adult male guards the eggs and the hatched larvae drift away from nest sites in the water column, making them susceptible to changes in flow regimes and loss into irrigation off-take channels and pumps. Spawning appears to occur in most years under various flow conditions and the survival of post-larval fish is thought to determine overall population recruitment. Survival of post-larval fish may be enhanced by increased food availability following flooding. Natural flow regimes also provide spawning cues for many other native species. Cold water releases from storages such as Lakes Dartmouth and Hume can reduce spawning and recruitment success, reducing fish populations.

Murray cod migrate upstream (up to 100 km) before spawning and then return downstream, usually to their original location (Koehn 1997), making both upstream and downstream fish passage important factors in their life cycle. Both adult and juvenile Murray cod select habitats with structural wood in the main river channels, close to the banks and with overhanging vegetation.

Figure 5.14 Murray cod.

Figure 5.15 Victorian distribution of Murray cod.



Source: Atlas of Victorian Wildlife 2006

Although they will use floodplain channels when they contain flowing water, the cod do not appear to use the floodplain itself. They also prefer slower, shallower waters. Removal of instream woody habitats has been widespread in major rivers in the past and the re-instatement of these habitats is now recognised as an important rehabilitation measure.

Past commercial catches of Murray cod have removed approximately 160 tonnes of fish per year (or 32,000 individuals weighing an average of 5 kg) from the lakes and rivers around Barmah in the 1860s (King 2005). The highest numbers were taken when the fish were spawning. Although these fisheries are now closed, Murray cod are still fished recreationally (Koehn 2005b). There is evidence to suggest that overfishing could be a problem for some populations. Illegal fishing also occurs and, although not quantified, is believed to be substantial in some areas. Artificial stocking of Murray cod to supplement the population is now widespread, but this may have implications for the genetic diversity of the population.

There have been substantial deaths of Murray cod in the Broken Creek, and Ovens and Goulburn Rivers in the past few years (King 2005; Koehn 2005a). These have caused considerable public concern and have resulted in the loss of valuable breeding stocks. While some recovery in Murray cod populations has been reported in NSW and Queensland, any recovery in Victoria is yet to be demonstrated scientifically.

As part of the requirements of being listed as a threatened species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Murray cod will be the focus of actions outlined under a forthcoming National Recovery Plan. This increased management, addressing the key threats and recovery actions for Murray cod is intended to assist in the rehabilitation of the species.

which is essential habitat for some species. Larger trees, however, are favoured for wood products or silviculture, and are therefore less abundant in the forest than other age classes of trees. One study on the northern plains of Victoria found that 55 percent of river red gums were 10-30 cm in diameter, 35 percent were 31-70 cm in diameter and only 10 percent were greater than 70 cm in diameter (Bennett et al. 1994). It is likely that in pre-European times there was a much greater proportion in the largest size class.

Hollow-formation is one of the most important ecological functions of these older trees. Most river red gums are thought to begin forming hollows at approximately 120 years of age (Gibbons & Lindenmayer 2002) although the age varies, depending on soil fertility, wind exposure and fire history (Harper et al. 2005). It takes even longer before the hollows are large enough to suit the full range of hollow-dependent fauna. A study of hollows on the northern plains found that river red gums have fewer hollows than black box, yellow box and grey box (comparing similar-sized trees). Only seven percent of river red gums had hollows overall, but 55 percent of the larger trees (with a diameter greater than 70 cm) had hollows (Bennett et al. 1994).

Hollows are very important for some threatened species and many populations are likely to be limited by tree hollow availability. Scattered clumps of hollow-bearing trees and even single hollow-bearing trees in paddocks can support animals (van der Ree et al. 2006). In Australia, 303 native vertebrate species use tree hollows for breeding and shelter—approximately 15 percent of all terrestrial vertebrate species, or ten percent of reptile species, 13 percent of amphibians, 15 percent of birds and 31 percent of mammals (Gibbons & Lindenmayer 2002).

The superb parrot is a threatened bird species characteristic of river red gum forests and woodlands. The birds fly from New South Wales to Victoria to breed between September and December before returning north. At the time of European settlement, the superb parrot was common along the Goulburn River as far upstream as Yea and was frequently recorded near Melbourne (Figure 5.4). As recently as the 1980s, superb parrots were regularly seen along the lower Ovens River. In Victoria, superb parrots are now found only in a narrow strip between Echuca and Yarrawonga and only breed in Barmah State Park and State Forest. The current Victorian population size is estimated to be 300 individuals (Deayton & Deayton 2005).

Superb parrots breed in tree hollows and nesting typically occurs in loose colonies in old healthy (but sometimes dead) river red gum trees with numerous spouts. The trees may be single or clustered but are usually close to water. The birds fly out of the river red gum forests to forage on flowers, fruits and seeds in nearby box woodlands. A key measure to protect nesting areas has been the establishment of Special Protection Zones (SPZs, see chapter 14) where timber harvesting is excluded from nesting areas in Barmah State Forest, although one of these areas was inadvertently logged in 2005.

Tussock Grassland

Native grasslands are tree-less environments that can support a rich diversity of species. Generally, grasslands are not well-recognised or appreciated and when not flowering it may be difficult to tell the difference between nationally significant grasslands and adjacent paddocks of exotic grasses. Native grasslands have been extensively destroyed since European settlement and less than one percent currently survives—mostly in small patches on roadsides, railways, other Crown land and freehold. Few of these remnants are in good ecological condition (Map 5.1). The Northern Plains Grassland Community is one of the most endangered vegetation communities in Victoria and is listed under the *Flora and Fauna Guarantee Act 1988*. Many processes that disturb soil threaten grasslands including cultivation, clearing, road works and compaction, while other threatening activities include inappropriate fires, over-grazing, absence of grazing, fertiliser and herbicide application or spray drift and tree-planting. A high proportion of grassland species are threatened, including the following three examples.

Chariot wheels is a small perennial herb (growing to less than 20 cm, see Figure 5.16) restricted to small areas around Birchip and Mitiamo in Victoria and in the western Riverina of New South Wales (see Figure 5.3). It is vulnerable nationally, in New South Wales and Victoria. The species is characterised by the woolly disc–shaped fruit (5-10 mm), which can be seen in spring and early summer. Ants like to eat the seeds and so the fruits can sometimes be found around the entrances to ants' nests. Chariot wheels is not found in areas that have been cropped and populations are restricted to roadsides and isolated remnants. It is further threatened by herbicide use, intensive grazing, tree-planting and soil disturbance.

Figure 5.16 Chariot wheels, a small perennial herb found in grasslands in Victoria.

Red swainson-pea is only found in Victoria to the south and west of Echuca in the Victorian Riverina Bioregion (see Figure 5.3). It also occurs in the riverine plains of New South Wales. It is endangered in Victoria and vulnerable nationally. It is a prostrate perennial herb with bright red, pea-like flowers in spring (Figure 5.17). In summer it dies back to a persistent woody rootstock from which it resprouts the following autumn. Like other grassland species, the red swainson-pea is threatened by soil disturbance, intensive grazing and herbicide use. As it prefers an open grassland habitat (not too dense with wallaby- and spear-grasses), light sheep grazing may be beneficial.

Figure 5.17 Red swainson-pea, a threatened perennial herb.

The grasslands of Terrick Terrick National Park are the Victorian stronghold of the critically endangered plains-wanderer—a quail-like grassland specialist (see Figure 5.4). Plains-wanderers prefer habitat where there is about 50 percent bare ground and most plants are less than 30 cm tall. They use this vegetation as cover from aerial predators but can stand on tip-toe to scan for terrestrial predators. Most of the diet of this bird is made up of insects and seeds from grasses and saltbush. Habitat destruction and modification, including cultivation, over-grazing, dense pasture growth, weeds and wildfire are the major threats to this species (Baker-Gabb 1995).

Saltbush

On the flat alluvial plains of the Murray Scroll Belt, extensive open woodland dominated by saltbush supports flora and fauna more typical of western NSW and SA. These plains provide the only Victorian habitat for Giles' planigale. Other characteristic species include red kangaroo, white-winged fairy-wren, inland dotterel, orange chat and samphire skink.

Giles' planigale is a semi-arid and arid zone species that just extends into the north-west corner of Victoria. The species was only discovered in Victoria in 1985 when individuals were found at Lindsay Island, Wallpolla Island and near Neds Corner (west of Mildura). Their habitat is confined to cracking clay soils on the floodplain and is mostly black box with dense but patchy ground cover such as lignum. Giles' planigales may also use logs, burrows and grass clumps to shelter from extreme heat and predators. This species is threatened by habitat degradation and predation. Lack of floods, firewood collection, ground cover trampling, overgrazing and recreation may contribute to habitat degradation.

Mallee

Very small parts of the study area between Swan Hill and the South Australian border support mallee vegetation. Mallee eucalypt communities support a characteristic and diverse fauna that includes many elements restricted to the Murray mallee region. For example, the mallee emu-wren inhabits mallee areas with porcupine grass hummocks. This species is responsive to the fire history of vegetation and populations peak 8-10 years after fire but begin to decline at 30 years after fire (Garnett & Crowley 2000).

PROCESSES IMPACTING ON BIODIVERSITY

The management and amelioration of key or potentially threatening processes is vital to conserving biodiversity. Many potentially threatening processes are listed under the *Flora and Fauna Guarantee Act 1988* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Appendix 8) which require plans for the amelioration of these threats. An example of a potentially threatening process listed under the *Flora and Fauna Guarantee Act 1988* is 'Prevention of passage of aquatic biota as a result of the presence of instream structures'. Management agencies have sought to reduce the impact of instream structures by installing fish ladders or fish ways (Figure 5.18) to help fish move around dam walls. The major threatening processes in the study area are discussed below under nine broad headings.

Figure 5.18 Fish ladder at Torrumbarry on the River Murray.

Clearing and Habitat Fragmentation

Habitat clearing is one of the major causes of biodiversity decline in Victoria (DNRE 1997b). Clearing reduces the area of habitat in which indigenous flora and fauna can live. For example, large losses of grassland habitat through cropping, ploughing, fertiliser and herbicide use and high levels of grazing have reduced many grassland-dependent species including darling-peas, swainson-peas and a variety of native grasses.

Habitat fragmentation is a major threat listed under the *Flora and Fauna Guarantee Act 1988* (see Appendix 8). It occurs when native vegetation is cleared, leaving habitat remnants separated from other blocks of habitat by areas with little or no habitat value—typically farmland. Such remnants can be characterised by their size and shape, distance to the nearest neighbour remnant and the land-use of the intervening areas.

Habitat fragmentation has a number of impacts upon biodiversity. Some remnants are too small to support populations of species that have large home ranges, such as barking owls which have home ranges of at least several hundred hectares. Small remnants may only be able to support small populations of other species, making them vulnerable to extinction due to chance events. Habitat fragmentation also increases the amount of edge, which is more vulnerable to disturbance, predation and weed invasion. Additionally, fewer populations can live in small remnants compared with larger ones. Thus, continuing fragmentation results in a simplification of the ecological community, disadvantaging specialist species and leading to a decline in ecosystem services.

Habitat Degradation

Habitat degradation may result from the removal of particular elements, leaving it unsuitable for some species. Firewood collection on public land within the study area is one example. Although the whole forest is not cleared, the removal of this important element can render the area unsuitable for many species that require fallen wood (or coarse woody debris) for protection from predators and extreme temperatures and as a place to forage (Mac Nally & Horrocks 2002a). Fallen timber loads of more than 40 tonnes per hectare are required for some vertebrates (Mac Nally et al. 2002a). Clearance of this habitat element is an important process in the decline of bush stone-curlews, carpet pythons and a range of other threatened species.

Road and track networks may reduce richness and abundance of species including invertebrates (Greenslade & Greenslade 1977) and increase the range and access for foxes. Recreational activities can also degrade habitat. Digging for bardi grubs disturbs the soil, which promotes weed germination. Power boating activities can damage river bank vegetation and contribute to soil erosion and sedimentation of rivers (see chapter 11).

There are many forms of habitat degradation and some of the major ones are described in detail below.

Altered Water Regimes

The Murray River has been increasingly regulated with water diverted for agriculture since Hume Dam was first constructed in 1936. The extension to Hume Dam was completed in 1961. Regulation remained the same until Dartmouth Dam was commissioned in 1979. There was an accelerating increase in diversion of water for agriculture from 1961 to 1995 when a cap was imposed on extraction in Victoria. The changes to the water regimes aimed at providing increased irrigation allocations have changed the river height, flow volumes, flooding frequency, duration and season of flooding (see chapters 3 and 15 for details).

Changed water regimes (flow, temperature, and flooding frequency, duration and extent) can greatly affect wetlands, floodplains and can greatly change the species composition of an area. Densities of the yellow-footed antechinus increase 20-fold after flooding (Mac Nally & Horrocks 2002), reflecting better survival when there are large numbers of invertebrates available (Ballinger & Mac Nally 2005). These population increases may also occur among bats (Lumsden et al. 2002) and insectivorous birds (Chesterfield et al. 1984; Mac Nally et al. 2001). Many bird species require specific flooding conditions for suitable habitat, particularly for breeding (Parkinson et al. 2002).

For other species, the water temperature and change of flow speed are important cues that conditions are right for breeding. 'The alteration to the natural temperature regimes of rivers and streams' and 'The alteration to the natural flow regimes of rivers and streams' are listed as a potentially threatening process under the *Flora and Fauna Guarantee Act 1988*. For example, the silver perch, a critically endangered species in Victoria, is thought to spawn in late spring and summer after water flow increases and the temperature rises above 23°C. Cold water released from the bottom of storage weirs may lead to localised unsuitable habitat as well as the absence of triggers for breeding. Additionally, eggs may not be as viable and larvae may not be suited to the lower temperatures. Reduced water temperatures are also thought to threaten the critically endangered trout cod, the endangered freshwater catfish, Murray cod and Macquarie perch, and the vulnerable golden perch.

Water flow and flooding regimes greatly affect aquatic and wetland vegetation. As discussed above, mature river red gums require flooding every few years. Seeds of this species germinate as a result of a disturbance such as flooding and a new generation grows. Typically, many of these new seedlings would die during the subsequent flood. With the present flooding regimes, such floods are only achieved infrequently and this results in forests of close growing, even age-structured cohorts surviving. These new trees are invading the Moira grasslands that previously persisted when more frequent flooding killed the juvenile river red gums (Bren 1992).

The main threat to wetlands in the study area is water storage, regulation and extraction associated with irrigated agriculture. Floodplain wetlands, particularly of the Goulburn and Murray Rivers, tend to be flooded less frequently, retain water for shorter periods and may be flooded in summer and autumn when river levels are high to deliver irrigation water instead of in the natural seasons for flooding (winter and spring). Hydrological threats on floodplains are exacerbated by flood control levees in some areas that isolate wetlands from floodwaters.

Many wetlands in the study area have been cut off from their natural floodplains or catchments and incorporated into the water regulation and storage system. Many former temporary wetlands (that went through wet and dry cycles) are often now permanently flooded. This has killed the river red gums and increased rushes such as giant rush. Other wetlands may be permanently dry as a result of being by-passed by irrigation channels. In other areas, the lack of flooding for many years has weakened or killed many river red gums (Brett Lane & Associates Pty Ltd 2005). Other hydrological changes have resulted from the use of wetlands as areas to dispose of excess irrigation waters or salinity disposal.

A mixed pattern of temporary and more permanent wetlands enables a diverse range of species to inhabit the floodplains of the study area (Figure 5.19) (Parkinson et al. 2002). Temporary wetlands are generally shallow with high light levels and warm temperatures. This leads to a high diversity and abundance of macroinvertebrates which provides a large food resource for wading birds such as egrets and spoonbills. Permanent water bodies may be of greater value to diving birds such as cormorants and azure kingfishers as the open water facilitates fish catching (Parkinson et al. 2002).

Figure 5.19 Lake Murphy, near Kerang, flooded due to an allocation of environmental water.

For the four Ramsar sites in the study area, strategic management plans have documented the level of risk to site values from various activities and processes (DSE 2003b, d, e, 2004h). They are summarised in Table 5.7. Although this summary does not assign a risk of grazing to wetlands in the Kerang wetlands, Gunbower forest and Barmah forest, grazing is detrimental to many species, communities and ecological processes in those ecosystems (Robinson & Mann 1998; Jansen & Robertson 2005).

Pest Plants and Animals and Pathogens

Pests and weeds are broadly defined as species that have undesirable impacts, which may be economic, environmental or social. Pathogens are disease-producing organisms, such as cinnamon fungus *Phytophthora cinnamomi*, that also have undesirable impacts. Many of these species, but not all, are introduced to Australia and their environmental impacts are particularly felt here because of the long prior period of isolation of the Australian continent.

Pest plants and animals are one of the greatest threats to the integrity of biodiversity in the study area (DNRE 2002g). They cause a wide range of impacts on the environment including damage to native vegetation, genetic pollution, displacement and loss of native wildlife and alteration of ecological processes, such as water-nutrient cycles and fire regimes. They affect primary production through, for example, direct competition for resources and introduction and spread of diseases that affect crops and livestock. They may affect amenity through preventing access to recreational areas and pose risks to human health (e.g. anaphylaxis as a result of bee stings). The seriousness of the threat is underscored by numerous pest and weed species and processes being listed, after rigorous scientific assessment, under the *Flora and Fauna Guarantee Act 1988*.

The *Victorian Pest Management—A Framework for Action* (DNRE 2002a) provides the broad strategic direction for pest management in Victoria. Subsidiary documents cover specific pests such as foxes, rabbits, wild dogs and weeds (DNRE 2002e, f, g).

Significant investment in prevention and control is occurring on public and private land. The Weeds and Pests on Public Land Initiative is a major state government program to support pest plant and animal control in national parks, state forest and other public land in Victoria. The four-year, $14 million, initiative aims to:

- Protect large areas of high value natural assets by preventing and reducing the impact of weeds and pests;
- Improve public land stewardship through a collaborative partnership approach at the landscape level;
- Minimise the movement of weeds and pests across the public/private land interface; and
- Engage the community in the management of public lands;

This program operates through on-ground projects in reducing pest plants and animals, increased strategic approaches to pest management with a pilot study in the Angahook-Otway region and through an increase in the Good Neighbour program, which supports private landholders by controlling pests and weeds on the border of public land. The complementary 'Tackling Weeds on Private Land' Initiative undertakes wide-ranging activities on private land.

Significant developments in pest and weed management include taking a 'biosecurity' approach, with a focus on preventing new problems. Large scale, cross-tenure, continuous programs, as demonstrated by the Southern Ark fox control project, also have great potential for improved outcomes (DNRE 2002d; DSE 2003g). A cooperative approach to tackling pest animals, weeds and pathogens seems to be the most effective. To this extent, government plays an important role in encouraging cooperation by all those with an interest in dealing with pest animals, weeds and pathogens.

Deliberate and ignorant introduction and spread of species remains a problem. For example, aquarium species are released by often well-meaning people but at great risk to the environment. Policing of these activities benefits from community surveillance and reporting.

A **weed** is a plant that requires some form of action to reduce its harmful effects on the economy, environment, human health and amenity (Australian Weeds Committee 2006). Weeds threaten the productive capacity of land, water and biodiversity assets in Victoria. It is estimated that they cost Victoria $900 million annually. Victoria faces new and increasing threats from weeds (despite the success of current approaches) due to the number of new species naturalising.

Table 5.7 Summary of risk levels to Ramsar site values.

Risk	Hattah-Kulkyne Lakes	Kerang Wetlands	Gunbower Forest	Barmah Forest
Altered Water Regimes	●●●	●●●	●●●	●●●
Pest Animals	●●●	●●	●●	●●
Pest Plants	●●●	●●	●	●●
Salinity	●●	●●●	●	●
Recreation	●	●●	●●	●●
Resource Utilisation	●	●	●●	●●
Fire	●	●	●●	●●
Pollution	●	●●	●	●
Grazing	●●●	—	—	—
Erosion	—	—	●	●

Source: DSE (2003b,d,e, 2004h)

●●● = higher priority risks; ●● = medium priority risks; ● = lower priority risks.

Increased risk also arises from climate change and globalisation. More than 40,000 species overseas are potential weeds in Australia. This underscores the importance of a greater focus on risk assessment and early intervention.

Weed spread pathways are an important focus of management. Weeds may be assisted by natural or human-induced disturbances, such as fire and soil disturbance, or distribution such as transport of propagules by animals, on clothing, vehicles and machinery, or in hay distributed to feed stock. Quarantine, surveillance and hygiene are important strategies to combat these issues.

Weeds directly affect agricultural production through competition with pastures and crops and effects on livestock health. They indirectly affect agriculture by, altering soil and water health, affecting machinery access and function. The cost of weed control negatively affects the terms of trade of agriculture and thus viability.

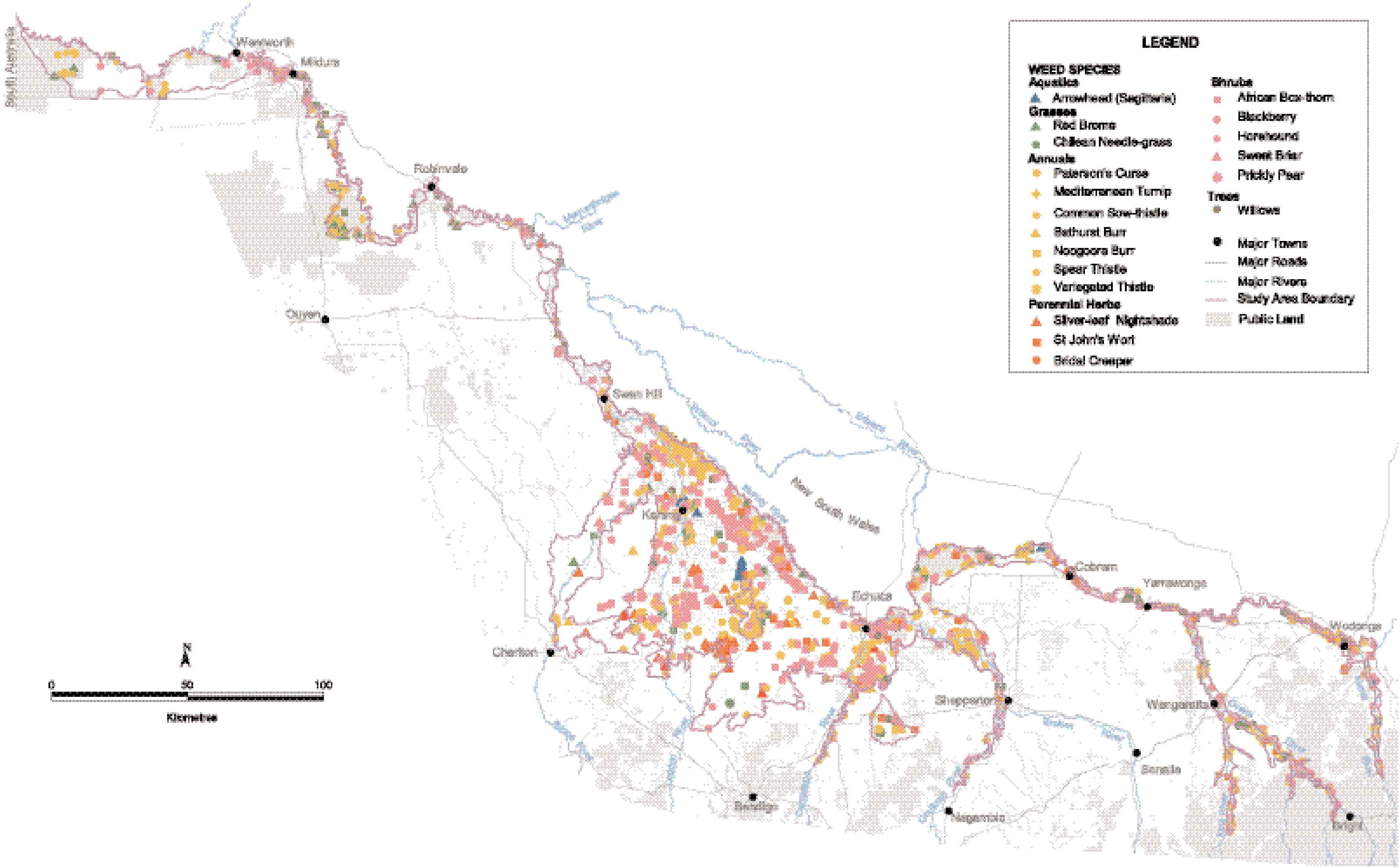
Declared noxious weeds are proclaimed under the *Catchment and Land Protection Act 1994*. Four sub-categories are recognised: State Prohibited, Regionally Prohibited, Regionally Controlled and Restricted with corresponding management obligations on landholders. The list primarily includes weeds of agriculture. Many weed species have not yet been declared. The noxious weed list is currently under review (Weiss et al. 2004).

Weeds are a major threat to biodiversity. Over 570 species of weeds that affect environmental values are recognised. In excess of $14.6 million was spent on weed management on public land in 2004-05 (DSE 2006d). Some weeds may be indigenous to other parts of Australia but damage local vegetation communities (e.g. Western Australian bluebell creeper invades heathlands, woodlands and forests in Victoria). Some species with benefits for agriculture and amenity (e.g. phalaris, trout) can have negative effects on environmental values.

In 2006, Interim Guidelines for managing the environmental impacts of weeds on public land were released for public comment (DSE 2006d). The Interim Guidelines propose that the priority for management is firstly to prevent new and emerging weeds from establishing and secondly, to adopt an asset-protection approach for all established weeds with the highest value assets at risk from weeds receiving the highest priority. The Interim Guidelines provide a description of the objectives, legislation, principles and priorities and foreshadow an improved strategy for protecting public land values. The government's Weed Alert Rapid Response Plan provides surveillance and a response process for potential, new and emerging weeds in Victoria.

Weed species in the study area differ between regions and habitat types. The fertile floodplains pose particular challenges to weed control methods. Study area weeds include woody weeds (e.g. willows (Figure 5.20), hawthorn, African boneseed), climbers and creepers (e.g. bridal creeper) and broad-leafed weeds (e.g. thistles, St John's wort and horehound), perennial grasses (e.g. Chilean needle-grass, serrated tussock and phalaris), annual grasses (e.g. quaking-grass and *Bromus* spp.) and aquatic weeds (e.g. alligator weed, arrowhead (*Sagittaria*, see Figure 5.21), salvinia and water hyacinths). Arrowhead threatens the health of streams and rivers and the function of irrigation channels. Control is problematic as repeated herbicide application in waterways may have detrimental effects. Some of the more common weeds in parks and reserves include Paterson's curse, African boxthorn, horehound, Bathurst burr and St John's wort. Map 5.5 shows the distribution of selected weeds in the study area, although many weed occurrences have not been systematically or comprehensively surveyed or mapped. For example, while willows are present along the banks of many streams in the northeast of the study area, only a few records show on the map.

Map 5.5 The distribution of selected weed species in the River Red Gum Forests study area.



Source: DSE (2006b)

Figure 5.20 Part of the North East Catchment Management Authority program to remove willows from the banks of the Ovens River in northeastern Victoria.

In the study area, Paterson's curse (also known as salvation jane) is an annual or biennial herb native to the Mediterranean region, with vivid purple flowers. It is a serious pasture weed that also invades native vegetation including lowland grassland and grassy woodland, dry sclerophyll forest and riparian vegetation. It is widespread and well-established in Victoria. Paterson's curse is poisonous to livestock but used as a pollen source by apiarists. It has a rapid early growth rate and spreading rosette of leaves and thus competes with pasture plants and indigenous vegetation. Birds and water disperse the seeds but movement of hay, especially during drought, is also an important means of dispersal. Thus, feeding contaminated hay to cattle on public land will contribute to weed spread. Careful measures to prevent its spread are integrated with herbicidal, physical and biological control techniques to suppress this established weed (Faithfull & McLaren 2004). Several biocontrol agents are established and continuing to spread.

African boxthorn is native to the southern coast of Africa and was probably originally planted in Victoria as a hedge plant forming a barrier to domestic stock. It is a densely branched perennial spiny shrub growing to about 5 m round with bright red berries. Boxthorn invades many habitat types and can form dense thickets, providing refuge to native and introduced animals. The attractive berries are eaten by birds and foxes, which spread the seed, and it will also readily shoot from broken roots. Removal with a chainsaw and subsequent painting of the stem with herbicide is the most effective method of control although follow-up work is required to remove seedlings. In some instances, where alternative accommodation is unavailable, this species provides valuable habitat and protection from predators for species such as small birds. In such circumstances, any programs to remove plants should be integrated with programs to concurrently restore native habitat. There are native plant look-alikes so, as with all weed control activities, identification before control is important.

Figure 5.21 Arrowhead (*Sagittaria*), an aquatic weed found in natural waterways and irrigation channels.

Horehound is native to many locations including southern and western Europe, western and central Asia, North Africa and is now widespread in southern Australia. It is a perennial, spreading herb growing to about 80 cm and its fruits are burrs that spread attached to the fur and feathers of animals, via water, clothing and vehicle tyres. Horehound invades pastures as well as red gum woodland, mallee shrubland, lowland grassy and grassy woodlands, black box woodlands and open grasslands particularly if the areas have previously been overgrazed or disturbed (Weiss et al. 2000; Blood & CRC Weed Management Systems 2001).

Figure 5.22 Koala in a river red gum on Ulupna Island in Barmah State Park.

A survey of Victorian parks in 1996 estimated that horehound infested 78,200 ha of public land, cost $19,000 to control and took 1900 work-hours per year (Weiss et al. 2000). Treatment techniques for horehound include the biological control agents horehound plume moth and clearwing moth.

Bathurst burr, introduced from tropical America, is prevalent in northern Victoria. It is an erect, branched herb commonly growing from 30 to 60 cm tall and, like horehound, its fruits are burrs. Bathurst burr is rarely grazed due to its long spines and poisonous seeds and seedlings. It invades grassy woodlands, wetlands and riparian vegetation and forms dense patches capable of excluding other plant species. Bathurst burr can be controlled using herbicides but control programs must extend for more than six years to exhaust the seed bank.

St John's wort is a perennial herb around 80 cm high with bright yellow flowers between October and January. It was first introduced to the Ovens Valley in the late 19th Century. It invades grasslands, woodlands, pastures, open forests, plantations, road and rail sides and riverbanks. St John's wort seeds can be spread by wind, animals, machinery, contaminated fodder, seed or soil, and in garden waste. Biological control agents (beetles and mites) have been partly successful in controlling this weed. There are two indigenous species of *Hypericum* that may co-occur with St John's wort (Blood & CRC Weed Management Systems 2001).

There are hundreds of weed species in the study area in addition to these common species. Less obvious species such as introduced fungi and plant rusts (e.g. Eucalyptus rust) could have significant impacts in the future.

Vertebrate pests such as cats, foxes and rabbits are a major problem in some areas. Their control consumes large parts of land management budgets. Feral pigs are also pests on the floodplains of the Murray. Other feral vertebrates in the study area include brumbies, goats, feral cattle and wild dogs. Eight species of introduced fish are present in the rivers and streams of the study area. Negative effects on river health and biodiversity are known for carp, rainbow and brown trout and mosquito fish.

Foxes have a varied diet. They prey on native species, particularly those weighing between 35g and 5500g (Burbidge & McKenzie 1989). Foxes also consume invertebrates and plant material, and are vectors for some weeds. The most common form of control is via the use of 1080 ('ten eighty') poison baits placed in bait stations. Recent work suggests that large areas of continuous baiting are required for baiting to reduce fox numbers (DSE 2006h). Baiting programs are integrated with Good Neighbour programs, which aim to reduce pests on the adjoining private land and on public/private land interfaces. In this circumstance, baiting is typically timed to protect newborn lambs.

Rabbits are a major problem in much of the study area. Myxamotisis and Rabbit Haemorrhagic Disease (RHD) have reduced populations in some areas. However, history suggests that diseases only offer short-term respite and that ongoing vigilance and control using established techniques is vital, especially while the effects of RHD are apparent. The Mallee Rabbits Project aims to reduce rabbit populations on public land such as Hattah-Kulkyne and Mulcra Island.

Cats and dogs carry disease and prey on native wildlife, including small mammals, birds and reptiles. Cats occur in domestic, farm (semi-domestic) and feral populations. In domestic situations, sterilisation and the use of enclosures can reduce the impacts of cats on the environment. Methods of effectively controlling feral cats have proven elusive although research is currently underway at both the state and national level.

Feral pigs are particularly deleterious in wetland environments where they root up the ground vegetation, leading to increases in soil erosion, sedimentation of waterways and weed invasion. They pose a significant risk to livestock as potential carriers of disease.

Feral cattle and horses (brumbies) pug wetlands and access points to water, trample vegetation and contribute to soil erosion (see grazing, above).

Exotic fish were brought to Victoria by European settlers in the late 1800s to stock waterways with edible and familiar species for angling. More recently introduced exotic aquarium fish are further upsetting the ecology of rivers and streams. Some introduced fish have become dominant, reducing native fish species by competing aggressively for food and for space. Exotic fish also introduce new diseases, parasites and pathogens with the potential to wipe out any native species susceptible to new pathogens.

Carp are recognised as a serious vertebrate pest and have expanded rapidly in distribution and abundance to dominate waterways in the Murray-Darling Basin and southeastern Australia (Koehn et al. 2000). They are the largest and most visible introduced fish species and have received much public and political attention. Barmah forest has been identified as a potential recruitment zone for carp (Stuart & Jones 2006) and although carp numbers have reduced in some areas over the past decade (Nicol et al. 2004) they remain an abundant large fish species, comprising 80 percent of the biomass in 1999-2001 (Stuart & Jones 2002). Commercial harvesting of adult carp in Moira Lake has varied between 76 tonnes in 2001 to less than 20 tonnes in recent years (King 2005). A National Carp Management Strategy and local carp action plans influence management.

Figure 5.23 Gum leaf skeletoniser on a skeletonised leaf.

Figure 5.24 Damage to eucalypt leaves by the gum leaf skeletoniser.

Locally overabundant native animals, while not classified as pests, can inflict significant damage on the local environment. For instance, overabundant kangaroos can severely overgraze landscapes, reducing the forage and habitat available for other native species. In the last financial year (2005-2006) five permits were issued for the destruction of 120 western grey kangaroos and 14 permits for 250 eastern grey kangaroos were issued in Loddon, Gannawarra and Campaspe Shires and Swan Hill Rural City Council (DSE, unpublished data). Overabundant koala populations in Victoria have, in some instances, killed the preferred food trees in an area with many koalas dying as a consequence. The koala (Figure 5.22) population on Ulupna Island (Barmah State Park) is at very high levels and may need future management to preserve the health of both the forest and the koala population.

Additionally, small populations of native animals may become nuisances in recreational areas. For example, birds that are fed in picnic grounds often become less wary of people and will pester them for food while other species may force entry into camp tents. Other native species are agricultural pests. For example, in the study area, cockatoos and corellas eat crops and flocks of small birds such as silvereyes can reduce grape harvests.

Invertebrate Pests

Some species that are becoming more widespread in Victoria include Portuguese millipedes, Argentine ants and European wasps. Argentine ants have been found in towns along the Murray River and European wasps also occur there. There is the danger of other species invading the riverine system, especially in the face of climate change. The main contenders are exotic species of tramp ants such as the red imported fire ant and the big-headed ant. The former is currently located in Queensland (with at least one incursion into Victoria that was destroyed) and the latter occurs along the coast of New South Wales.

A wide range of insect species damage river red gum forests to varying degrees. The majority of these insect pests cause damage on an infrequent basis with the immediate effects generally short-term and localised.

Examples include the larvae of leaf-feeding sawflies and larvae of the leaf-mining leafblister sawfly (Farrow 1996; Phillips 1996; Elliot et al. 1998). While the causes of such outbreaks are not fully understood, factors such as availability of food resources, prevailing climatic conditions, foliage nutrient conditions, age status of individual host trees and stands, and population status of predator species all appear to play a role (Collett 2001).

Observations over many years in Victoria have identified two insect species causing significant economic and aesthetic damage to wide areas of river red gum forest. These species are the gum leaf skeletoniser and the red gum basket lerp psyllid. These outbreaks either occur regularly causing defoliation damage or on an infrequent widespread basis causing significant by defoliation.

The gum leaf skeletoniser (Figure 5.23) is a defoliating insect native to eastern Australia, capable of causing severe damage to foliage on river red gum in native forests, roadside plantings and plantations (Farrow 1996). It lays eggs in young leaves where the young larvae feed on the upper and lower surface leaf tissue avoiding the oil glands and veins, thereby creating a "skeleton" (Figure 5.24) (Elliot et al. 1998). The first significant outbreaks were recorded in 1933 (DCFL 1986). Subsequently, large outbreaks occurred regularly at decade intervals in 1944 and 1957 along the Murray River (Harris 1974) culminating in a major defoliation event in 1975 when more than 40,000 ha of river red gum forest was stripped of leaves in the Murray and Goulburn Valleys (Harris et al. 1977; DCFL 1986). Since then, several smaller localised outbreaks have occurred with the most significant being along the Goulburn River near Shepparton in the mid-1990s. Outbreaks of gum leaf skeletoniser appear to be linked to a lack of flooding. Populations were lower on sites with nearby floodwaters while flooded sites had negligible populations of gum leaf skeletoniser (Harris 1972). It seems likely that increasing length and severity of drought, coupled with increased demands on available water resources, may further increase the incidence of such outbreaks.

Figure 5.25 Feral honeybees in a tree hollow at Heywood Lake in northwest Victoria.

The red gum basket lerp is a sap-feeding psyllid insect native to south-eastern Australia. It lays eggs on the surface of mature leaves and, once hatched, the larvae construct a shell (known as a 'lerp') from starch derived from the host plant, defoliating the leaf in the process. The lerp probably protects the psyllid insect from predation and desiccation during hot weather. Red gum basket lerp are most active during summer when attacked foliage dries rapidly. By late summer trees can be totally defoliated. Some affected trees die while older trees produce epicormic shoots, which can affect timber quality (Collett 2001). Extensive areas of river red gum have occasionally been defoliated by large populations of lerps near Orbost (1950s), in the Seymour-Euroa area (1950s), Lakes Entrance (1980s and 90s), Mansfield (1940s and 50s) and in plantations around Shepparton and western Melbourne (Collett 2001). Hot weather, high soil moisture, absence of flowering and variations in leaf chemistry (e.g. phenolic feeding inhibitors) have all been associated with psyllid outbreaks (Morgan 1984).

Further research is needed to investigate the interactions between various outbreak factors. A network of regularly examined forest health assessment plots, management of insect pest outbreaks and the associated impacts on tree growth in river red gum forests will assist in quantifying the extent of this problem. In some cases, while the symptoms are obvious, their underlying cause is unknown. Treating defoliation symptoms chemically does not address the underlying cause of the outbreak. However, because the underlying cause is often difficult to determine, alternative, effective more environmentally friendly management is hard to achieve.

European honeybees are an important part of the economy (see chapter 13), yet there is considerable debate on their effects on the Australian environment. While they have been present in Australia for about 170 years, their abundance and distribution has increased dramatically over the last 60 years (Paton 1996). Honeybees potentially affect native flora and fauna though (i) competition for tree hollows (Figure 5.25), (ii) competition for nectar and pollen, and (iii) disruption of plant-pollinator systems. A distinction needs to be made between commercial honeybees housed and transported in hives and feral honeybees occupying tree hollows. Honeybees can forage at least 20 km from their hives or hollows.

Paton (1996) concluded that tree hollow use by feral honeybees broadly overlaps with those used by native birds and mammals, but feral bee colonies appear to only occupy a small proportion of the available hollows. However, he acknowledges that few studies adequately assessed the availability of suitable hollows, particularly their internal characteristics. The low availability of tree hollows is a limiting factor for many threatened species. Even low levels of competition for hollows from feral bee colonies could have significant adverse effects on these species.

Competition between honeybees and native bees may occur when floral resources are low (Schwarz & Hurst 1997). However, studies need to consider the impact of both commercial (short-term bee presence in areas experiencing good flowering) and feral honeybees (year round presence including when floral resources are low). Honeybees are able to forage earlier in the day than native bees and therefore have first access to resources (Paton 1993). This may directly affect the health of native bees. For instance, a native bee (*Hylaeus alcyoneus*) was found to produce about 25 percent fewer nests in the presence of commercial honeybee hives (Paini & Roberts 2005).

Over millions of years, close and specialised relationships have developed between native plants and the species (mostly insects and birds but also mammals) that pollinate them in return for pollen and nectar resources. The establishment of feral bees in an area can disrupt this relationship by out-competing the native species for the resources but failing to pollinate the plant in the process. This may result in a reduced seed-set (Gross & Mackay 1998)

Pathogens

Plant and animal pathogens, including zoonotes (diseases transferable to humans) are a concern in all ecosystems. Pathogens may be natural or introduced. They can be introduced as a result of the introduction of another species. Both native and introduced species can be reservoirs of disease. Inappropriate management, such as faecal or nutrient input to waterways, can affect pathogen populations. Two important arboviral (arthropod-borne) infections, Ross River Virus and Barmah Forest Virus, can be contracted by humans in parts of the study area. They are spread by mosquitoes and are important because of their frequency and the disabling rheumatic symptoms they can cause.

Although the study area is currently considered to be outside the climatic range associated with Cinnamon Fungus, climate change may alter this in the future (DSE 2006). Eucalyptus rust is considered to be one of the most serious offshore threats to Australia's eucalypts (and other genera of Myrtaceae) and the country's hardwood timber industry. The species has recently been detected in Hawaii. A national response plan is in preparation (Office of the Chief Plant Protection Officer 2005).

Mundulla Yellows causes progressive dieback in eucalypts (Figure 5.26) and other native species and was first reported in river red gums in the 1970s. The syndrome was first observed near Mundulla, South Australia, but has since been reported in most states

Figure 5.26 Tree with Mundulla Yellows and close up photo of leaves showing yellowing or interveinal chlorosis.

of Australia. The first symptom of Mundulla Yellows is leaf yellowing or interveinal chlorosis, initially in young leaves and later spreading to mature leaves and causing defoliation. Epicormic growth occurs on branches, and new leaves are stunted and yellow. The symptoms gradually spread throughout the tree, causing the whole canopy, and tree, to die over several years. Mundulla Yellows generally affects disturbed vegetation, particularly near roadsides. At least 87 species and 29 genera have been recorded with Mundulla Yellows-like symptoms in South Australia. Insects were initially thought to be the causative agent, but recent research has shown that Mundulla Yellows is caused by a complex interaction of soil properties (texture and parent material), nutrients, soil compaction, water availability,

Figure 5.27 Cattle on the bank of the River Murray in Barmah State Forest.

increased alkalinity and salinity, and the accumulation of bicarbonate in the soil solution.

Mundulla Yellows has been reported from the leaves of river red gums near Hattah-Kulkyne but soil properties were not investigated. The distribution of Mundulla Yellows within the River Red Gum Forests study area is unknown and further work is required.

Grazing

Domestic stock grazing can potentially lead to pugging, selective plant removal, weed invasion, soil compaction, erosion and increased sediment in rivers and streams. In turn, these processes can simplify the structure of the habitat (Tasker & Bradstock 2006), stock compete for food with native animals and remove habitat (such as abolishing invertebrate burrows through soil compaction). The social and economic benefits of grazing, legislation and administrative arrangements (including licencing and agistment permits) and extent of grazing on public land within the study area are discussed in chapter 13. Some of the effects of grazing have been established, but the wider grazing issue is controversial and is further discussed in chapter 19.

The removal of palatable vegetation alters the composition, function and structure of vegetation communities. The selective nature of grazing has the potential to significantly change the biodiversity of an area. This effect has been well documented for trees and groundcover plants, particularly in riparian landscapes (Robinson & Mann 1998; Robertson & Rowling 2000; Spooner et al. 2002; Jansen & Robertson 2005).

The tendency for domestic stock to graze selectively is well demonstrated in Barmah forest. Early accounts of Barmah forest indicate that cumbungi and common reed were preferentially grazed by cattle and are now restricted in occurrence (Chesterfield 1986).

Cattle are also attracted to Moira grass, in preference to any other fodder. This species grows in flood-prone grasslands and breaks a period of winter dormancy growing prolifically during spring flooding. The combined effects of altered water regimes and the preferences of cattle grazing have substantially reduced the distribution of Moira grass. Domestic stock grazing also limits the recruitment of red gum populations, with this effect decreasing as stocking rates decrease (Jansen & Robertson 2005). This effect is exacerbated by an increased abundance of seed-eating ants at sites grazed by cattle (Meeson et al. 2002).

Other studies found that increased grazing reduces the ecological condition of riparian habitat and results in the loss of bird, frog and plant diversity in river red gum habitats (Jansen & Robertson 2005). Frog diversity and wetland condition declined with increasing grazing intensity on the floodplains of the Murrumbidgee River (Jansen & Healey 2003). Declines in bird populations were found to be related to loss of vegetation structure due to grazing (Martin & Possingham 2005), probably because grazing removes the grass tussocks and shrubs where species such as yellow-faced honeyeaters and rufous songlarks nest (Ford et al. 2001).

There have been no studies on the effects of grazing on river red gum invertebrates although stock grazing in grey box woodlands alters the populations of ground-dwelling invertebrates by inducing changes to vegetation and litter layers (Bromham et al. 1999). In grey box woodlands, ungrazed woodland had a more diverse ground invertebrate fauna, most likely due to the greater diversity of food and habitat resources provided by the less disturbed vegetation. Additionally, soil compaction by grazing animals can result in changes to invertebrate faunal composition by its effect on ground and shrub layer plants and on plant litter (Scrougall et al. 1993).

Grazing may also: reduce the capacity for riparian zone vegetation to act as a nutrient 'filter'; compact soil; and increase erosion where bare soil has been exposed, therefore increasing sediment input into waterways (Figure 5.27).

Alternatively, domestic stock grazing can positivly affect the environment if applied in a strategic manner. Grazing cattle and sheep for a limited time in spring can help to reduce weeds by restricting seed set and flowering in certain annual species. Low-level sheep grazing is applied in grasslands such as Terrick Terrick National Park to maintain an open habitat preferred by many threatened flora species.

The limited studies that have been undertaken to determine the effectiveness of different grazing strategies for maintaining and enhancing biodiversity suggest that intermittent grazing provides the best biodiversity outcomes by creating vegetation heterogeneity through both time and space (Dorrough et al. 2004). Continuous and intensive grazing can cause a significant loss of habitat value through species selectivity, changes to vegetation structure and impacts on habitat values (e.g. Chesterfield 1986; Jansen & Healey 2003). However, a varied vegetation structure can have less useable forage and therefore has not generally been favoured by graziers (Dorrough et al. 2004). This mismatch in land management objectives is one of the main impediments to the introduction of strategic grazing management with biodiversity conservation as a primary objective across parts of the public land estate.

Changes due to intensive grazing may be irreversible in the short to medium term, and a significant allocation of resources may be required to restore native vegetation. In particular, damage to stream frontages is significant. A site's ability to recover from grazing damage depends on stocking density, soil type, geomorphology and topography and is therefore highly variable (Robertson & Rowling 2000; Martin et al. 2006). There may be a substantial time lag between the time of revegetation and the re-establishment of animal populations (Vesk & Mac Nally 2006)

In addition to domestic stock grazing on public land within the study area, there are native grazers (kangaroos and wallabies) and feral grazers (feral cattle, rabbits, hares, fallow deer, feral horses/brumbies, goats and pigs). When in large populations, these additional grazers contribute to over-grazing of vegetation. The hard-hoofed feral cattle, brumbies and goats also contribute to trampling, soil compaction and erosion.

Climate Change, Greenhouse and Biolinks

Climate change, both natural and due to increased levels of greenhouse gases in the atmosphere, is described in chapter 4. This section looks specifically at the potential effects of climate change on biodiversity. Climate change represents a major new threat to biodiversity and ecosystem services for the 21st century with some predicting mass extinctions (Thomas et al. 2004). Climate change is predicted to change the distribution, configuration and abundance of species and ecosystem services.

The types of species most at risk from greenhouse effects have been divided into six categories (Mansergh & Bennett 1989; Brereton et al. 1995):

- Genetically impoverished and/or localised populations
- Poor dispersers and annual plants
- Specialised species, especially those dependent on mature vegetation, e.g. superb parrot
- Peripheral or disjunct populations
- Coastal species
- Montane and alpine species

The implications of climate change on the flora and fauna of river red gum ecosystems require further studies, especially for invertebrates. In theory, global warming could affect invertebrates by increasing the developmental rate of species, thus resulting in more generations each year for some species. This could occur both for herbivorous insects and for their natural enemies. Another possibility is that insects from cooler regions of the river red gum range could be displaced by species better adapted to warmer temperatures. This could promote invasive invertebrate species currently only found further north. The knowledge base regarding the invertebrate fauna on river red gums is inadequate to allow further speculation.

Modelled responses of fauna to climate change in southeastern Australia has lead to the identification of climatic refugia (areas where species will experience a climate similar to the present) and a series of biolink zones in Victoria (Bennett et al. 1992; Brereton et al. 1995), which have since been recognised in government policy (DCE 1992b). Biolink zones are areas that will maximise the capacity for species to "move", recolonise and reconfigure as they adapt to climate change (see Mansergh et al. 2005). The Murray River and associated riparian vegetation and wetlands have been identified as a key sub-continental scale "biolink".

A National Action Plan (NAP) has been developed for Australian biodiversity in response to greenhouse climate change (NRMMC 2004). In strategy action 5.1 (p. 27) the NAP seeks to implement "*strategies to reduce the physical barriers to movement to facilitate the migration and dispersal of terrestrial species and communities that are vulnerable to climate change*". The River Red Gum Forests study area has been identified as a major link, provided by its contiguity in linking different habitat zones (DCE 1992b; Brereton et al. 1995). However, vegetation conditions could be improved to maximise the river red gum's value as a biolink (ARIER et al. 2004). Further, recommended actions of the NAP include to "*identify and implement opportunities to re-establish native vegetation and enhance habitat for vulnerable species on private land through revegetation, vegetation management and land-use change program*". The varying width of native vegetation (in both NSW and Victoria) along the rivers provide opportunities to improve the area as a biolink.

Fire

Fire (see chapter 4) is vital for many Australian ecosystems and shapes the composition and distribution of plant and animal communities across Victoria. Plants have adapted to fire over millions of years and have various survival mechanisms. Some trees with thick bark may lose their canopy but survive the fire and grow new

Table 5.8 Comments on fire from explorers' journals.

Explorer (year)	Area	Extract
Hamilton Hume William Hovell (1824-25)	Ovens River & Goulburn River	'All the country from where we started this morning is all burning in every direction and the bush is all on fire….the blacks….'. (Hovell 1921:343)
		'…all the country around us appears to be on fire…'. (Hovell 1921:359)
		'The country is on fire in all directions. This appears to be the season for burning the old grass to get new.' (Hovell 1921:361)
Thomas Mitchell (1836)	Loddon River	'Fire, grass, kangaroos, and human inhabitants, seem all dependant on each other for existence in Australia….. Fire is necessary to burn the grass and form those open forests'. (Mitchell 1969:412)
Charles Sturt (1838)	Murray River (near junction with Edwards River)	'….. under a dark wood of gum trees scathed by fire to their very tops.' (Sturt 1838 cited in Sturt 1899:138)
	Murray River (general)	'When timber was again seen it was like the reeds, blackened by native conflagrations. Huge trunks and leafless limbs lay one across another on ground as black as themselves.' (Sturt 1838 cited in Sturt 1899:143)
		'The reeds had been burnt by the natives and in burning had set fire to the largest trees and brought them to the ground.' (Sturt 1838)

shoots from buds on the surface of the trunk and branches. Individual plants in other species may die but produce prolific seed, which take advantage of post-fire light, moisture and nutrients. A substantial proportion of native plant and animal species are dependent on fire for their continued survival and propagation. The life history characteristics (also termed 'vital attributes'; see below Noble and Slatyer (1980)) of individual plant and animal species determine their tolerance to fire. Different habitats and their resident species, such as grasslands, heathlands, woodlands and rainforests all have their own tolerances to fire.

Fire regimes are classified by frequency (interval between fires), intensity, season, and scale. Inappropriate fire regimes are fires occurring at frequencies, intensities, seasons, and scales that lie outside the ecological and physiological tolerances of resident plants and animals. The interplay of fire with plant and animal species and communities is complex, and inappropriate fire regimes are now recognised as a potential threat to sustainable ecosystems and biodiversity conservation under the *Flora and Fauna Guarantee Act 1988* (Scientific Advisory Committee 2003).

Native animals survive fire through mobility, shelter, and survival in unburnt areas. Although many individual animals are killed, populations survive and generally recolonise burnt areas as they recover. Sometimes, species in isolated small populations occupying a narrow ecological niche, such as the mountain pygmy-possum, may be at risk in a major fire.

Studies of charcoal records from sediment cores indicate that fire has played a role in shaping the landscapes surrounding the Murray River (C. Kenyon unpublished). Extracts from the journals of early European explorers (see Table 5.8) and overlanders suggest that low-intensity fires were a frequent occurrence in the River Red Gum Forests study area (Mac Nally & Parkinson 2005). An early settler in the Barmah region noted that Indigenous people set fire to the region approximately every five years (Curr 1883). Table 5.8, reproduced from Mac Nally (2005), compiles extracts from the journals. Unfortunately these reports do not refer specifically to riverine forests. It is likely that wildfires started by lightning, also occurred in riverine forests.

Current knowledge suggests that while river red gum saplings are fire-sensitive (Dexter 1978), large trees are generally able to survive low intensity fires (Mac Nally & Parkinson 2005). The Arthur Rylah Institute is currently curating and managing DSE's Vital Attributes database. This project includes interim recommendations in relation to the maximum and minimum fire intervals for different vegetation types (Cheal & Carter 2006). According to this data, riverine woodlands and forests are flammable only occasionally (i.e. after seasons with extended summer rains or flooding promote extensive new grass growth). Few species are geared to regenerate post-fire and thus fire is not a major regeneration opportunity for typical species. Floods are the main regeneration events. If fires occur, they are usually rapid, of relatively low intensity and limited extent, driven by fine fuels in the ground layer. Undisturbed forests are generally less flammable than logged and/or grazed stands as there is less grass in undisturbed forests.

Nor does the succession of plant species found in regenerating river red gum forests suggest that fire is a natural part of their life cycle. This vegetation does not have a suite of fire ephemerals and the hard- or cone-seeded species requiring fire to germinate are neither common nor dominant. Many riverine species from genera usually dependent on fire, germinate successfully and abundantly without fire. For example, while many wattle species (*Acacia*) in other habitats germinate after fire, local riverine species such as eumong and willow wattle do not use fire as their prime germination cue. Further, the river red gum forests and their associated riverine vegetation contain species with regeneration strategies that are keyed to different environmental cues, notably flooding.

DSE's Fire Management Branch is responsible for fire management in state forest, national, state or other parks, reserves or other Crown land. Other bodies, such as the Country Fire Authority, Parks Victoria and plantation managers, assist in both fire prevention and fire suppression activities.

DSE describe three different types of fire:

- wildfires that begin through processes not induced by management agencies (e.g. lightening strikes);
- fuel reduction fires that are lit by management agencies specifically to protect life and property; and
- ecological fires which are the active use of fire to alter vegetation and habitat structure to achieve specific biodiversity outcomes.

As described above, river red gums are particularly sensitive to high intensity fire and as such, fire needs to be managed to provide for low intensity and low frequency fire regimes throughout the majority of red gum forests. Accidental fires from escaped campfires need to be suppressed quickly for protection of both life and property and ecological values.

The maintenance of tracks is an integral part of most fire protection plans, including part of the permanent road network in the study area. Temporary tracks and firelines aid wildfire suppression, control regeneration and fuel reduction burns. These temporary tracks are generally closed and rehabilitated when the particular operation is completed. Development of additional tracks for fire suppression can have negative consequences for biodiversity conservation through direct removal of habitat, fragmentation of habitat and increasing access for predators such as cats and foxes.

Pollution, Chemicals and Salinity

Pollution in the study area occurs in many forms and has many causes. Water pollution by grey water and sewage into the River Murray from houseboats is discussed in chapter 11. Such pollution can increase nutrients in the water leading to algal blooms and fish deaths. Fertilisers, sediments and herbicides also run off farms into rivers and wetlands and have negative impacts on aquatic fauna. 'Rivertender' projects are currently being conducted in the Ovens River catchment to fence riparian zones and exclude stock with the aim of decreasing sediments introduced to the river systems (NECMA undated).

The broadest recent chemical application in the study area was used against plague locusts. This involved spraying young hoppers with insecticides or the Orthopteran-fungus *Metarhizium*. The non-target effects of insecticides or the fungus have not been assessed. Furthermore, larger-bodied insects such as locusts and grasshoppers are a major food of many water birds, and information of any adverse effects is lacking.

Salinity occurs naturally in the environment but is exacerbated by some current land uses (see chapter 3 for a further description). It is estimated that approximately 140,000 ha of irrigated land and 120,000 ha of dryland in Victoria are significantly affected by salinity, costing about $50 million per year (DNRE 2000). Salinity occurs when shallow rooted plants (such as annual crops) and the clearing of vegetation allow rain to pass through the root zone and into the ground water. This extra water dissolves salts, which are then drawn up to the surface and kill remaining vegetation. This is exacerbated by a reduction in floods. Intensive salinity can lead drive local fauna and flora extinct. Salinity extends beyond property boundaries (including that between public and private land) and is important for aquatic as well as terrestrial ecosystems.

The Kerang Lakes systems have been greatly changed by the altered water regimes in the area. Many lakes are much saltier and support much less biodiversity than they once did (RMCG & Brett Lane & Associates 2004). This increased salt comes from salty ground water in some cases, while other lakes have been used as salt disposal basins (e.g. Lake Tutchewop in South Australia). On the Chowilla plains 65 percent (greater than 6500 ha) of the floodplain trees are affected by salinisation (Overton et al. 2006).

SUMMARY

The biodiversity of the River Red Gum study area is both rich and rare, providing an important refuge and corridor for many species adapted to floods and wetter environments in an otherwise arid landscape. The forests and their associated wetlands contain significant cultural and environmental values and are internationally, nationally and locally recognised for their importance to a wide range of threatened and vulnerable species, including migratory birds. While little is known about many constituent species of the river red gum ecosystems, such as invertebrates, many threats have been identified and management strategies developed to reduce their effects on the biodiversity of this region.

6 Indigenous Land Associations

This chapter explores the relationship between Indigenous peoples and the land as well as the current extent of Indigenous involvement in land management and ownership. Opportunities to involve Indigenous people, including groups and representative organisations, in future public land management decision-making are examined.

HISTORY OF INDIGENOUS LAND ASSOCIATIONS

Indigenous associations with the land are profound and may be difficult for non-Indigenous people to understand. The Terms of Reference for the River Red Gum Forests Investigation specifically direct VEAC to consider possible opportunities for Indigenous management involvement and the Yorta Yorta Co-operative Management Agreement covering public lands within the study area (see Appendix 9). These matters are explored below together with information on public land management options and general models used for Indigenous involvement in land management. Aboriginal cultural heritage and its management are described in chapter 12 Cultural Heritage.

Relationship with the Land

For at least the past 50,000 years the River Red Gum forests along the Murray River and its tributaries have supported and nurtured Indigenous people. Resources gathered from the forests include plants, animals, water, minerals and stone. These resources were used to sustain a lifestyle that not only serviced basic needs such as food, clothing, tools, medicine, housing and heating, but also a rich cultural life with jewellery, ornaments, transport, mythology, art and crafts (Atkinson & Berryman 1983).

Understanding the physical environment and managing natural resources formed an important and integral part of the lifestyle patterns of everyday living for Aboriginal people. Accumulated knowledge gathered over hundreds of generations about specific foods, weather conditions, and seasonal patterns played an important role in influencing how Aboriginal people lived and practised their cultural beliefs. Significant forward planning and forethought was given to what plant, other food stocks and natural resources would be available in each location at different times of the year.

One of the best-known and most recorded land management practices was use of fire. Small-scale low-intensity fires were used to clear the landscape of bushy growth, and stimulate a flush of new shoots to attract animals to the local area. This practice formed an important food source for many Indigenous communities, although the specific details of timing and intensity have in many cases been lost (Esplin 2003).

River Red Gum forests supported many Aboriginal peoples including Bangerang, Bararapa Bararapa, Dhudoroa, Dja Dja Wurrung, Jarra Jarra, Jupagulk, Latje Latje, Ntait, Nyeri Nyeri, Robinvale, Tati Tati, Taungurung, Wadi Wadi, Wamba Wamba, Way Wurru, Wergaia, Yorta Yorta, and Yulupna. Each of these groups had deep spiritual links with the land.

These Traditional Owner groups have spiritual ties with specific tracts of land established over hundreds of generations often based on belief systems, practices, social and ceremonial rules and responsibilities that have developed over hundreds of generations and continue to evolve and exist today. The connection between people and land is expressed in terms of 'being related to' rather than 'owning' the land or country. Aboriginal people often express this relationship as being custodians rather than landowners.

> *Country is a place that gives and receives life. Not just imagined or represented, it is lived in and lived with.*
>
> *Country in Aboriginal English is not only a common noun but also a proper noun. People talk about country in the same way that they would talk about a person: they speak to country, sing to country, visit country, worry about country, feel sorry for country, and long for country. People say that country knows, hears, smells, takes notice, takes care, is sorry or happy. Country is not a generalised or undifferentiated type of place, such as one might indicate with terms like 'spending a day in the country' or 'going up the country'. Rather, country is a living entity with a yesterday, today and tomorrow, with a consciousness, and a will toward life. Because of this richness, country is home, and peace; nourishment for body, mind, and spirit; heart's ease.*
>
> *Each country has its sacred origins, its sacred and dangerous places, its sources of life and its sites of death. Each has its own people, its own Law, its own way of life. In many parts of Australia, the ultimate origin of the life of country is the earth itself… (Rose 1996)*

In some locations in the study area, Aboriginal people were also very active in altering the physical landscape to take advantage of natural seasonal events. Stone fish traps found at Barmah forest are evidence that local Aboriginal people had successfully manipulated waterways to provide readily accessible food sources.

Hundreds of other Indigenous cultural heritage sites are recorded from the study area including fresh water middens, scar trees, surface scatters, axe grinding grooves and mounds containing charcoal, burnt clay or stone heat retainers from cooking ovens, animal bones, stone tools and burial sites such as those at Barmah and Robinvale. Aboriginal associations with country are not limited to an interest in these particular sites or places, although the physical evidence found today is nonetheless important (see chapter 12).

Geographical or totemic features such as hills and rivers were (and still are) used to define and confirm tribal boundaries or country (see Map 6.1). Aboriginal people moved frequently between areas and met other groups for purposes of trade, ceremony, social gatherings, marriages, and so on. Highly developed and agreed protocols governed movements between or entering the traditional area or country of another group. Many of these protocols still apply and tribal boundaries are observed by many Indigenous people today.

These protocols are of particular relevance for the River Red Gum Forests Investigation because Traditional Owners continue to assert their right to exercise traditional laws and customs including accessing their homelands, decisions regarding who within the group is authorised to 'speak for country' and what can be spoken about. The continued existence of recognised language and clan groups who have responsibility for areas that form part of the study area will be a major consideration in the development of recommendations for River Red Gum Forests public lands. These Traditional Owner groups are recognised by government as having aspirations and authority to participate in discussions and decision-making processes for specific areas of land or country, particularly in relation to cultural heritage matters (DSE 2004g).

Post-Contact Aboriginal History in Victoria

The first European explorers to travel through the study area were Hume and Hovell in 1824, Sturt in 1830 and Mitchell in 1836, closely followed and in some cases preceded by cattle drovers and squatters who began to settle the region with little regard for the Indigenous inhabitants. Squatting was legalised in 1836 and Aboriginal dispossession increased as more people moved to the area.

By 1838 Aboriginal peoples had started a concerted resistance campaign retaliating against the invasion of their homelands by harassing stock and killing isolated Europeans (e.g. conflicts at Faithfull Creek near Benalla, Rufus River near Lake Victoria in NSW). Europeans responded by attempting to arrest Aborigines, frequently resulting in large numbers of Aboriginal deaths (Clark 1999). There are reports of massacres, abuses and deliberate poisoning—in many cases involving ancestors of the present-day Traditional Owners from the study area (Christie 1979; Clark 1995; Clark 1999).

The official response to these problems was to concentrate the Aboriginal population in missions or reserves. Missions were established and progressively disbanded at Buntingdale near Geelong (1836–1848), Mitchellstown on the Goulburn River (1839–1940), Lake Boga (1851), Yelta near Wentworth (1869–1885), Coranderrk near Healesville (1863–1924), Gayfield at Kulkyne Station (1874), Maloga NSW (1874–1888), Ebenezer near Dimboola (1859–1904), Cummeragunja near Moama NSW (1881–1953), Wahgunyah or Lake Moodemere (1891–1937) and Moonacullah near Balranald NSW (1916–1961). A number of Aboriginal people and families who originally occupied land in the study area were forcibly moved to other parts of Victoria or New South Wales. Many were relocated to missions at Mitchellstown, Maloga, Cummeragunja and particularly to Coranderrk where many children were sent (Atkinson & Berryman 1983).

Figure 6.1 Canoeing at Maloga (Caire, N.J. c.1884). The River Murray near Echuca and Barmah has always been an important site for Yorta Yorta and Bangerang peoples.

Source: Reproduced with permission of National Library of Australia, Image: an3096938-3-v.

Illness and starvation brought about by dispossession forced many Aboriginal people to depend on mission life. Although initially people were free to come and go, others were forcibly removed from their land and families. The social conditions of missions were usually very harsh and at some missions the policy of removing children began almost immediately with rations withheld if the children remained with their parents. Managers had a great deal of control of the movements of people to and from the mission grounds. Typically Indigenous languages and other customs were forbidden. Aboriginal people were frequently exposed to violence and abuse outside and sometimes also within missions (Clark 1999).

What written documentation exists of traditional Indigenous culture was largely prepared by squatters and missionaries, who may have been biased or lacked in-depth understanding of social structures or practices. However, a vast volume of oral history has been passed on by Indigenous communities, consistent with past traditions.

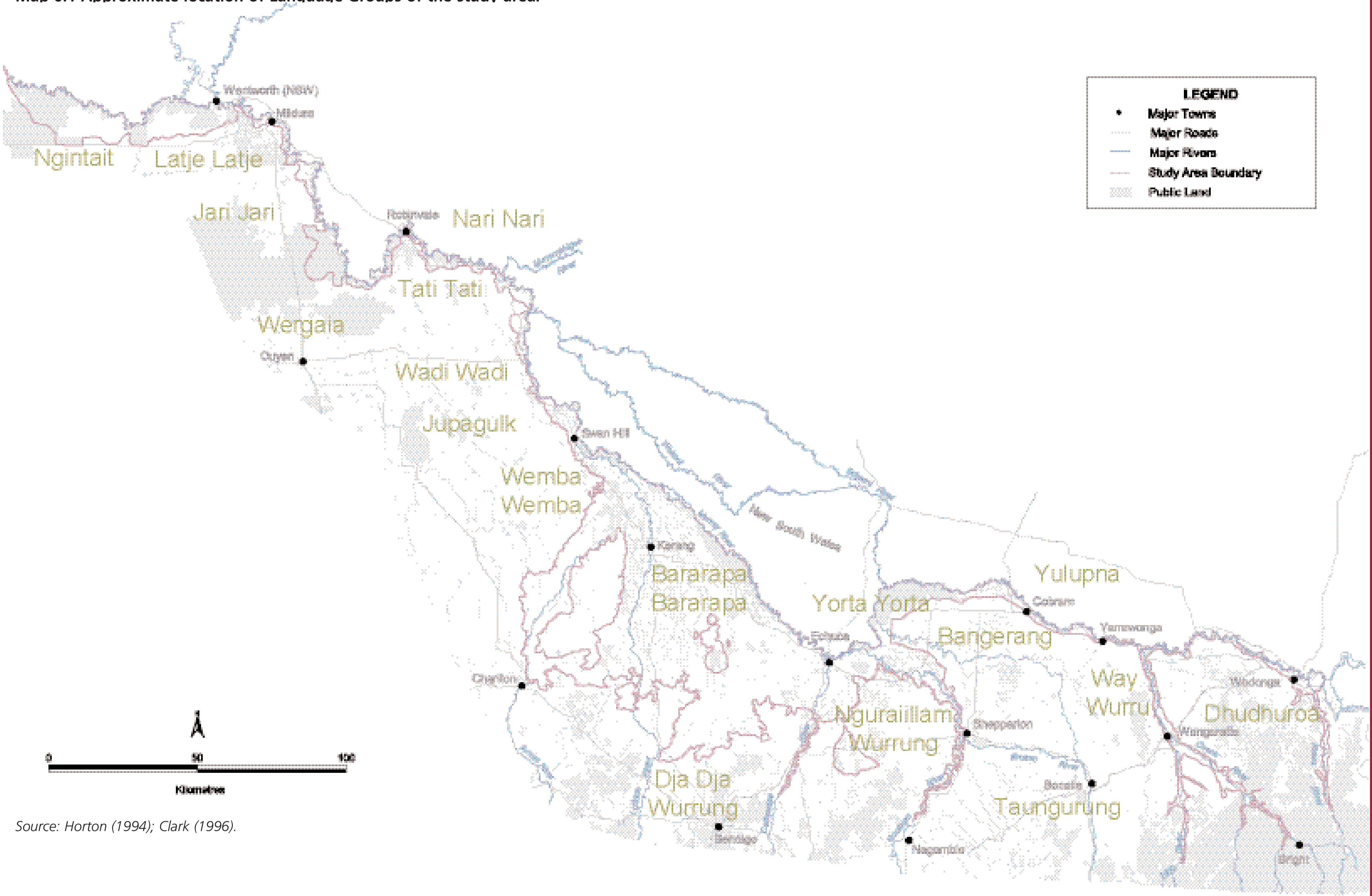
By the end of the 19th century only a small population of Aboriginal people lived on missions and government stations, with most living and working in nearby areas. Most missions and stations were phased out by the 1920s. Some mission lands are now under the control of Aboriginal communities (e.g. Cummeragunja and Coranderrk).

Present Day

Aboriginal people have continued to live throughout Victoria, often with strong ties to their original clan and tribal areas. Today, Aboriginal people contribute a vibrant and valued aspect of Australia's multi-cultural landscape expressing unique cultural identities, and having an important role to play in providing advice to government about land management issues. Whilst open racism has declined as a result of more enlightened community attitudes and anti-discrimination legislation, Aboriginal disadvantage in health, education and employment remains a challenge for governments and for Aboriginal people (see chapter 8 Current Social and Economic Setting).

For many years, equality and social justice has been the highest priority for Aboriginal people. Recent Australian history has been marked by an ongoing effort to gain official recognition and compensation for Indigenous peoples' individual and collective cultural rights. In 1835, John Batman signed a 'Treaty' with eight Aboriginal 'Chiefs' to acquire large tracts of land in what is now

Map 6.1 Approximate location of Language Groups of the study area.



Source: Horton (1994); Clark (1996).

Source: Reproduced with permission of National Library of Australia, Image: an3096938-2-v. Caire, N. 1884.

the State of Victoria. The British Government repudiated the Treaty asserting that (under British law) Aboriginal people did not have title to or ownership of the land—the notion of *terra nullius* (for further discussion of this complex issue see Borch 2001; Buchan & Heath 2006).

Successive generations of Aboriginal people have used the legal system and other means to gain recognition for their rights and to regain control and title over their traditional lands. Significant events include:

- Correnderrk Indigenous community petition to the State government (1886) requesting permission to leave the premises for work and the good of their health;
- Cummergunja 1939 walk-off in which over 200 Indigenous residents protested the poor conditions—the first mass strike of Aboriginal people in Australia;
- the 1967 Referendum to alter the Australian Constitution conferred legal responsibility for all Aboriginal people in Australia on the Commonwealth Government;
- the Land Rights Movement in the 1960s which led to the 1968 Yirrkala Aboriginal people (Arnhem Land, NT) claim seeking recognition of traditional title to land;
- the Aboriginal Tent Embassy set up on lawns of Parliament House (Canberra) in 1972;
- the first motion in the new Parliament House (Canberra) in 1988 acknowledging Aboriginal and Torres Strait Islander people as 'the original occupants of Australia';
- the 1992 ruling by the High Court of Australia rejecting the doctrine that Australia was *terra nullius* (land belonging to no-one) at the time of European settlement confirming that the common law of Australia recognised the existence of native title to land (*Mabo v. Queensland*);
- the 1993 High Court majority decision which held that Queensland pastoral leases under consideration in the *Wik* case did not confer exclusive possession upon the lessees;
- the Commonwealth *Native Title Act 1993*,
- Yorta Yorta Native Title claim and appeal (described in more detail below); and
- in Victoria, the 2005 Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagulk native title claim negotiated agreement which confirmed that native title exists in parts of the determination area comprising some 45 ha of public land in western Victoria.

Access to natural resources on public land remains a commonly expressed aspiration of Indigenous people within the study area. This includes take and use of wildlife, fish and plants for personal, domestic and under certain conditions commercial use. Aboriginal people are subject to the same laws or policies as other people in relation to use of resources. However, the *Native Title Act 1993* allows native title holders to carry out certain activities under certain conditions, including hunting, fishing, gathering and camping. Similarly, the *Wildlife Act 1975* allows the Secretary of DSE to permit the take, use and so on of wildlife for Aboriginal cultural purposes while the *Fisheries Act 1995* enables a special permit to be issued for fishing associated with a cultural or ceremonial event.

CURRENT AND POTENTIAL INDIGENOUS INVOLVEMENT IN LAND MANAGEMENT

Indigenous Land Ownership in Victoria

Indigenous policy, strategies and resources are fragmented and distributed across various government and non-government bodies. There is no central database or land registry containing specific information about the amount of land owned by Victorian Aboriginal people, groups and organisations or by Victorian Aboriginal businesses (private).

The total area Aboriginal people 'own' and manage in Victoria is approximately 11,340 ha equating to approximately 0.05 percent of the state (228,138 km^2) (Strategy for Aboriginal Managed Lands in Victoria Project team 2003). This land comprises the following:

- 8158 ha (68 percent) is used primarily for non-commercial activities. Except for Lake Tyers the seven largest blocks of land are in southwest Victoria:
  - > Lake Condah 1820 ha
  - > Lake Tyers 1627 ha
  - > Framlingham Forest 1120 ha
  - > Deen Maar Indigenous Protected Area 453 ha
  - > Framlingham 248 ha
  - > Tyrendara Indigenous Protected Area 480 ha
- 3770 ha (32 percent) is used mainly for commercial purposes.

These figures do not include land purchased by the Commonwealth under the Community Housing Infrastructure Program (CHIP) or land purchased by the Aboriginal Housing Board of Victoria. Approximately 1000 ha at Cummeragunja Mission is owned by the NSW Aboriginal Land Council and occupied by Aboriginal people—the majority of whom are from Victoria—and 4047 ha of land at the Warrakoo property in NSW near Mildura owned by Mildura Aboriginal Corporation.

Properties 'owned' by Indigenous communities or groups purchased through Commonwealth and State or Territory governments and the Aboriginal and Torres Strait Islander Commission (ATSIC) have caveats on the title which constrain or restrict the sale or mortgaging of property subject to approval by the relevant agency. The existence of caveats means that, in most cases, the land cannot be used by Aboriginal land holders to secure finance for enterprise development.

Table 6.1 Summary of area in Victoria owned by Indigenous people.

Land Acquisition Method	Area (ha)	% of Total
Land acquired through Victorian Legislation	1710	15
Land acquired through Commonwealth Legislation	1163	10
Land acquired through ILC purchases	4273	38
Land acquired through Government Department grants*	4196	37
Total	**11,342**	

Note: Asterisk denotes that ATSIC land is included in this category

The Indigenous Land Corporation (ILC) has purchased 28 properties on behalf of Indigenous people or groups in Victoria. In limited circumstances, the ILC has allowed land holders to seek loans using the land as security, and in some instances provided security on behalf of the land holder.

When compared with land owned or controlled by Indigenous peoples in most other Australian States and Territories, the amount of land owned by Victorian Aboriginal people, groups and organisations is small (Table 6.2). This partly reflects higher Indigenous population numbers interstate, both numerically and as a proportion of the general population, and the existence of more Aboriginal specific communities in these States and Territories (many of which are overseen by Aboriginal Local Governments).

It should be noted that information contained in Table 6.2 is a minimum estimate. The actual extent of land holdings by Aboriginal people has increased since these calculations were made as a result of land purchases by the ILC and governments, and under various management agreements, although detailed information is difficult to obtain and no nationwide summary has been prepared for more than ten years e.g. Mutawintji National Park (NSW) was returned to its Traditional Owners in 1998 and comprises 68, 912 ha.

Native Title

On 20 May 1982, Eddie Mabo and others of the Meriam people began their legal claim for ownership of the island of Mer in the eastern Torres Strait. It was not until 3 June 1992—by which time Eddie Mabo had died—that the case was decided. The High Court determined that the Meriam people did have traditional ownership of their land and that British possession had not eliminated their title—'the Meriam people are entitled as against the whole world to possession, occupation, use and enjoyment of the lands of the Murray Islands' (Mabo and Others v. QLD (No. 2) 1992).

The judgments of the High Court in the Mabo case inserted the legal doctrine of native title into Australian law. In recognising the traditional rights of the Meriam people to their islands, the Court also held that native title existed for all Indigenous people in Australia prior to Captain Cook's declaration of possession in 1770 and the establishment of the British Colony in 1788 (AIATSIS 2004). The new doctrine of native title replaced the doctrine of *terra nullius* (no-one's land) on which British claims to possession of Australia were based. In recognising that Indigenous people in Australia had prior title, the Court held that this title exists today in any portion of land where it has not legally been extinguished. This decision altered the foundation of Australian land law.

Following the High Court decision, the Federal Parliament passed the *Native Title Act 1993*, enabling Indigenous people throughout Australia to claim traditional rights to unalienated Crown land. The Act adopts the common law definition of 'native title' as a recognition of rights and interests over land and water possessed by Indigenous people in Australia under their traditional laws and customs.

The Act was extensively amended in 1998 (the 'Ten Point Plan') following the 1996 *Wik v Queensland* High Court native title decision, which clarified that native title rights and interests may co-exist over land which is or has been subject to a pastoral lease, and possibly other forms of leasehold tenure.

The main objectives of the *Native Title Act 1993* are to:

- provide for the recognition and protection of native title;
- establish ways in which future dealings affecting native title may proceed and to set standards for those dealings;

Table 6.2 Area owned in Australia by Indigenous people (areas are in thousands of square kilometres).

Category	NT	WA	SA	QLD	NSW	Vic	Tas	ACT	Total	% of Aust
Freehold	516.8	-	189.0	20.5	0.4	<0.1	-	-	726.7	9.5
Leasehold	19.2	126.1	0.6	18.9	1.1	<0.1	-	-	165.9	2.1
Reserve	-	199.4	-	2.8	-	-	-	-	202.2	2.6
Total	536.0	325.5	189.6	42.2	1.5	-	-	-	1,094.8	15.24
% of Total	49.0	29.7	17.3	3.9	0.1	<0.1	0.0	0.0		

Source: Land Tenure database 1993, Geoscience Australia, ©Commonwealth of Australia

- establish a mechanism for determining claims to native title; and
- provide for the validation of developments invalidated because of the existence of native title.

The Act also established the National Native Title Tribunal and governs how native title applications are administered across Australia. A number of Aboriginal groups have submitted claimant, non-claimant and compensation applications to the National Native Title Tribunal. A 'Claimant Application' made to the Tribunal over land owned by Commonwealth or State or Territory governments does not confer land ownership to the applicant. The Tribunal may confirm that 'native title' exists to a specific area of land, however, this usually relates to the applicant having the right to continue to practice their law and customs over traditional lands and waters while respecting other Australian laws. This could include visiting an area to protect important places, making decisions about the future use of the land or waters, hunting, gathering, and collecting bush medicines (NNTT 2000).

Victorian Traditional Owner groups have continuously stated that they and previous generations have never sold, traded or freely given their traditional lands to European settlers or any Australian government. This includes all public land within the River Red Gum Forests study area. To date, Victorian Aboriginal people have lodged 73 native title applications with the Tribunal (NNTT 2006c).

Yorta Yorta People Native Title Claim

One of the first native title applications was submitted on 21 February 1994 by Victoria's Yorta Yorta people. The claim area covered 1140 sq km of land and waters along the Murray, Ovens and Goulburn Rivers in Victoria and 720 sq km of land and waters in New South Wales bounded roughly by Albury, Finley, Deniliquin, Cohuna, Shepparton, Benalla and Wangaratta. A significant portion of public land within the study area lies within traditional country claimed by the Yorta Yorta people. The Yorta Yorta people sought (among other rights):

- the right to use, occupy, inhabit and possess the area and the natural resources;
- the right to restrict access to the claimant area;
- the right to exercise their rights, obligations and duties in accordance with their traditional laws and customs; and
- the right to use mineral and natural resources found in or below the area.

On 18 December 1998, Justice Olney of the Federal Court determined that native title did not exist in relation to the claimed land and waters because a continuity of acknowledgment and observance of traditional laws and customs could not be demonstrated. On 28 January 1999 the Yorta Yorta people appealed this decision asserting, among other things, that an incorrect test was applied to decide whether native title existed. The Yorta Yorta people also argued that Justice Olney had erred in his evaluation of the oral evidence of the native title claimants. The appeal made to the Federal Court in February 2001 and a subsequent appeal made to the full bench of the High Court in December 2001 were both dismissed, albeit not unanimously. The determination issued by the National Native Title Tribunal stated that 'native title does not exist' in areas claimed by the Yorta Yorta people. Yorta Yorta people continue to pursue land justice and compensation for loss of their traditional country.

This process of litigated native title determinations has proven to be extremely long, expensive, resource-intensive, with long-term uncertainty for all parties involved. It has also proved painful and divisive with many assumptions and interpretations of past Indigenous relationships to country made by non-Indigenous people, and places modern legal judgements upon what current practices are 'traditional' in order to demonstrate continuity with country. In essence native title is a legal concept that has developed a specific legal meaning as cases have been pursued through the courts. The anthropological meaning of native title—traditional law and customs and connection to country—is likely to be in many cases very different to the legal definition that has evolved under the *Native Title Act 1993* (Ellemor 2003).

The very slow progress with Victorian native title claims through the courts is evident. Current Victorian Government policy is to mediate rather than litigate native title applications and to comply with the provisions of the *Native Title Act 1993* (DoJ 2000). Government has developed Guidelines for Proof of Native Title, Victoria (DoJ 2001).

The native title process has been the main mechanism used by governments to determine whether the rights of Indigenous people still exist for specific Crown land areas. There are, however, a number of other options that can be implemented which will significantly reduce the costs associated with a native title claim and recognise the relationship that Indigenous people have with country.

Negotiated Agreements Approach —Yorta Yorta Co-operative Management Agreement

On the June 10, 2004, the Victorian Government signed a Co-operative Management Agreement with the Yorta Yorta People which established a formal and on-going role for Yorta Yorta people in the management of 50,000 hectares of Crown land and waters. The agreement covers Kow Swamp, Barmah State Park, Barmah State Forest, and public land and waters along the Murray and Goulburn Rivers. The Agreement does not affect fees or access arrangements to parks, forests or reserves. An extract from the agreement is presented in Appendix 9. The Joint Body was formally appointed in December 2005 at which time the agreement commenced. There is an opportunity for ongoing internal review of the Joint Body role and structure and review by the Minister after two years.

The Yorta Yorta Co-operative Management Agreement is a partnership based on recognition, mutual respect and shared goals under which the State of Victoria recognises the cultural connection Yorta Yorta people have to areas covered by the Agreement. Key points under the Agreement include the establishment of a committee known as the Yorta Yorta Joint Body to provide advice to the Minister for Environment in relation to management of designated Crown land and waters. The Joint Body is funded to employ staff for work outlined under the agreement and provides a forum in which ideas may be exchanged, management issues discussed and recommendations made for the future use of land and water under the agreement.

Government decision-making processes and management outcomes involve Traditional Owners, and the Minister must consider recommendations of the Joint Body as well as other bodies with management responsibilities. The Minister for Environment retains ultimate decision-making authority.

Indigenous Land Use Agreements (ILUA)

Aboriginal native title groups may enter into voluntary Indigenous Land Use Agreements (ILUA) with land holders over the use and management of land and waters as well as about matters such as exploration and mining developments, sharing land and exercising native title rights and interests. ILUAs can be made separately or as part of a formal native title determination. Courts are not involved in the ILUA process which is conducted entirely between the parties and may relate to specific issues such as future developments, coexistence of native title rights with other rights, access to an area, extinguishment of native title, and compensation.

By making agreements, Aboriginal people have in some places gained benefits such as employment, compensation and recognition of their native title whilst other parties to the agreement may obtain the use of land for development or other purposes. Since the *Native Title Act 1993* was amended in 1998 the Native Title Tribunal has registered 229 ILUAs (area agreements) throughout Australia between Indigenous groups and others—including pastoralists, miners, state, federal and local governments (NNTT 2006a) (Table 6.3). A broad range of agreements has been reached over national parks, exploration areas, local government areas and pastoral leases (NNTT 2006a). Examples of recent agreements are provided below.

Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalak Native Title Determination

The Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk native title determination (finalised in December 2005) was the first to be made by agreement or consent in Victoria. All parties agreed, through mediation, that the native title claimants have non-exclusive rights under traditional laws and customs over part of the area they claimed in the Wimmera region of western Victoria. These rights are also subject to the laws of the State of Victoria and the Commonwealth of Australia and the terms and conditions of co-existence protocols between the parties established under the agreement (NNTT 2006d).

The consent determination is limited to approximately 26,900 hectares of Crown reserves along the banks of the Wimmera River, and does not include the waters of the river. This represents about two to three per cent of the original claim area. Part of the agreement comprises the grant of freehold title to three parcels of land (15.7 ha in total) over which the native title holders demonstrated a strong cultural and historical connection (including land near the former Ebenezer Mission site). The terms of the settlement involve a determination that native title does not exist over the remainder of the claim area, although native title holders will have other rights and benefits in the remaining area (see below).

The ILUA sets out how and when the native title holders will engage with the Victorian and Australian Governments about future dealings in the agreement area. The rights of others, whether covered by the agreements or where native title exists, have not changed. All non-native title interests within the area are recognised and protected by the determination. For example, a person with a grazing licence in the area is able to continue to operate according to their grazing licence and there will be no change to current public access to the area.

Among other things, the ILUA ensures that the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk peoples will continue to have a say about certain types of developments in the area where their native title rights have been recognised. The ILUA acts as an umbrella agreement for several other related agreements that form part of the settlement package between the native title claimants and the Victorian Government but which are not part of the consent determination. These related agreements provide for a range of other measures, including:

- recognition (including signage) of the cultural ties the native title claimants have to the area;
- establishment of a consultation process for certain types of developments;
- streamlined processes for the approval of licences and permits for Traditional Owners to hunt, fish, gather and conduct cultural events;
- co-operative management of some areas e.g., national parks; and
- funding to support administrative expenses, capital funding for a cultural centre and freehold land improvements.

Adnyamathanha Native Title Claim (South Australia)

A recent ILUA and associated co-management agreement negotiated between the South Australian Government and the Adnyamathanha native title claimants provides for the Traditional Owners to co-

Table 6.3 The numbers of Indigenous Land Use Agreements (Areas) registered to 30 June 2006 in each State or Territory.

ILUA	QLD	NT	Vic	NSW	SA	WA	ACT	TAS	Total
Total	117	73	22	5	9	3	0	0	229

Source: NNTT website last updated 30-6-2006, ©Commonwealth of Australia manage the Vulkathunha-Gammon Ranges National Park in the northern Flinders Ranges (NNTT 2006b). This is the first such agreement relating to a national park in South Australia. As part of the agreement, the native title claimants excised the park from the claim area in exchange for recognition of traditional rights and interests, and equal representation on the board appointed to manage the park. Public access to the area encompassing about 128,000 ha will not be affected by the ILUA.

Resolution of the native title claim covering the national park via an ILUA process has allowed the claim over the remaining area to proceed. This process has been facilitated by a statewide ILUA strategy (SAMLISA Steering Committee 2000) and supported by the 2004 amendments to the legislation governing national parks in South Australia (NNTT 2006b).

Models of Indigenous Involvement in Land Management

Indigenous people are involved to varying degrees in land management throughout Australia. Various models of land management have been used to describe the level to which Aboriginal people are involved.

A spectrum of arrangements exists for the involvement of Indigenous people in land and resource management. These can be divided into several categories, with a grouping of three categories commonly referred to as co-operative management (Figure 6.2).

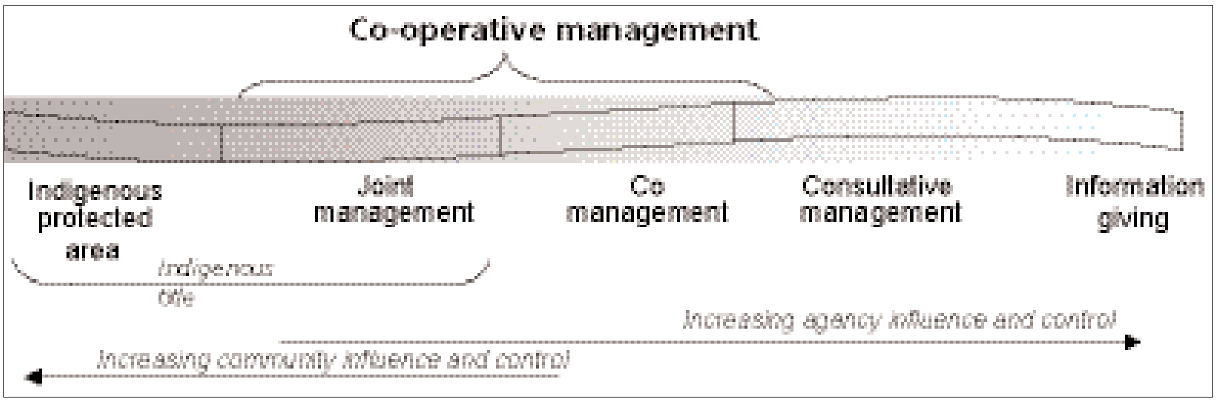
The difference between the various co-management and consultative arrangements, in particular, is not always distinct. Consultative management is considered by some to be a lower-level decision-making structure than forms of co-management and joint management. However, this is largely dependent upon the relationship established between Traditional Owners and land management bodies.

While there is no blueprint for successful arrangements, the arrangements offer an important and flexible mechanism to test and develop cooperative relationships between management partners, making long-lasting agreements easier to achieve. It is possible a Traditional Owner group may initially become involved in land and resource management through a consultative model and progress to another model with more decision-making power as partnerships, capacity and capabilities develop.

This staged approach perhaps offers a way of limiting the disappointment felt by Traditional Owners when aspirations for governance and decision-making powers have not been met because plans for increased involvement have progressed only where community capacity and management relationships have become established. It also limits outside criticisms that target a perceived inability for a 'new' Indigenous land management regime to meet mainstream expectations or standards.

Described below are examples of existing arrangements under Consultative, Co-management, Joint management and Indigenous Owned or Managed Land models, with examples provided for each. Possible approaches for Indigenous land management and the way in which these models have been used is described in chapter 19 Issues.

Figure 6.2 Current arrangements for Indigenous involvement in public land management.



Source: Modified after Borrini-Feyerabend (1996).

Consultative Management

Consultative Management involves consulting Indigenous people and groups about management matters, but without any formal role in decision-making and limited recourse if a decision is unfavourable or contrary to Traditional Owner practices or desires for land management. This is the main model used by the Department of Sustainability and Environment (DSE) and Parks Victoria (PV) in its dealings with all stakeholders, including Indigenous groups. Consultative management arrangements provide an entry into public land management that may progress to arrangements with greater decision-making responsibilities over time.

The Yorta Yorta Co-operative Management Agreement is an attempt to establish a model for Indigenous Community participation in public land management in a more structured and formal way. While called a co-management arrangement, there is no authority vested in the Joint Body with regard to land management decision-making.

Co-Management

Co-management enables certain public land management issues to be addressed in a close working relationship between government and one or more Aboriginal groups, in accordance with a memorandum of understanding or other forms of agreement. Management decisions are shared to varying extents between the Aboriginal group or groups and the state agency commonly through a body such as a board, committee of management or advisory body, with ultimate decision making powers remaining with the jurisdiction. In other forms of co-management, the body could also include other interest groups in, for example, an advisory group or committee of management comprising representative interests.

In Victoria, management arrangements with the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk and Yorta Yorta peoples are restricted to an advisory capacity under the current provisions of the *National Parks Act 1975*. Management responsibility, including resource allocation, remains with the government land management agency and overall responsibility with the Minister. These examples are more clearly *consultative* than *co-management* models of land management.

The Forests Act 1958 and the *Crown Land (Reserves) Act 1978* contain provisions that enable increased levels of involvement and shared decision-making with Indigenous groups in State forests and Crown reserves. Recently a co-management arrangement has been established between government and Latji Latji Traditional Owners and other key community members for two areas of cultural heritage significance in Wallpolla West State Forest. The area will be managed as an Archaeological and Natural Interests Reserve under the *Forests Act 1958*. The committee of management has evolved from a working group established in 2003 to undertake rehabilitation and protection works for Aboriginal burial sites located on the floodplain forests west of Mildura.

An example of co-management is the recent agreement between the South Australian Government and the Adnyamathanha native title claimants to jointly manage the Vulkathunha-Gammon Ranges National Park (see above). Under the ILUA the Traditional Owners will be involved in all management decisions and have equal representation on the board appointed to operate the park (NNTT 2006d). In NSW the National Parks and Wildlife Service (NPWS) has established at least nine co-management arrangements in which the government and local Aboriginal groups share responsibility for management and decision-making.

Joint Management

Joint Management transfers title to Crown land to an Aboriginal group or groups and then leased back to the

State for a finite period or some other form of agreement where existing rights and interests are guaranteed. This is sometimes referred to as a 'hand-back lease-back' model of land management. Management decisions are shared between Traditional Owners and the relevant land management agency of government (the lessee) normally through a body of management. The lease agreement continues beyond its agreed term until a new lease is negotiated. This guarantees the continuation of existing rights and interests, including those of the State's for decision-making authority, and is usually secured by legislation.

An example of Joint Management is Kakadu National Park and World Heritage Area in the Northern Territory comprising approximately 50 percent Aboriginal land under the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976.* Key features of this agreement are the lease arrangements between the Aboriginal owners and the Commonwealth Government over a 99-year term. A breach in the lease conditions will return full control of the land to the Aboriginal owners and the termination of the lease. An annual rental and percentage of park revenue is returned to the Traditional Owners as well as enterprise development opportunities including tour operators' induction schemes, Aboriginal involvement in park management, encouragement in business and commercial initiatives. The original lease agreement did not provide for formal joint management structures, but this was subsequently incorporated. Other examples exist at five NSW national parks at Mutawintji, Biamanga, Gulaga, Mount Grenfell Historic Site (NSW), Booderree and Booderee Botanic Gardens near Jervis Bay (Commonwealth Territory) and some 30 further parks and reserves in the Northern Territory including the Nitmiluk National Park encompassing Katherine Gorge.

To date, no joint management arrangements for national parks have been entered into between Traditional Owners and the Victorian Government. Amendment to the *National Parks Act 1975* would be required to enable this management arrangement to be established over any Victorian land scheduled under the Act.

Indigenous Owned or Managed Land

An example of Indigenous owned or managed land can be found at the *Tyrendarra Indigenous Protected Area*, which is owned and managed by the Winda Mara Aboriginal Trust (see detail below).

In Victoria, such lands may have been acquired through site-specific legislation (e.g. *Aboriginal Land (Ebenezer, Ramahyuck and Coranderrk) Act 1991*), a restricted Crown grant or through funds provided from the Commonwealth Indigenous Land Fund. In the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagalk Native Title settlement the State Government has allocated funds and three parcels of culturally significant land totalling some 45 ha and $2.6 million over five years to meet costs associated with land management activities.

For protected areas, agreements may be reached with government agencies for support in areas such as pest plant and animal control, fire protection, threatened species management and management planning. Such arrangements enhance the opportunities for increased Indigenous participation in the management of government-controlled protected areas, including through contracted services or co-management arrangements.

Examples of Aboriginal owned or managed land in Victoria include:

- Deen Maar Indigenous Protected Area (428 ha) which is a nationally significant ephemeral wetland system on the southwest Victorian coast near Yambuk. Purchased in 1993 by ATSIC (the now abolished Aboriginal and Torres Strait Islander Commission) for the Framlingham Aboriginal Trust, the area is culturally significant having connections with Deen Maar Island and the Creator Spirit Bunjil. It is also a site where numerous battles were fought with colonists during the Eumeralla wars in the 1840s and 1850s.
- The Tyrendarra Indigenous Protected Area (480 ha) owned and managed by the Winda Mara Aboriginal Trust was purchased in 1997 by ATSIC. The site contains archaeological remains of a large-scale pre-contact aquaculture system of the Gunditjmara people which is still visible today.
- Wallpolla West State Forest contains a number of culturally significant sites. Government land management agencies have established a joint committee of management with the Latji Latji Traditional Owners under the *Forests Act 1958* to formalise working relationships established during rehabilitation and management of Aboriginal cultural heritage sites.

In other states, Aboriginal communities have freehold ownership of land. In Queensland, 55 Land Trusts have been established under the state's *Aboriginal Land Act 1991* or *Torres Strait Islander Land Act 1991*. In this case the grantees may restrict access to the land, however it can never be sold or transferred, and any lease issued to a non-Indigenous person or group for more than 10 years must be approved by the Queensland Minister responsible for Natural Resources.

Public Land Use Categories

VEAC and predecessor bodies have in the past encouraged government and Indigenous peoples to work together in public land management (VEAC 2004). However, to date there has been no public land use category that specifically requires Indigenous management. In some cases, Indigenous people have been more concerned with the level of Indigenous involvement in management than the underlying land use category (e.g. VEAC 2004). Implications of increased Indigenous involvement for the existing public land use system are explored in chapter 19 Emerging Themes.

VEAC will undertake a special consultation program to pro-actively seek the views of Indigenous people and groups in the study area on opportunities for increased involvement in public land management. The models described above will serve as the basis for this consultation, but should not limit the development of variations to the models—or indeed entirely new models—to suit particular local circumstances.

7 Non-Indigenous History

The resources of the river red gum forests and floodplains along the River Murray have sustained European settlement since 1836. This chapter explores key themes of European history and locations of significant cultural heritage.

European explorers, travellers and settlers have responded in various ways to the physical environment of the study area. Their responses have, in turn, shaped the cultural landscape of the river red gum region. The post-contact history of the study area can be traced through the key stages of settlement including pastoralism, gold seeking, selection and closer settlement. Records of the various waves of settlers who made homes for themselves, and the government infrastructure, which has supported European settlement, survives in many places, today.

The most enduring legacies of the first white explorers and overlanders are the names they chose for places and features of the study area. Markers and cairns trace their physical tracks. These memorials are typified by cairns to Sturt east of Merbein, to Hume and Hovell at Myrtleford and to Mitchell at Mount Hope. Substantial homes define the later squatting era. For the most part, little remains of the original pastoral complexes except for tanks, sheep washes and small graveyards, for example on the former Boort run. The remains of a stub fence belonging to Tyntynder station can be seen on a section of the Murray Valley Highway north of Swan Hill.

Gold discoveries in the early 1850s in the Ovens Valley brought thousands of prospectors to the areas of Myrtleford, Rutherglen, Wahgunyah and other places just outside the study area. The physical evidence of the fevered hunt for gold is found today in many places within these townships and in the nearby forests.

The riverboat or paddle-steamer industry, focused on the port of Echuca, played an important role in transporting timber and wool to markets—a role consolidated by the building of the railway in 1864 connecting the town to Melbourne. The intact wharf, port area and paddle-steamer of Echuca provide an evocative link with that period of history. Markers noting distances were used for navigation and can still be seen along the banks of the River Murray.

The era of selection, especially under the *Land Act 1869*, saw the subdivision of the study area into wheat and sheep farms, and has broadly defined land subdivision and land-use since that time. Many farmhouses built at this time of settlement survive today. Several townships surveyed during selection continue to serve their farming hinterland while all that remain of other settlements are sites—some on public land—of schools established under the state system of education from 1872, lone community halls, churches and cemeteries.

Roads and railways connected communities within the study area with larger townships and markets. Part of an early coach road between Swan Hill and Wentworth can be seen at Wood Wood, north of Swan Hill. Surveying of railways often initiated the establishment of townships and, in some cases, resulted in towns being moved to take advantage of rail services. Rochester was moved from east of the Campaspe with the opening of the Echuca line in 1864, and Pyramid Hill was moved in 1883 when the Kerang line was built. A chimney, cemetery and a commemorative plaque mark the former Pyramid Hill town site.

Other lines were built to transport raw products. In 1899, a narrow gauge railway between Wangaratta and Whitfield, perhaps initially used for timber, later transported local produce such as tobacco. Parts of it can still be seen today, as can the Kerang-Koondrook light rail which opened in 1924 and transported timber from the River Murray region. Bridges were also important connections between regions. Significant bridges in the study area include those over the Goulburn River, for example, Stewarts Bridge at Kanyapella, McCoys Bridge at Wyuna and Yambuna Bridge between the two.

Water supply to the study area started with the establishment of irrigation trusts from 1883. A pump shaft and canal at Murchison hint at an ambitious scheme by the United Echuca and Waranga Waterworks Trust to irrigate a large tract of land between the Goulburn and Campaspe Rivers in 1885. The old Cohuna headworks (from around 1889) can be seen on the River Murray at Gunbower Island. Much of the irrigation infrastructure constructed by the State Rivers and Water Supply Commission for closer settlement from the early 1900s is still in use. This infrastructure demonstrates how water was brought to the area and, after the effects of waterlogging and salinity were realised, how surface water was drained away. The Waranga channel, surveyed in 1905, is a significant example of how water is transported for stock, domestic and irrigation use through the one system. Flumes were erected in the 1920s to carry water across the Mallee and can still be seen at Miralie. Large pumping stations to raise water to channel levels are evident at Mildura, Redcliffs, Merbein, Millewa and Robinvale.

Several former forest mill sites are known with other forest activities, such as grazing, exemplified by the muster yards in the Barmah State Forest. Arbuthnots mill at Koondrook and Murrays mill in Echuca are still in use as timber mills on public land. These themes are explored in more detail below.

SETTLEMENT

European settlement of the study area commenced in 1836 and may be characterised by a number of themes including exploration, settling, transportation, water management, industries and recreation. Each of these are important for understanding the history of the region and are described in detail below.

Explorers and Overlanders

The earliest recorded European view of the study area was by Hamilton Hume and William Hovell on an exploratory expedition from New South Wales to Corio Bay. They crossed a large river they named the Hume (the Murray) near the site of present day Wodonga in 1824 (Figure 7.1). They crossed the Hume again and the

Mitta Mitta above their junction, and named the Ovens, near present day Everton, and the Goulburn, near Cathkin (Powell & Duncan 1982).

Charles Sturt charted the course of the River Murray in 1830 below the junction with the Murrumbidgee and gave the river its present name in honour of George Murray, British Secretary of the State for the Colonies (Davison et al. 1998). Surveyor General Major Thomas Mitchell made an exploratory excursion through the area in 1836. Mitchell named the Loddon, Campaspe and Avoca Rivers on this expedition. Mitchell made several errors in identifying rivers, naming a stream at Swan Hill, the Goulburn when it was actually the Marraboor (Little Murray) River which connects the Loddon River and River Murray. He also named a watercourse the Yarrayne, which was already known as the Loddon. On two later occasions he crossed this same stream again, this time identifying it as the Avoca (Mitchell 1839).

Following the positive reports of earlier explorers, Edward John Eyre made for Port Phillip and Adelaide in December 1837 with 300 cattle from near the site of present day Canberra. Eyre crossed the Goulburn and headed to the Loddon River but became hopelessly lost. He eventually arrived in Adelaide some seven months after his date of departure. In January 1838 Joseph Hawdon and Charles Bonney drove a mob of cattle from Howlong (near Albury) to Adelaide via the Goulburn River and River Murray. They travelled close to today's site of Echuca. Hawdon's experience of the country crossed by Mitchell was coloured by the hues of a hot summer. From the vantage point of Mount Hope in February he described the vastness of the plains being of the 'worst description' (Hawdon 1952).

Sturt returned in 1838 to drive his cattle along the Murray crossing to the left bank at Barmah Forest and moving on to Adelaide using the tracks of Hawdon and Eyre. By 1866, it was estimated that 350,000 sheep were being moved along this route (Holmes 1948). The first overlanders were able to ford the rivers they came across with reasonable ease, suggesting dry conditions. The routes taken by these explorers and overlanders are today marked by cairns and plaques (Figure 7.1). The intensive use of the River Murray track led to clashes between Aboriginal people and overlanders. The worst of these collisions occurred at Rufus River (Lake Victoria) during 1841 when 4–5 overlanders and at least 30 Aboriginal people were killed in battle (Sinclair 2001).

Pastoralism

It was Mitchell's triumphant view of the country he crossed, published and widely promoted, that brought a wave of squatters to the Port Phillip district. The advance of pastoralism was rapid, especially in the years 1838–40 after the official opening of the Port Phillip District in 1836. 'The Major's Line', the track left by Mitchell's 1836 expedition, marked a clear path followed by overlanding graziers searching for the abundant natural pastures Mitchell had labelled 'Australia Felix'. Translated from the Latin as *happy* or *fortunate southern land*, this was used by Mitchell to describe the lands of the Port Phillip district, and later the Colony of Victoria. The Major's Line acted as a kind of internal boundary line for the province. It was used by subsequent overlanders and runs were defined in relation to the line. Parts of the track were still visible in the 1850s and can still be seen near Heathcote today with the name remaining in use in the 1880s.

Figure 7.1 Cairn near Wodonga commemorating the 1824 exploration route of Hume and Hovell.

Many squatters arrived in the study area by striking out from Mitchell's tracks and river crossings. Land within the study area was taken up for sheep and cattle grazing from as early as 1835. Bonegilla station (near present day Wodonga) was claimed by William Wyse on behalf of Charles Ebden in that year. White settlement was halted when overlanders encountered resistance by Aboriginal people along Mitchell's route on the Broken River in April 1838. For two to three months after conflicts at Faithfull's Creek near Benalla, in which eight white men and several Aboriginal people were killed, there was open warfare between 'blacks and whites' in this region (Christie 1979).

Runs were taken up on the best land along the rivers of the study area. A general trend saw the River Murray plains taken up from Ebden's run to the Goulburn, then west along the Murray. The lower reaches of the Campaspe, Loddon and Avoca Rivers were taken up to the north along those river courses with the plains being settled in later years. Runs were also taken up along the Murray in an easterly direction from South Australia. The

Figure 7.2 Murray Downs homestead (NSW) near Swan Hill.

vast Neds Corner run was established on the South Australian border by Ned Bagot in 1857.

The 1847 Order-in-Council provided for the issuing of leases through the Colonial Secretary which enabled squatters to take up the choicest agricultural land and river frontages. By 1850, most of the country of the study area was divided into sheep stations. Homesteads were located on river and creek frontages and boundaries were defined by blazed trees, ploughed furrows and the deployment of stock. Squatters and their herds and mobs were quick to make their mark on the land. The rapid introduction of domestic animals with hard hooves affected vegetation cover and soils as did introduced grasses.

Evidence today of the period of squatting occupation include homesteads which still stand at the sites of the Strathmerton, Wharparilla, Restdown Plains, Terrick Terrick, Mount Hope and Madowla Park (formerly Lower Moira) runs. Remains of sheep wash areas are found in various locations such as those at Woolshed Lake near Boort. Murray Downs (NSW) and Tyntynder homesteads near Swan Hill, and Burramine homestead near Yarrawonga are open to the public, and the Swan Hill Pioneer Settlement also evokes this era (Figure 7.2).

Gold Mining

Alluvial gold was discovered in the study area in 1852, in the 'Buffalo Ranges' of the Ovens district. Subsequent goldfields were opened at Myrtleford in 1853, Eldorado in 1854 and Wahgunyah and Rutherglen in 1858. The major gold discoveries in nearby areas such as Bendigo, Rushworth and Beechworth also had significant implications for settlement in the study area. The vicinity of Myrtleford was dredged from 1908. Cyaniding of deep lead dumps was undertaken at Wahgunyah and Rutherglen between 1937–1950 (Heritage Victoria 2005). The impact of gold mining on affected parts of the region was devastating. Vegetation was cleared and topsoil turned over. Trees were felled to line drives and mine shafts and to stoke boilers. Creeks and rivers were polluted, silted, and riverbanks eroded and removed. Material reminders of the gold era exist today in the areas of Myrtleford and Wahgunyah (DNRE 1999).

Selection

Agriculture in the study area began in earnest with the passing of the Land Acts in 1860, 1862, 1865 and 1869. The aim of the Land Acts was to settle a class of yeomen farmers on small holdings across the colony of Victoria. The motives that fed the pursuit of this ideal were complex and varied, but the clear objective of the Land Acts was to break the squatter stronghold. Each consecutive Act brought with it conditions that made it more difficult for squatting interests to select land. Despite this, squatters had actually consolidated their holdings by 1869 by manipulating how the Acts were implemented by 'dummyimg' (nominal selectors acting on behalf of someone else) and 'peacocking' (selecting prime land such as waterways and fertile areas so as to make surrounding land untenable).

Most of the Riverine Plain of the study area was divided into 320 acre farms under the *Land Act 1869*. This Act required lessees to live on the selection for at least two and a half years, and within three years build a house, to fulfil residency conditions. They also had to fence the selection, cultivate at least ten per cent of the land, and improve their selection through clearing vegetation, constructing of water storages and erecting outbuildings. If all the conditions were met, at the end of three years the selection could be purchased. By the dry year of 1876 however, farmers in the area were experiencing difficulties. The onset of drought, continuous cropping and the depletion of soil nutrients, the invasion of rabbits, low commodity prices, and the reorganisation of marketing and handling facilities to provide for local consumption, all impacted on farmers. These years of hardship brought another wave of change to the landscape. Many selectors left the land enabling those who were already established to buy up neighbouring properties to increase their holdings. By 1885, those who managed to stay had established an expanding wheat industry on the plains.

In 1883, the Mallee was chosen as the new frontier for the Land Acts in an effort to rid the area of rabbits and to preserve the land for the Crown for disposal in 1903. Under the *Mallee Pastoral Leases Act 1883*, the Mallee was divided into 'fringe' and 'interior' sectors. The 'fringe' sector comprised 500–1200 acre to 20,000 acre blocks. The 'interior' land was divided into 'A' and 'B' blocks of 60 to more than 500 square miles. 'A' blocks fronting water sources (mostly the River Murray) were expanded through grazing licences and were made available on twenty year leases. 'B' blocks were leased for five years. Those farmers able to endure the hardships of establishment experienced more favourable conditions in ensuing years. Subsequent Land Acts of 1901, 1911 and 1915 saw the Mallee Pastoral Leases divided up when they expired. The stump-jump plough and the mallee roller helped clear, large tracts of the Mallee for wheat farms by the 1920s. In an attempt to boost exports during the onset of the depression in 1929, the Commonwealth Government initiated a 'grow more wheat' campaign. By 1930 this had resulted in a huge increase in wheat production accompanied by a collapse in prices. In the early 1930s, the clearing and bare-fallowing had caused wind erosion and billowing dust storms across the Mallee and northern Victoria.

Some Mallee Pastoral Leases were retained so that not all Mallee land passed into private ownership. An example of such a lease was that issued for the Berribee property, a soldier settler block, now part of the Murray Sunset National Park.

Figure 7.3 Big Lizzie, built to remove mallee vegetation can now be seen along the Calder Highway at Barkly Square, Red Cliffs (see Figure 12.3).

Source: Reproduced with permission State Library Victoria H2002.106/144.

Closer Settlement

The drive to settle more people on the land continued with a number of closer settlement schemes made attractive and accessible through government support. The first of these was in response to the 1890s depression. The *Settlement of Land Act 1893* established villages to settle unemployed people from Melbourne on the land 'to bring idle hands and idle land together'. The Act provided settlers with one to twenty acres and cash advances while they cleared and began farming. Village settlements were set up in the study area in the areas of present day Nyah–Vinifera, Wood Wood and Kunat Kunat, and at Echuca East. The *Closer Settlement Act 1898* allowed the government to acquire large estates by agreement with the owner, subdivide them, and sell the small blocks under an instalment plan. However, it was not until closer settlement was linked with irrigation schemes administered from 1905 by the State Rivers and Water Supply Commission (SRWSC) that intense farming of smaller blocks began in earnest.

By 1913, in preparation for closer settlement, land near Shepparton, Swan Hill, Nyah, Cohuna, Merbein, Bamawm, Nanneella, Koyuga, Tongala, Rochester and Cornella Creek had been subdivided into blocks averaging 27–86 acres (Priestley 1984). But a Royal Commission in 1916 concluded that the results of closer settlement did not justify the expense. Blocks were too small or infertile, too few settlers from overseas had been attracted and those who did arrive had insufficient capital or experience (Broome 1984).

The Discharged Soldiers' Settlement Acts of 1917–24 in conjunction with the Closer Settlement Acts of 1915, 1918 and 1922 formed the legislative basis for Australian soldier settlement. More land was made available for farming through the resumption of old Crown grazing leases, Mallee blocks and the compulsory and voluntary purchase of large properties. Further irrigation channels were established in 1919–20 and soldier settlers took up irrigation blocks in the areas of Swan Hill, Shepparton, Rochester, Kerang, Woorinen, Nyah, Tongala, Red Cliffs, Robinvale, and in the Mallee. New technology enabled soldiers to pursue dairying, intensive cropping or fruit-growing.

A Royal Commission on Soldier Settlement in 1925 found that the scheme was mostly a failure due to a settlers' lack of capital and experience, the inadequate size of blocks and drainage problems. The War Service Land Settlement Agreement of 1945, however, continued to establish soldiers returning from World War II on farms. Dryland farms were allocated for soldier settlement in the Mallee and at Rochester. Irrigated blocks at Robinvale were also made available. Soldier settlements were provided in the Murray–Goulburn Irrigation Area around Cobram and Numurkah with the development of 120,000 acres of irrigated blocks for fruit growing and dairying. War memorials and road names in many districts attest to the profound impact distant conflicts had on the history of the study area.

The siting of major defence facilities at Bonegilla in 1940 and Bandiana in 1942 stimulated local farm production. These permanent camps consisted of rows of huts, canteens, kitchens, ablution and toilet blocks. Some of the facilities at Bonegilla were used for a Migrant

Reception Centre established in 1947. After the war Bonegilla camp housed 300,000 migrants during their first months or years in Australia. It closed in 1971 (Priestley 1984). The Kiewa Hydro Electricity Scheme and expansion of the Hume Reservoir provided employment for large numbers of post-war immigrants who subsequently settled in the area.

The study area, like most of rural Victoria, experienced a loss of population from the 1930s. The 1950s saw a return to better times with good seasons, extension of irrigation, control of rabbits and record prices for wheat and wool.

OTHER THEMES

Transport and Communications

One of the first heavily used tracks was the overland route between Sydney and Melbourne, with the section from Albury becoming known as the Port Phillip road. After the 1836 Faithfull Creek conflicts, mounted police parties were stationed along the track. Eventually towns were established as part of a military strategy to secure the route. The towns of Albury and Wangaratta were surveyed in 1839 as part of this strategy (Pennay & Pennay 1998). A mail run operated between Melbourne and Sydney from 1838.

Early tracks made by the movement of stock between markets and stations were stamped on the landscape from the late 1830s. On his 1838 journey, Sturt referred to the overland path made by Hawdon and Eyre as a 'high-road' (Holmes 1948), and indeed, the Murray became the most favoured route by which to deliver stock to the market of Adelaide from New South Wales. Some stock-routes were included in the first surveys as Three Chain Roads. An 1853 map of Victoria shows 'roads' or 'bush tracks' following the rivers of the study area and diverging to the head stations of the district's pastoralists (Ward & Lock 1853). Other more permanent tracks were turned into roads along bullock wagons and coaches routes.

By the late 1850s it was becoming increasingly obvious that the task of road making in Victoria was beyond the ability of one central body. The responsibility for road works was thus handed over to local districts with support given through government grants, rates and tolls under the *Roads Act 1853*. The *Local Government Act 1863* allowed municipalities to become boroughs and enabled larger road districts to become shires. Much of the early activity undertaken by local government authorities involved removing trees and stumps from roads, constructing kerbs, channels and pavements in red gum, and building of drains. Until 1860, most Central Roads Board funds were used to construct a road north to the River Murray via the gold diggings at Mount Alexander. The road terminated at Hopwood's punt at Echuca and is known today as the Northern Highway.

Bridges replaced punts as the arrival of railway lines increased traffic flows. A flurry of bridge building occurred on the rivers within the study area in the 1870s and 1880s. Stewarts Bridge, for instance, built across the Goulburn River at Kanyapella, was opened in 1879 and is still in use today although a new bridge is under construction (Figure 7.4).

Figure 7.4 Stewarts Bridge was constructed across the Goulburn River at Kanyapella in 1879.

Rivers

The major rivers and streams of the study area were important trade routes for the developing agricultural economy of the region. Squatters who moved into the region from 1836 used river crossings made by Hume and Hovell and Mitchell. As wool and meat production increased to supply Victoria's goldfields, punts were established to transport livestock across the waterways. Colonial parliaments were granted the right to impose custom duties on goods coming in from other colonies in 1850. Ports with associated infrastructure were established at Echuca, Swan Hill, Albury and Wahgunyah to oversee the collection of custom duties.

Trade on the Murray–Darling river system served South Australia, western New South Wales, the Riverina, and northern Victoria. Steamboats or paddle-steamers were introduced to the Murray in 1853 for commercial trade and operated principally between Goolwa and Echuca. Albury was the upper navigable limit of the Murray navigation, being reached by a paddlesteamer in 1855. To ensure safe navigation, 'snagging' steamers cleared the river of snags. Echuca became the major port of the trade being visited by 189 boats between 1866 and 1875 (Ward 1992). Red gum, valued for its durability, strength and resistance to air, water and insects, comprised the bulk of trade. Timber was sent to Melbourne, Sydney, Adelaide and to the British colonies such as India for railways. Later, wool and wheat were also significant. Boat building and maintenance was another significant river activity. A total of 124 steamboats and barges were built at Echuca between 1858–1913 with the industry peaking in the 1870s (Ward 1992).

The Goulburn River was made navigable through de-snagging by 1875. Steamers and barges engaged in regular trade between Echuca and Shepparton, and hauled timber, railway sleepers and logs for the fellers and saw millers in the red gum forests near the Goulburn–Murray junction.

River traffic declined in the 1880s with the building of railway lines to the region. By 1888, with the exception of red gum collection in the Barmah–Millewa forests, commercial traffic above Echuca had all but ceased. Trade between Shepparton and the Murray ceased in 1890. River transport from the western Riverina ended when rail lines were opened from Echuca to Balranald in 1926. Today paddle-steamers operate as a tourist attraction on the River Murray, principally from Echuca, Swan Hill and Mildura.

Railways

Significant changes were mooted for the colony of Victoria when the Surveyor General, Captain Andrew Clarke, was authorised to survey for railways throughout the central portion of the colony in 1855. Routes had been opened as far as Ballarat and Sandhurst by 1862 and then to Echuca by 1864, establishing the town as a major inland transport hub between river trade and the emerging rail network. A railway bridge over the River Murray for the line between Deniliquin and Moama was opened at Echuca in 1878. The Melbourne–Wodonga line reached Wangaratta and Wodonga in 1873 and branch lines were opened to Beechworth and Myrtleford in 1883. Albury was linked with Sydney in 1881. The Melbourne–Swan Hill line opened in 1890. The Mallee railway network to Yelta, Morkalla and the Nowingi line were constructed between 1891–1923. After demands from closer settlers, railway lines were extended to serve other communities. The railways continued to convey passengers and goods well into the 1950s when diminishing returns caused by the declining rural population and competition from road traffic lead to closures. Further closures took place in the 1970s, the late 1980s and early 1990s.

Water supply and management

Pastoralists

Squatters in the area watered their stock at rivers, creeks and Aboriginal soaks. With cycles of dry seasons and increasing stock numbers, river and creek systems were modified to meet the growing number of stock. Dams, or tanks, were excavated and levees built across rivers to create weirs. Frederic Godfrey at Boort station in 1850 made a cutting from the Loddon River to the Kinypanial Creek allowing water into a former swamp creating Lake Boort. He also constructed a weir at the inlet to Lake Boort on the Kinypanial Creek, remains of which are still in evidence.

Goldminers

Creeks were dammed or diverted by channels and races to provide the water for puddling and washing gold. Race-holders often made a better living selling water than the diggers did seeking gold. The availability of water not only affected activity on the goldfields but also their hinterlands. By 1865 goldmining activity, especially in the Bendigo area, had silted up the Loddon and Campaspe Rivers and many creeks, rendering them unfit for drinking. Sludge in the Ovens River filled up creeks and alluvial flats downstream and accounted for surface elevation through the Tarrawingee and Wangaratta districts down to the River Murray.

Goldmining raised the issue of managing public resources for the 'perpetual benefit of the people' rather than for the benefit of a minority. Editorials in local and city newspapers raised questions about the ownership of water and condemned the continued pollution of water sources by mining activity. By 1860, the need to improve control of access to and use of water throughout the Colony was judged a priority. Reserves protecting water frontages of watercourses were introduced under the *Land Act 1860*.

Wells and Dams and Other Schemes

Wells were sunk in towns and on farms as the first attempts at supplying water to growing populations. Waterworks were constructed in towns. Standpipes, which provided water from local water supplies, were a feature of early settlements. Creeks and rivers were accessed where possible. Swamps were drained and dams were built by farmers. Community tanks, often waterholes once used by squatters, were fenced and new ones sunk eight to nine miles apart by local government throughout the study area for both stock and domestic use. Government dams can still be seen on the Murray Valley Highway at Tongala. Selection from 1860 and the settlement of the Mallee provided stock and domestic water supplies via open channels. Water trains delivered water to the Mallee until the channel system of supply was finished in the 1920s.

Irrigation Trusts

A series of dry years in the late 1870s led to the formation of the Water Conservancy Board in 1880. In 1881, all unalienated land within one-and-a-half chains of watercourses was reserved. Water trusts were constituted under the *Water Conservation Act 1883* and given authority to carry out water supply projects. The *Irrigation Act 1886* vested in the Crown the right to the use of water in any stream, lake or swamp, and provided that no riparian rights could be established in the future which might prevent the use of water for irrigation.

Water supply and irrigation schemes instigated by Trusts at this time often relied on weirs built on rivers or creeks. Water was diverted from these storages down natural watercourses or constructed channels. An example of such a scheme was that undertaken by the Loddon United Water Trust in 1882. The Trust constructed a weir at Bridgewater to divert the Loddon River through sluice gates to a main channel running across country linking with Bullock Creek to the east with subsidiary channels to Myers and Piccaninny Creeks, to Serpentine township and to Bears Lagoon and Calivil. To supply the west side of the Loddon River, a timber weir was built below the off-take of Kinypanial Creek in 1885 to direct water via channels to Lake Leaghur and Lake Boort. Remains of this weir can be seen today.

Private irrigation schemes were set up in 1886 by the Californian Chaffey brothers in Mildura and at Renmark in 1887. Due to financial difficulties, the Chaffey Brothers Irrigation Company was disabled in September 1892. In December 1895 the Mildura Irrigation Trust Act was passed by the Victorian Government establishing the First Mildura Irrigation Trust, that exists today. The Chaffey's house, Rio Vista was built in Mildura in 1889 and is open to the public as a museum.

In 1887 the first national irrigation storage project was started—the Goulburn Weir. Work began on a second Goulburn River water storage, the Waranga Basin, formerly Gunns Swamp, in 1902. With farmers reluctant to take up irrigation and problems with irrigation infrastructure, most trusts were in financial difficulty by the turn of the century—a situation which paved the way for state ownership and management of water.

Centralised Control

The *Water Act 1905* made three significant policy changes in the management of water. First, irrigation and rural water supply became the responsibility of a central 'expert' Commission. Second, the beds and banks of most watercourses were 'nationalised'. Third, properties were given a fixed water right attached to a compulsory minimum payment (Powell 1989). Land for irrigation districts was purchased by the SRWSC at White Cliffs (Merbein), Swan Hill, Cohuna and Nyah along the River Murray, at Rochester, Bamawm and Nanneella along the Campapse, and at Shepparton, Koyuga and Tongala in the Goulburn Valley (Dingle 1984). Tresco was re-developed as an irrigation area in 1913. These areas were supplied mainly from the Murray and Goulburn Rivers or their tributaries. Irrigation infrastructure established in the study area in this era included the Waranga Western Main Channel (1909) and a siphon under the Campaspe River north of Rochester. Wood powered the steam and gas pumps used for irrigation in the Sunraysia region until the late 1950s. During the irrigation season, the pumps consumed 32 to 35 tons of wood per 24 hour day, and stockpiles of several thousand tons were frequently maintained (Powell 1993).

Under the terms of the River Murray Waters Agreement of 1915, all run-off into the Murray system above Albury was to be shared between New South Wales and Victoria, with provision made for agreed minimum quantities to pass down to South Australia. The River Murray Commission was appointed in 1917 to implement the River Murray Waters Agreement and coordinate the construction of locks on the Murray to ensure sufficient depth of water for river transport. Other works undertaken included the building of the Torrumbarry Weir in 1924, the Hume Weir begun in 1919 and the Yarrawonga Weir completed in 1939. Water from these storages greatly increased irrigation in the Murray Valley.

In 1945, the SRWSC embarked on a post-war construction expansion. By the 1960s irrigation waters were supplied to the study area from Waranga and Eildon (Goulburn River), and Torrumbarry (the River Murray) storages, as well as from the Campaspe and Loddon Rivers. Approval was given in 1960 for the Lake Cooper–Greens Lake project to store 20,000 acre feet of unwanted flood and drainage water (Webb & Quinlan 1985).

In 1984, the Rural Water Commission was established to operate and maintain most of the State's water supply system, including storages and watercourses. In 1992, with the establishment of the Rural Water Corporation, regions were consolidated and greater local management powers given to Regional Management Boards. Rural water authorities were created in 1994. Current water management is described in more detail in chapter 15.

While irrigation has massively changed the economy and society of the study area, it has also had a significant environmental impact. Land was subdivided and fenced into smaller holdings. Channels were built on the highest ground, often on sand dunes that marked the banks of former rivers. The building of channels and levee banks in addition to roads and railways has interfered with natural flooding and drainage processes and altered winter flood hazards. By 1911, salt-affected land caused by rising water tables induced by irrigation was in evidence near Cohuna. By the early 1930s salt was threatening more than 300,000 ha of irrigation country around Kerang (Powell 1993). Drainage channels were constructed for a more regular watering regime to leach out the salt. Surface drains often followed the routes of the beds of prior streams. In 1990, more than sixty percent of the Campaspe West irrigation area had water tables within two metres of the soil surface. In 1988, the Salt Action: Joint Action program was put into place to evaluate and ameliorate secondary salinity in Victoria (ECC 1997). Major surface drains continue to take irrigation water into local swamps and the River Murray. The effects of water regulations on the biodiversity of the study area are detailed in chapter 5 and 15.

Industries

River Trade

As described above, river trade centring on the port of Echuca made a significant contribution to the local economy from 1858 until 1888 when a decline occurred in favour of railway transportation routes. Imports peaked in the years 1875 (£2,206,620), 1880 (£2,502,750) and 1881 (£2,278,248). Exports were significantly high in 1878 (£352,990) and 1885 (£349,212) (Priestley 1984).

Agriculture

The trend post World War II has been to extend farm sizes, increase mechanization and reduce farm employment in response to the global trade in horticulture and agriculture .

Grazing and Cropping

The first industries in the study area were those developed by the squatters. Those able to access the gold-mining markets were involved chiefly with cattle raising. Other pastoralists were involved in raising sheep for wool. Selectors taking up land in the study area from the 1860s, and later soldier settlers, grazed sheep and cattle as a supplement to their cropping activities. Grazing licences, issued from 1869 under the Land Act of that year, allowed the holder to depasture livestock upon any park lands, reserves or other Crown lands. Many of these licences were issued for the forests of the study area. The growing of wheat was the mainstay of agricultural activity on the Riverine Plain of the study area before the introduction of irrigated horticulture from 1910. Some areas located principally in the western section of the study area, are still employed for cropping activities, however grazing and dairy industries dominate agriculture (see chapter 13).

Dairying

The centrifugal cream separator, invented in the 1870s, established a factory-based dairy industry. From the mid 1880s, settlers took their milk and cream to a centrally located butter factory or creamery. With the advent of irrigation from 1910, dairying took place on 50–100 acre farms with a carrying capacity of 12–15 cows milked by hand. Superphosphate, introduced in the 1930s, increased the carrying capacity of the land and hence milk production. Technological advancement of the industry, including the milking machine, refrigerated holding vats and transport, the herringbone shed and bulk milk collection, further increased production. More recently, dairy deregulation has led to rationalised and larger farming units. Dairying remains an important industry within the study area, particularly around the Kerang, Echuca and Shepparton districts see chapter 13.

Horticulture

Viticulture enterprises centred on the areas of Mildura, divided into irrigation blocks by the Chaffey brothers in 1886, and Mulwala from the 1890s. Irrigation today continues to support vineyards, as well as the cultivation of fruit, olives, nut groves and vegetables in Victoria. Major production areas are the Goulburn Valley, Robinvale–Mildura, Swan Hill and Cobram areas. Tobacco and hops are grown in the King, Kiewa and Ovens valleys. Each region has its own characteristics and produces a range of different products (see chapter 13).

Forestry

Timber Production

The river red gum forests of the study area have been utilised for timber production over the years of European settlement, and before that time, were extensively used by Indigenous people. The first white settlers harvested timber for fence posts, housing and fuel. The cypress pine of the Riverine Plain and the Mallee, for instance, was sought for constructing outbuildings and fence posts. Similarly, swamp woodlands in the study area were felled for construction materials and fuel. The exploitation of red gum forests was most evident during the paddle-steamer and gold eras, especially with the operation of quartz reef mining during the 1860s and 1870s. Estimates suggest that on average, a steamer burnt half a tonne of fuel an hour in its boilers (LCC 1987). The massive demand for timber for boat building, underground timbering and fuel for boilers had taken a significant toll on forests by the early 1870s.

Early sawmills were established at sites where timber grew. Commercial sawmills were established along creeks, rivers and on swamps. With the opening of the railway from Melbourne to Echuca in 1864, several mills set up in the area to provide red gum to the export markets of the British colonies which were heavily engaged in railway and wharf building (Priestley 1984). In some parts of the study area timber tramways transported logs to mills. The remains of a timber tramway are in evidence east of Echuca.

Foresters experimented in planting non-endemic species especially from the 1930s. Softwood plantations were established near Myrtleford between about 1930 and 1980. Commercial forestry is conducted today in both hardwood and softwood plantations on private and public land using modern machinery, in contrast to the hard physical labour of hand felling. Forestry on public land in the study area is discussed in more detail in chapter 14.

Charcoal Burning

Charcoal burning occurred during the gold rush to meet demand for blacksmiths. By the early 1900s, goldmining companies were attempting to reduce firewood consumption by introducing steam boilers and gas-producer plants to power crushing batteries. These plants were fuelled by charcoal. The industry received another boost during World War II when charcoal became a vital alternative to liquid fuel used in the military, such as kerosene. Today charcoal burning is still conducted in red gum forests, but is a small industry largely used for specialised purposes.

Figure 7.5 Alf (left) and Frank Corry, near Moira Lakes, early 1900s River Murray.

Source: Reproduced with permission National Library of Australia Image: an24548312-v.

Forest Management

The *Land Act 1865* enabled reserves to be declared for 'the protection and growth of timber.' Timber reserves were put aside, and from 1866 state forests were established. Timber reserves were to be used by settlers until the supply was exhausted, while state forests could only be used by approved licensed timber millers and fellers. Under this legislation, the Moira, Barmah and Yielima state forests were proclaimed in 1870. Further reserves were created at Gunbower, Nyah and Walpolla.

An export duty was placed on red gum in 1877 causing some mills to close, however red gum forests on the Murray continued to be heavily exploited for saw logs. Such was the ongoing denuding of the forests that a series of bills to actively conserve forests, repair damage and encourage growth were presented to Parliament in 1879, 1881, 1887 and 1892 (DSE 2003h). None of these bills were enacted by successive governments because of their commitment to land settlement and pressure from interested parties (Dingle 1984).

The 1901 Royal Commission on State Forests and Timber Reserves noted that the Barmah Forest had been cut over several times, and that at the current rate of cutting would yield no more than five years supply (Fahey 1987). In 1908 the first effective forests legislation in Victoria, the *Forests Act 1907*, came into operation. A Department of Forests was formed to more effectively manage forest resources. The Forests Commission was established in 1919. Initiatives such as fire protection, thinning and coppicing and reafforestation of forests were put into place in the 1920s and 1930s (Fahey 1987).

Fisheries

The collapse of the Murray cod fishery is one of the earliest, least known and most dramatic examples of poor natural resource management in Australia's history. In 1855 Joseph Waldo Rice established the Murray River Fishing Company at Moira Lake and along the River Murray to Picnic Point—probably the first inland commercial fishing enterprise. By 1869 the company was netting the lakes and over two hundred miles of the river. The majority of the fish were Murray cod but also included golden perch, silver perch and goldfish (not carp). Murray cod typically weighed over a hundred pounds. In the late 1860s the catch varied seasonally between 1 to 6 tons per week equating to an annual figure of approximately 160 tonnes of fish. At the time the company was criticised for taking large quantities of fish during the spawning season and there was conflict between commercial, recreational and Indigenous fishing.

By the 1890s, the catch had declined substantially with an annual catch of about 35 tonnes, primarily of golden perch. In 1896 the Victorian Government introduced a closed season, aimed at protecting Murray cod (Leslie 1995; King 2005). Current limits such as closed seasons, size and number apply to fishing for Murray cod in NSW, South Australia and Victoria. There are now no commercial fisheries based on the River Murray, however recreational fishing attracts many visitors to the region (Figure 7.6, chapter 11).

Other Industries

Other industries in or near the study area included salt harvesting and gypsum extraction across the Mallee, and the quarrying of granite at Mount Hope. Chapter 16 describes these industries in more detail.

Recreation

Leisure activities enjoyed by European settlers have centred on the natural features of the study area. The River Murray and its tributaries have been the focus of social interaction since the first days of settlement. Sand bars attracted swimmers who bestowed them with familiar names such as 'St. Kilda'. Favourite swimming holes in later years sported other facilities. Horseshoe Bend near Swan Hill, for example, was a popular swimming place made more so by the addition of a floating platform in the 1920s. Picnics were traditionally held on Boxing Day and New Year's Day. Some of the earliest picnics were those organised by the Officer family of Murray Downs station near Swan Hill in the 1870s. A punt was provided to ferry children to the other side of the river where they were transported to a nearby lake to play games. Sunday School picnics were held regularly at Pental Island. The information centre at Torrumbarry Weir gives a sense of riverside recreation from the 1920s onwards.

Fishing, camping and water skiing have proved popular recreational pursuits. Yacht clubs have been formed at Lake Boga and Lake Mulwala. The forests of the study area have continued to provide popular picnic spots (Figure 7.7), as have the weirs built for water storage. Current recreation and tourism on public land in the study area are described in more detail in chapter 11.

Figure 7.6 Murray cod fishing on the River Murray.

Source: Reproduced with permission Museum Victoria collection.

Figure 7.7 Picnicking on the River Murray in the 1930s.

Source: Reproduced with permission Museum Victoria collection.

8 Current Socio-Economic Setting

This chapter reviews the socio-economic characteristics of the River Red Gum Forests study area. Population distribution and change over the past two decades provides a context for understanding the range of community characteristics across this diverse region.

Although people generally live outside the boundaries of public land, the proximity and nature of communities near public land affect how it is used and managed. Towns near public land are often a major source of visitors, volunteers and resource users. In turn, public land provides economic and ecosystem services to the surrounding community. As communities change, the nature of these community–public land relationships also changes. Public land planners and managers therefore need to understand local communities and the socio-economic factors affecting them. This chapter reviews the socio-economic characteristics of the population within the study area and its immediate surrounds.

Key sources of data in this chapter are Australian Bureau of Statistics (ABS) census data and the Victorian Government publication *Regional Matters. An Atlas of Regional Victoria 2005* produced by the Department of Sustainability and Environment (DSE 2005g). In this Atlas, as in this chapter, regional Victoria is defined as "all parts of Victoria outside the Melbourne metropolitan area".

Where possible, socio-economic analysis has been undertaken at the smallest geographical level available in order to compile and match data to the study area boundaries. For census data, the smallest available unit is the Census Collection District (CCD), generally comprising 200–400 households. CCDs vary in size with population density, so the degree to which census boundaries can be matched with the study area boundary varies, particularly for sparsely populated areas. Because time-series data are not available at CCD level larger geographical units such as Statistical Local Area or Local Government Area are used instead.

HUMAN SETTLEMENT PATTERNS

The study area follows natural boundaries rather than human settlement boundaries. As a result, it is difficult to estimate the total population for the study area. Use of public land and its various assets is likely to vary across different sectors of the community and community groups. Recreation and firewood collection activities are a case in point. The population catchment area for public land will be determined by factors such as catchment size, visitation levels, population density and proximity to major regional centres.

Patterns of population density may be a more useful measure than total population, in relation to public land use (Figure 8.1). There are clear variations between the more densely settled areas to the east and in the Goulburn Valley, and the more sparsely settled country to the northwest. Hotter and drier conditions to the northwest have limited population density and, while irrigation supports higher numbers, these are largely confined to relatively narrow corridors along the River Murray.

Figure 8.1 Population density 2001, ABS Census Collection Districts in and near the study area.

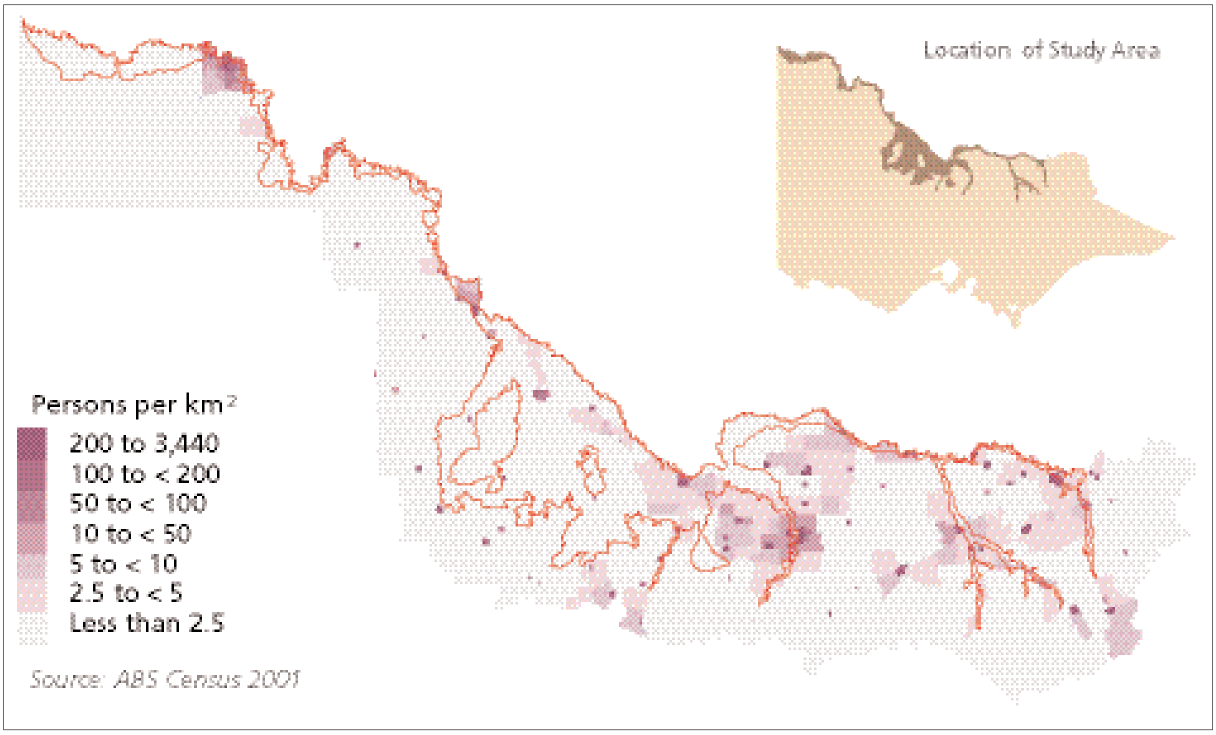


Figure 8.2 Urban settlement patterns in the study area, 2001.

Urban settlement patterns also reflect the difference between eastern and western parts of the study area. The largest city is Shepparton which had a population of 28,951 at the time of the 2001 Census. Of similar size are the regional cities of Wodonga in the east with a population of 28,160 and Mildura in the west with a population of 26,626 (Figure 8.2).

Shepparton, Wodonga and Mildura have very different geographic and hinterland characteristics. In both economic and social terms the 'hinterland' (or more sparsely inhabited area surrounding a major town, city or river) often provides a significant source of much economic activity and wealth generation for the city, as well as being a general sphere of influence for the city's services and employment opportunities. Mildura, located in the Mallee, has a concentrated population within the area of irrigation infrastructure. Beyond this, the Mallee landscape comprises large scale dryland farming and national parks. The population density is therefore very low beyond the immediate area of Mildura. In many ways, Mildura and its irrigated surroundings form an 'island' within a relatively remote and inhospitable region. In contrast, Wodonga and Shepparton have more densely settled hinterlands which are more suited to small scale farming and hobby farms. Consequently population densities within their hinterlands are higher than in western parts of the study area and the range of economic activities more varied.

Apart from these three regional centres, there are approximately 35 settlements which have populations of more than 100 people. Their economic and demographic characteristics are largely determined by whether they are located within irrigation or dryland farming areas. These primary economic bases influence the types of secondary and tertiary industries found in the region. The production of perishable horticultural goods often leads to secondary industries such as fruit and vegetable processing. Dryland products such as wheat and wool were historically exported in bulk with little, if any, processing. Small towns servicing dryland agriculture may be more vulnerable to change with their economies heavily dependent on one industry.

The issue of change and its effects on small towns raises the question of town size and population thresholds to maintain services. While it seems logical that larger towns provide more services, other intervening factors can also affect services. For example, increases in personal mobility and car ownership as well as improvements in car design, safety and road quality, allow people to travel further and more often in regional areas. At the same time there have been structural and economic changes—goods and services are delivered in larger more centralized ways. There is less need for small rural towns to have general stores when nearby regional cities have large supermarkets. Public services are also delivered in line with principles of economic efficiency and smaller government leading to amalgamation of Local Government Areas in the 1990s and concentration of government services into larger centres. The combined effect of all these changes has been to alter any 'threshold' of population size for particular services.

Surprisingly, however, the forces of concentration are not the only influences at work in regional areas of Australia. Around the larger regional centres, hinterlands have seen a growth in population both in rural areas and in small towns. The important factor here is the ability of individuals to *access* services within a reasonable distance and time rather than whether a service is located within the small town itself. Furthermore, those areas which have more densely settled hinterlands are more likely to see this kind of small town growth than areas which have very low population density in their hinterlands. For this reason, understanding the demographic differences between Mildura's or Wodonga's hinterland is important for understanding the social and economic dynamic of each region.

POPULATION CHARACTERISTICS AND TRENDS

Indigenous Population

Indigenous populations within the study area tend to be concentrated in specific towns and cities—a settlement pattern which reflects the historical loss of Aboriginal lands and the settlement policies through the 19th and 20th centuries by various state and federal governments (see chapters 6 and 7).

The proportion of Indigenous people in cities such as Shepparton, Swan Hill and Mildura, and in smaller centres like Robinvale and Barmah, is very high compared to most other regions in Victoria (Figure 8.3). According to the 2001 Census, Shepparton had the highest number of Indigenous residents of any town in regional Victoria (1460) while Robinvale had the highest proportion (9 percent). Indigenous people comprise approximately 1 percent of the total population in regional Victoria compared to 0.4 percent of Melbourne's population (for further details see chapter 6).

It is difficult to determine accurately population changes among Indigenous people in Victoria over recent decades because census counts rely on self-reporting of Indigenous status and this varies between individuals. Community attitudes towards Indigenous people have changed over the past half century and this has led to a greater degree of self-reporting. Nevertheless, even with higher levels of self-reporting, there can still be problems of 'undercounting' of the Indigenous population. Census collection can be difficult in areas where population levels fluctuate or where housing shortages create homelessness. In Robinvale both these factors have been identified as contributing to undercounts of Indigenous and immigrant populations in the town (Success Works 2004).

While exact numbers of Indigenous people may be difficult to ascertain, Victoria's Indigenous population overall has very different demographic characteristics compared to the total Victorian population. A combination of higher than average fertility and mortality rates among the Indigenous population has created a much younger age structure than for Victoria overall (Figure 8.4). Life expectancy rates vary enormously with Indigenous Victorians expected to live around 18 years less than their non-Indigenous counterparts (DSE 2005g).

The Overseas-born Population

Migrants from the United Kingdom and New Zealand account for a large number of people born overseas in country towns. However, there are a number of ethnic groups including Italian, Turkish, German and Dutch communities, living in the study area. Shepparton, Mildura and Robinvale show the greatest diversity of non-English speaking migrant groups. Overall, however the ethnic diversity of regional areas is much lower than for major metropolitan areas such as Sydney and Melbourne.

Irrigation areas along the River Murray and around Shepparton show higher proportions of overseas-born people than in the dryland farming areas of regional Victoria (Figure 8.5). The labour-intensive nature of some irrigation farming has continued to attract workers from a variety of countries. The larger cities of Mildura, Shepparton and Wodonga have more diverse economic bases and this too has contributed to the general attraction of people from a range of backgrounds.

Figure 8.3 Indigenous people as a proportion of total population for Census Collection Districts in and near the study area.

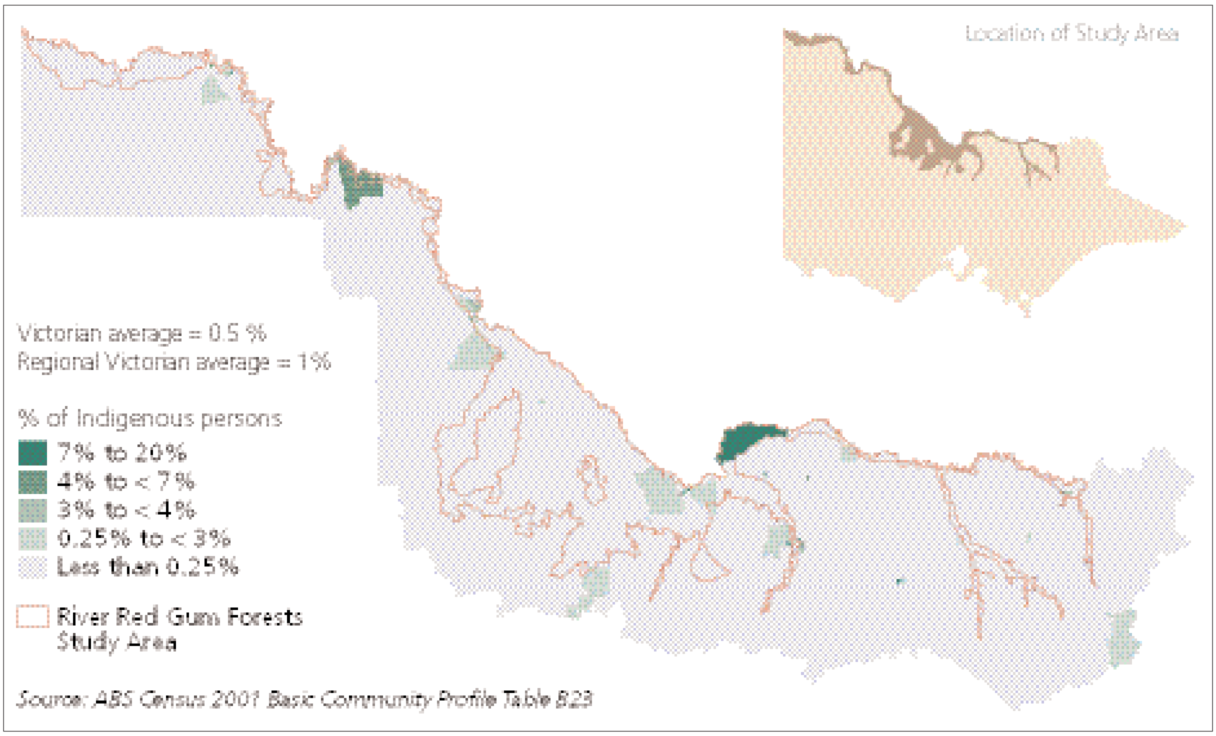
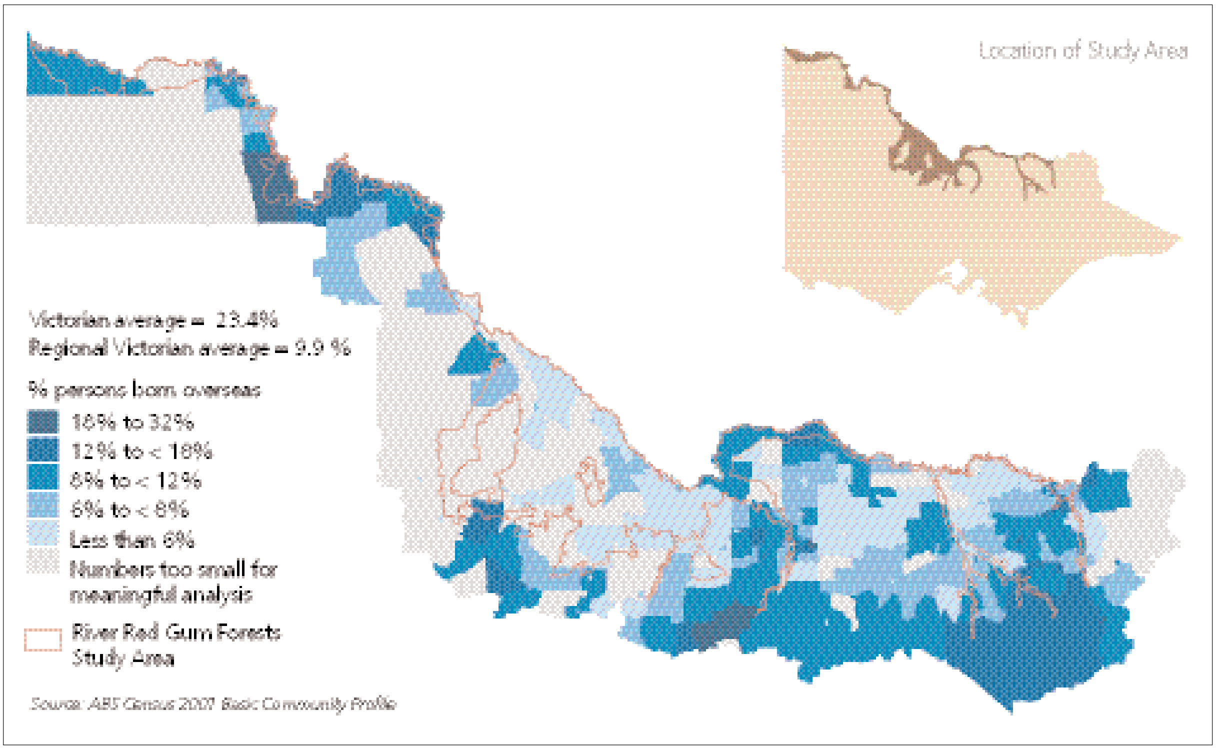


Figure 8.4 Age structure of Victoria's Indigenous and non-Indigenous population 2001.

Figure 8.5 Overseas-born people as a proportion of total population for Census Collection Districts in the study area.



Population Growth and Decline

Populations have risen and fallen across regional Victoria, often quite rapidly. Areas which have experienced population growth over the past decade include:

- Areas within 100–200 kilometres of Melbourne, especially along the coast;
- Areas attracting retirees and tourists, especially those with water features such as Echuca and Yarrawonga and those with unique landscape values such as the alpine areas;
- Larger regional cities such as Shepparton, Mildura and Wodonga; and
- Irrigation areas associated with diverse primary and secondary industry economic bases.

Areas which have experienced population decline include:

- Dryland farming regions in the western third of the State;
- Declining irrigation districts such as around Kerang; and
- Remote regions in the northeast, southeast and southwest of the State.

The range of geographic and economic characteristics results in areas of rapid population growth as well as areas of ongoing population decline (Figure 8.6). The largest cities, Shepparton, Mildura and Wodonga, have grown strongly in recent years (Figure 8.7). Between 1996 and 2001 Shepparton grew by an annual average of 2.7 percent, Mildura by 2.0 percent and Wodonga by 1.4 percent. The average annual population growth rate for regional Victoria was 0.7 percent during the same period.

Cities along the River Murray have used their riverside location and sunny winter climates to attract tourists and retirees, thus maintaining economic diversity and population growth. Intensive agriculture has provided a base for secondary processing industries and enabled the development of specialist irrigation engineering enterprises and producer services, for example around the Shepparton region. The development of these specialist industries adds to economic diversity and provides a greater range of employment opportunities and services within the local economy. Wodonga, Echuca, Shepparton and Mildura are important key transport nodes in the national road freight network and this has boosted transport and logistics employment. Echuca and Wodonga are also key nodes in the national rail freight network.

More working age people are found in irrigation areas than other areas, because of the higher labour intensity of irrigation agriculture compared to other forms of farming, as well as employment in related manufacturing and service industries. In contrast to this, the dryland farming areas have developed capital-intensive agriculture requiring relatively few labour inputs. Advances in private transportation, technology and infrastructure (such as freeways) have increased peoples' mobility and allowed more remote working arrangements and longer distance commuting. The outcome is a landscape with fewer townships and service centres than in the past.

Figure 8.6 Average annual population change from 1981–2001 for Statistical Local Areas in the study area.

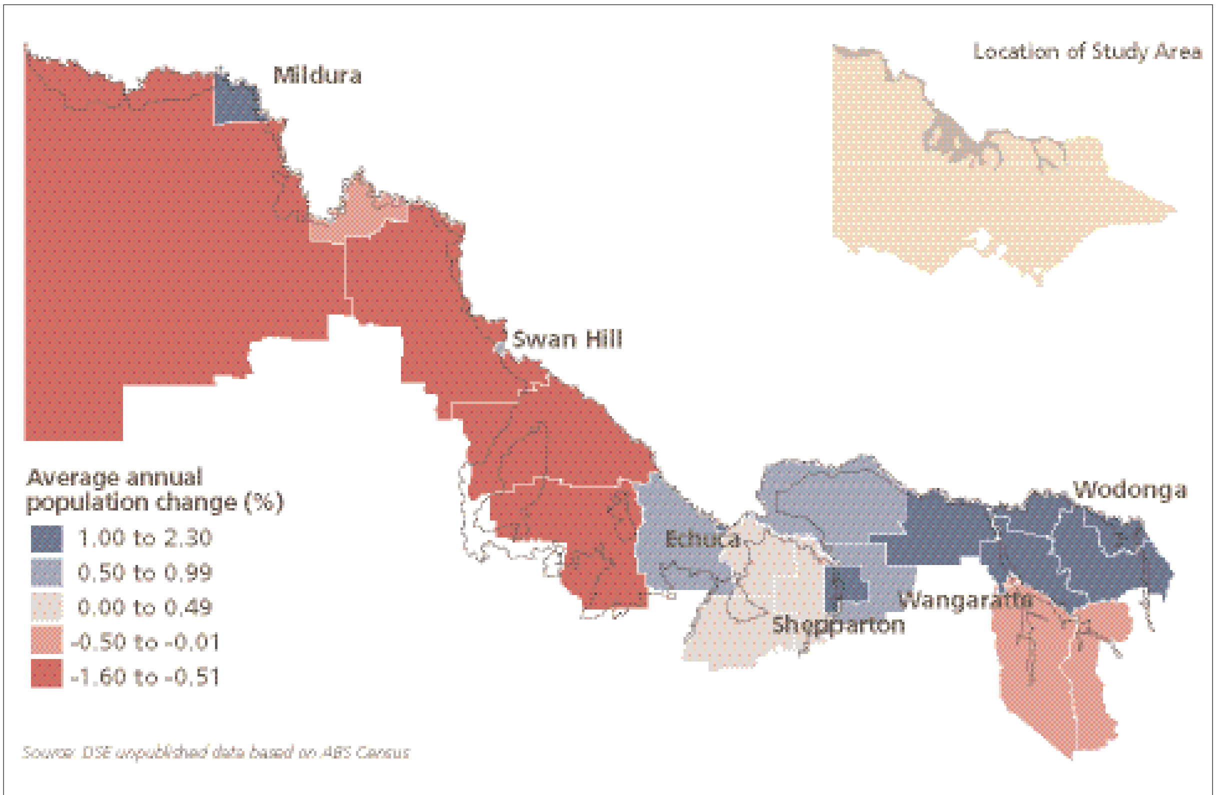
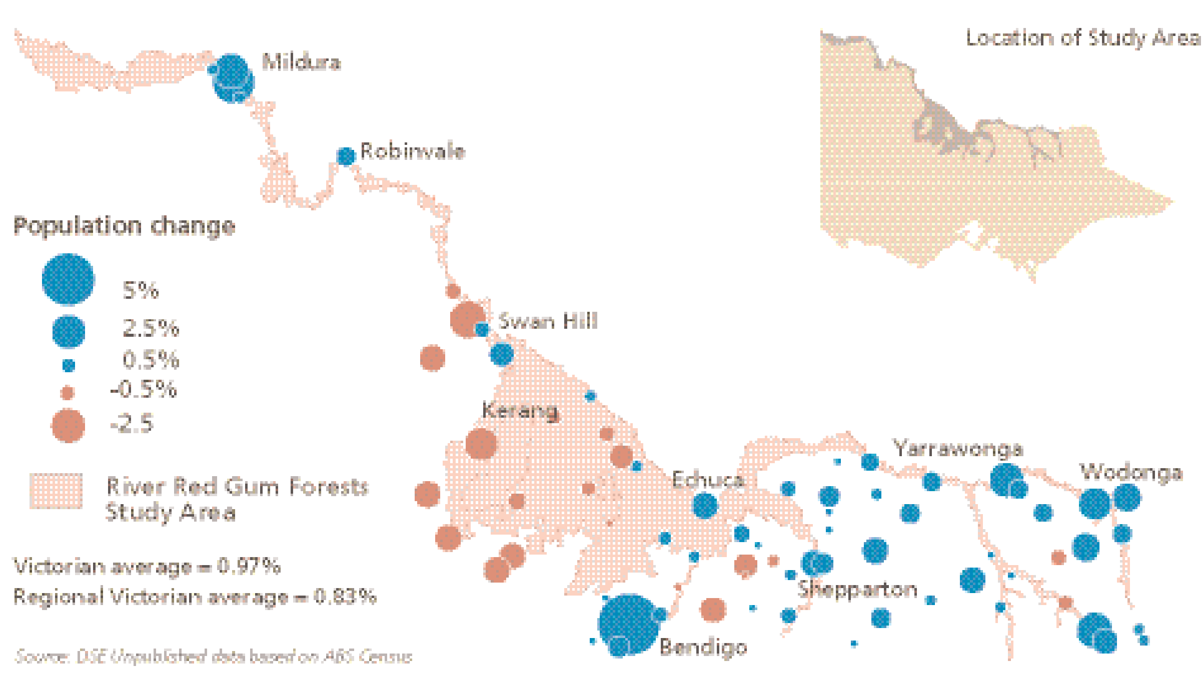


Figure 8.7 Average annual population change from 1981–2001 for towns and cities in the study area.



The rural, non-irrigated parts of Mildura, Swan Hill, Gannawarra and Loddon, share similar characteristics:

- net migration loss across most age groups but especially young adults;
- ageing in place of existing residents leading to a much older than average age profile;
- low numbers of women of child bearing age (15–44 years) and very low number of births;
- an increasing number of deaths due to the older age structure of the population); and
- limited, if any, immigration to the area.

Population projections for areas like Gannawarra predict losses in numbers of people across all but the very oldest age groups over the next 25 years (Figure 8.8).

Another feature of these dryland areas is a noticeable gender imbalance among young adult age groups (20–29 years of age) with fewer women than men. A greater degree of out-migration by women than men is the contributing factor. It highlights a significant demographic issue in that these age groups are those most associated with partnering and child-bearing. Out-migration of these women is potentially removing future children from the community. For men who remain, the issue of remaining single is a significant social issue and has been implicated in problems of isolation, loneliness and depression in some rural areas.

Implications of Population Growth

Population growth is often seen as a positive trend in regional communities, but it can place demands upon infrastructure and local service capacities. Rapid growth can cause pressure on housing, resulting in shortages and increased cost. Demand for new housing affects farmland and public land. In almost all cases housing attracts a higher price per unit of land than other land uses, meaning urban land use generally 'out-bids' other land uses.

Population growth caused through immigration may change the social and economic composition of a community. Education, income, age, occupation and industry characteristics of the population may change, causing changes in the demand for services. Volunteer emergency services (e.g. Country Fire Authority, State Emergency Service) may need to increase services as larger populations increase the risk of fires and accidents.

Population growth near public land is likely to increase visitor numbers and may increase resource demands, for example through local firewood collection or recreational fishing. Use of camping areas and other recreational facilities may also increase the workloads of Committees of Management and volunteer service providers involved in public land management. A growing population potentially increases the pool of available volunteers for Committees of Management activities, but only where the role of volunteers in public land management is publicised and encouraged.

Population growth may also alter demand for the protection of key environmental values, when newcomers have different environmental values and when existing residents wish to protect environmental values from the effects of increased use. New residents may have stronger commitments to environmental values, or may lack an understanding of rural and public land management issues such as weed and pest animal invasion, illegal firewood collection or unregulated camping.

Implications of Population Decline

Regions where population have declined over a long period are likely to experience a cycle of service loss and further population decline. Loss of young adults over time represents a loss of potential community capacity and regeneration. While remaining populations often show a high degree of social involvement and volunteering, the ageing of such populations challenges longer term continuity in community building and regeneration.

Figure 8.8 Projected change in population by age group for Local Government Areas, 2001 to 2031.

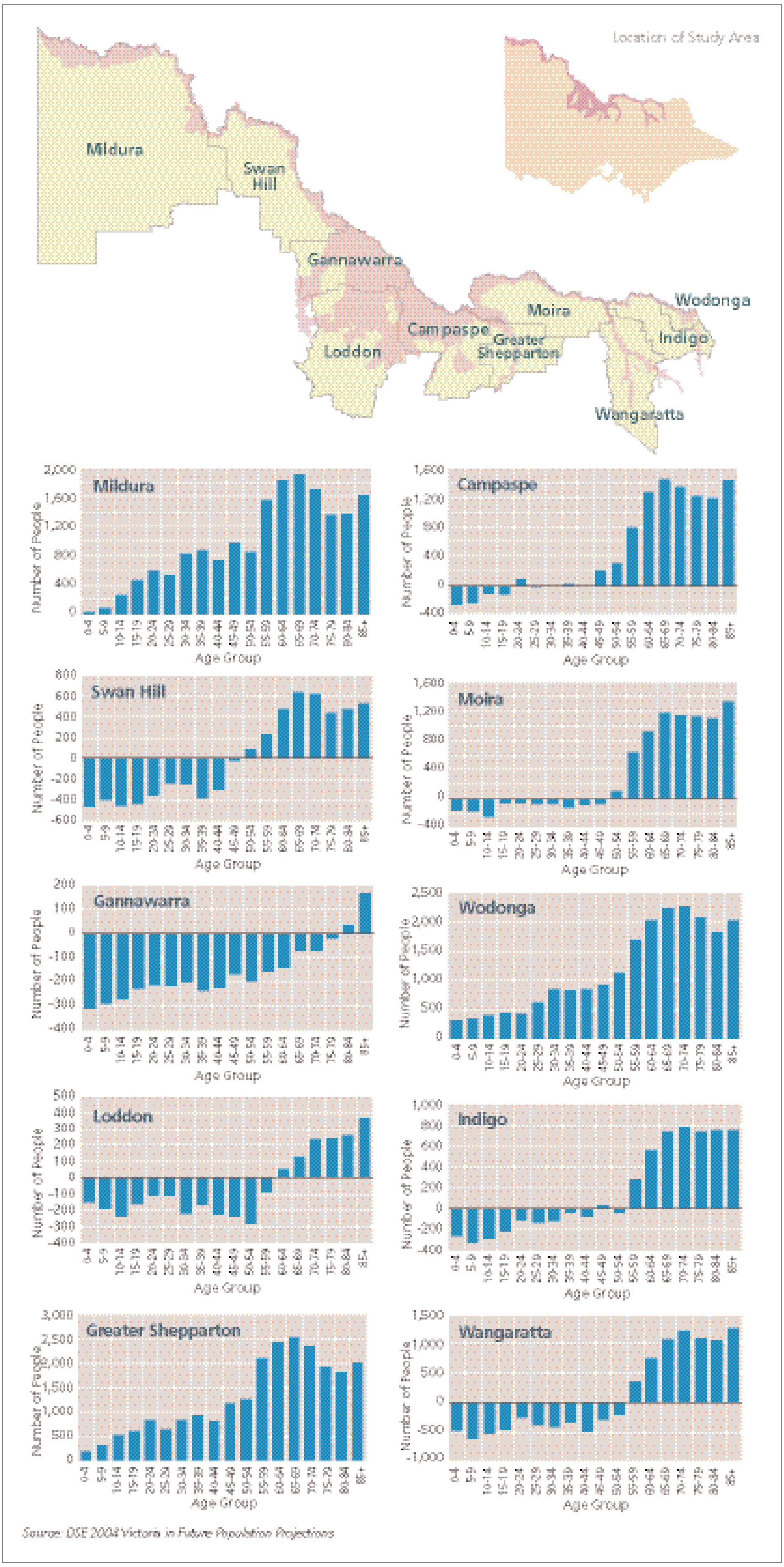
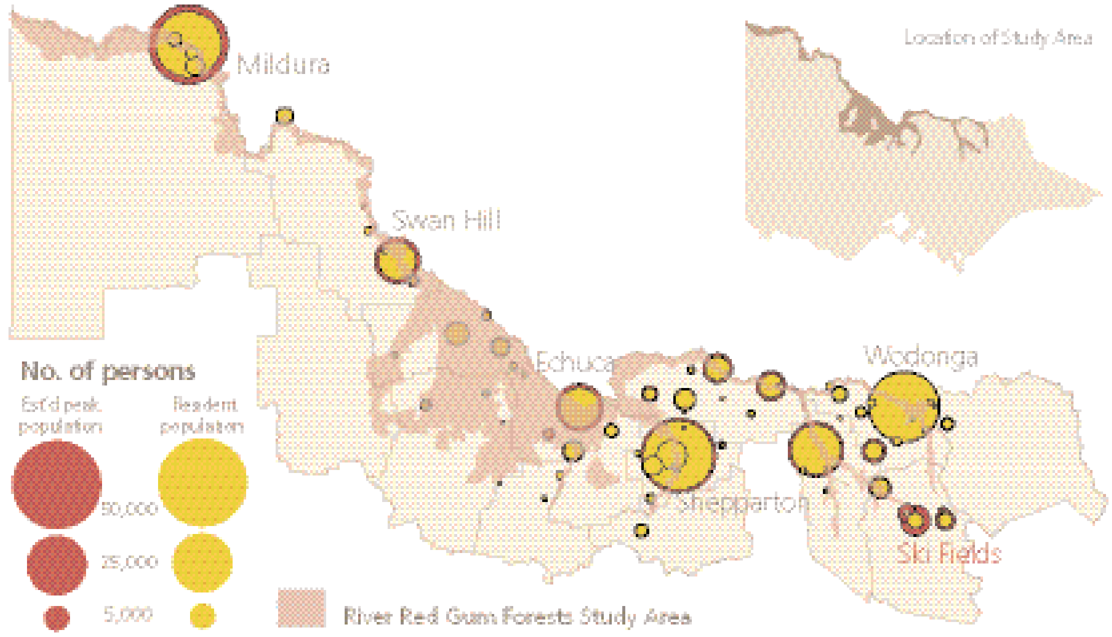


Figure 8.9 Peak population estimates for selected towns in the study area, 2001.



Note: Peak population estimates take into account potential population should unoccupied dwellings & tourist accommodation be filled
Source: Victorian Government 2006 Regional Matters An Atlas of Regional Victoria 2005

Community engagement may also be difficult in areas where population is widely dispersed. Populations have declined in most dryland farming regions of the study area because of more economically efficient agriculture. Changing settlement patterns are inevitable as farming moves towards more capital intensive private land management practices.

Temporary Populations

Most population counts are based on permanent resident populations. However, some regions display large variation in population depending on the time of year and the nature of housing and land use (e.g. holiday purposes, part-time or full-time residence). The size of the peak population is important for planning infrastructure and services and for assessing potential environmental impacts. Temporary populations, by definition, are unlikely to provide a strong and sustained base for community development and engagement.

Within the study area there are several places with highly variable populations. Tourists are attracted to river locations such as Echuca, Swan Hill and Mildura, as well as Shepparton, often visiting for short periods (Figure 8.9). These populations may place additional demands on infrastructure and services (e.g. water and waste) especially if there are seasonal peaks in visits.

Populations also vary with seasonal harvesting labour, particularly in horticulture. Thousands of harvest labourers are employed throughout the irrigated parts of the study area (Figure 8.10). Although some centres along the River Murray now harvest throughout the year, this does not necessarily mean that casual labour will be drawn from the permanent resident population. This casual workforce may have limited ties with a particular community or may remain marginalised from the day-to-day activities of longer term or more permanent residents in the district.

The degree to which the unemployed, homeless or those on low incomes are transient is unclear. Gathering reliable quantitative and qualitative data on mobile or marginalised populations is extremely difficult. Analysing problems such as temporary encampments on public land needs to take into account this difficulty as well as recognising that some may be living in these areas out of necessity because of housing shortages and social marginalisation. Solutions to such social problems are likely to require integrated social and economic responses, rather than simply being seen as an issue of illegal use of public land.

Age Structure

The general age structure of regional Victoria shows a distinct pattern of fewer people in the 15 to 29 year age groups (Figure 8.11). This reflects the net migration loss to metropolitan areas of this age cohort as young adults seek education and employment opportunities. Despite this net loss, regional areas generally gain in all other age groups.

Ageing of the population and retiring ‘baby boomers’ is contributing to a shrinking work population in most industries. Horticultural industries are somewhat protected from this broad trend because of their younger age structure. However, even in these industries the issue of skills shortages has emerged (DSE 2005g).

Using the regional Victorian pattern as comparison, population age structures across the study area reveal four distinct patterns, examples of which are presented in Figure 8.12 and described below:

Cities

Swan Hill, Wangaratta and Wodonga are regional cities which show relatively even age structures across all age groups. This reflects the ability of such locations to attract and/or retain young adults, family groups and older age people. Mildura, while having fewer young adults still has many family and older age groups. In many cases these cities are acting as 'sponge' cities—a term which describes their tendency to draw in people from the hinterland who are seeking better access to facilities and services than can be found in rural areas or small towns.

Retirement Destinations

Echuca and Yarrawonga have age structure patterns weighted to older age groups, highlighting the degree to which they have attracted retirees. Retirees often have many active years left in their lives, however, the oldest residents of the communities may have limited capacities for involvement and place increased demands on certain services such as health and community services.

Unlike most other rural areas, irrigation districts retain young adult populations. This is due to the greater labour intensity of irrigation agriculture and associated industries compared to dryland farming. The Statistical Local Area of Robinvale is an example of this type of age profile.

Dryland Farming Areas

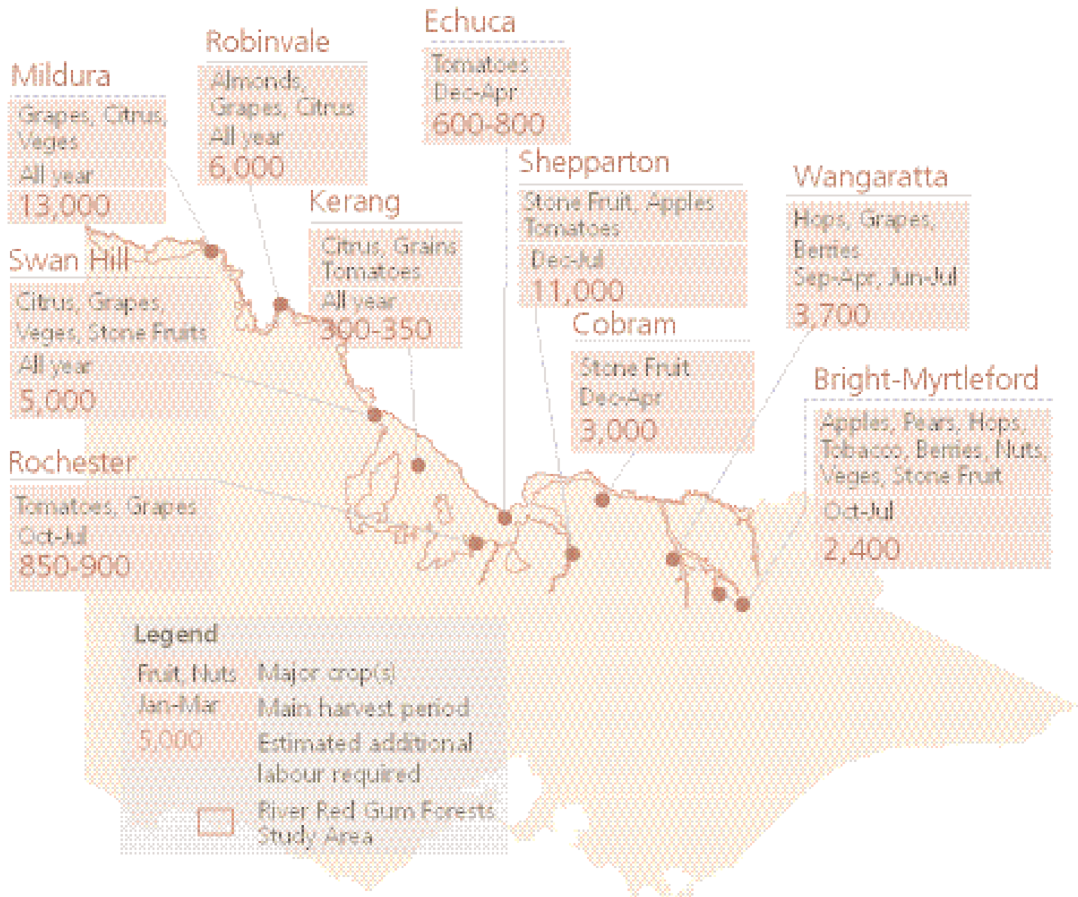
Populations in dryland farming areas have declined over many decades as agriculture has become more capital-intensive, personal mobility has increased and services have withdrawn. This population loss is particularly apparent among young adults, with young women being more likely to leave the study area (e.g. Statistical Local Area of Loddon North) than young men, resulting in a gender imbalance in this age group. This imbalance greatly reduces the potential for child-bearing in the population and reduces partnering opportunities, exacerbating isolation and depression among young male farmers. These problems may contribute to higher suicide rates in such regions (Molloy & Fox 2002).

ECONOMIC CHARACTERISTICS

Industry Profile

Census data on employment and industry provides insights into the region's economic profile. It also provides information on variables such as education which are both social and economic in nature. Although agriculture dominates the rural landscape of the study area, the labour needs of agriculture have declined over the past 50 years as capital inputs and farm sizes have increased. In some areas like the Shire of Loddon, around half of the workforce is still employed in agriculture, but the absolute numbers involved are still relatively small (1,500) (Figure 8.13). Rural communities are not synonymous with farming communities, with

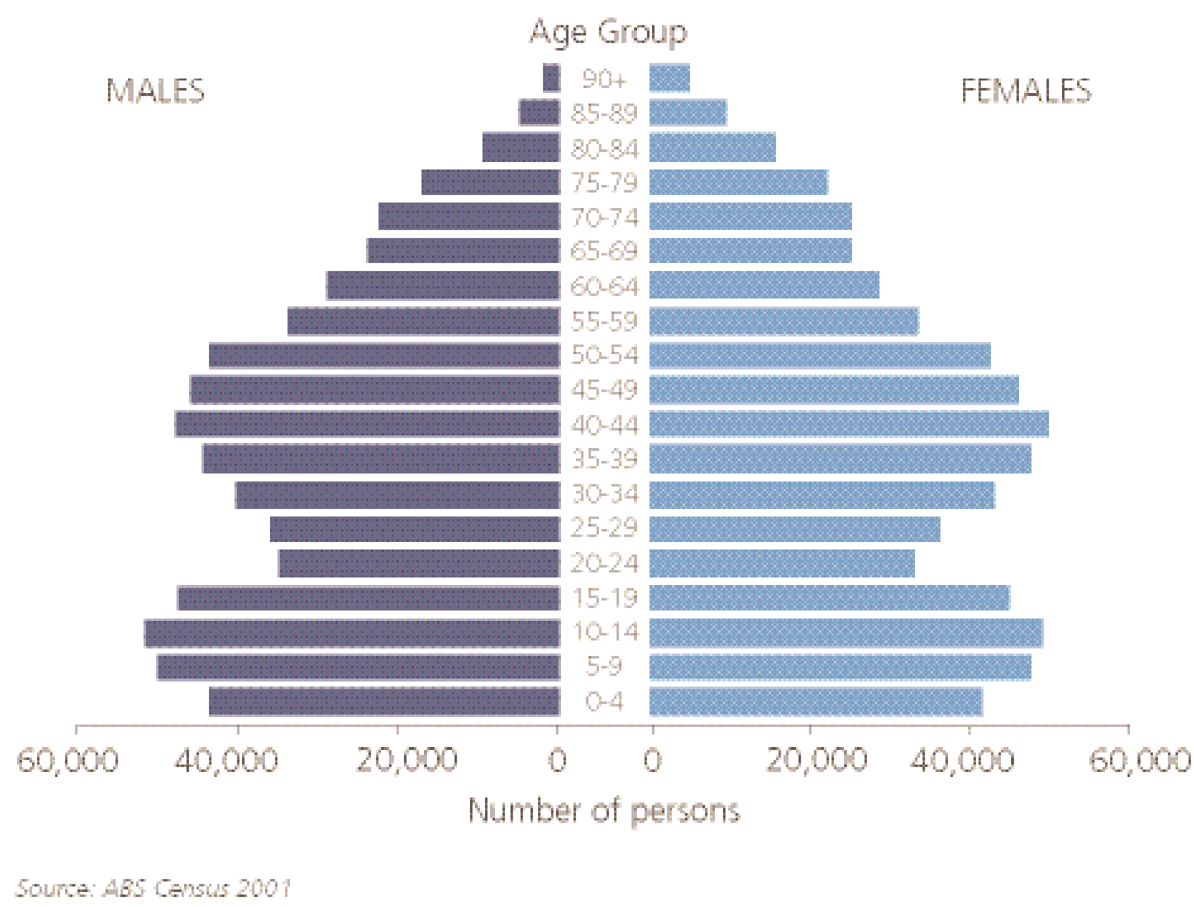
Figure 8.10 Estimated labour demands for harvest seasons in selected towns 2004.



Note: Harvest crops listed are major crops in the respective regions but do not indicate the complete range of horticultural products produced. Harvest periods and labour requirements indicated above may be subject to change depending upon seasonal climatic variation and changing economic conditions.

Source: Victorian Government 2006 Regional Matters An Atlas of Regional Victoria 2005

Figure 8.11 Age and sex structure for regional Victoria 2001.



more people employed in retail, manufacturing or community services. Engagement with regional communities needs to recognise this variability.

Employment in secondary industries varies in importance across the study area with Shepparton and Campaspe Shires maintaining high employment in this sector. Of greater significance, however, are consumer services, particularly retail trade, for most of the region. While much retail activity provides a service for local markets, it also contributes to the tourist trade. Estimates of tourism employment include a proportion of retail employment along with other tourism-related industries such as accommodation, cafes and restaurants. On the basis of such estimates the main region attracting tourism lies along the River Murray from Wodonga to Swan Hill as well as the cities of Shepparton and Mildura (Figure 8.14).

While the agricultural workforce has consistently declined between 1981 and 2001, the pattern of change has been more complex for secondary industries where restructuring has had different effects. In the early 1990s the Victorian manufacturing sector experienced economic downturn, industry restructuring and movement of some industries offshore. These trends left many regional centres vulnerable to change. Job losses and unemployment rates tended to be higher in the early 1990s than before or since. Manufacturing employment has since expanded in most regions (Figure 8.15).

The greatest increase in employment has been in the services sector, particularly consumer and community services. The ageing of Victoria's population is one factor in the expansion of industries such as health services. Unlike manufacturing or agriculture, such sectors require considerable labour and therefore account for a large proportion of workforce employment.

Employment change is not necessarily an indicator of industry success. Like agriculture, some secondary industries have seen a move towards more capital intensive enterprises which may still contribute to economic growth within a community even if actual job numbers appear to have declined. Furthermore, restructuring in some industries like manufacturing has created a 'category-jumping' effect in situations where certain functions are outsourced and become categorized as service employment (e.g, consultancy or contracting services) rather than manufacturing employment.

Education

Patterns of educational attainment show a clear urban–rural difference as well as a distinct east–west difference across the study area (Figure 8.16). The urban–rural difference can be explained by the greater range of professional occupations located in larger centres. In part this also explains the east–west difference as the western parts of the study area are generally more rural in character comprising fewer and smaller settlements. Labour force characteristics also affect the east–west difference as areas with a strong

Figure 8.12 Age and sex structure characteristics for selected Statistical Local Areas.

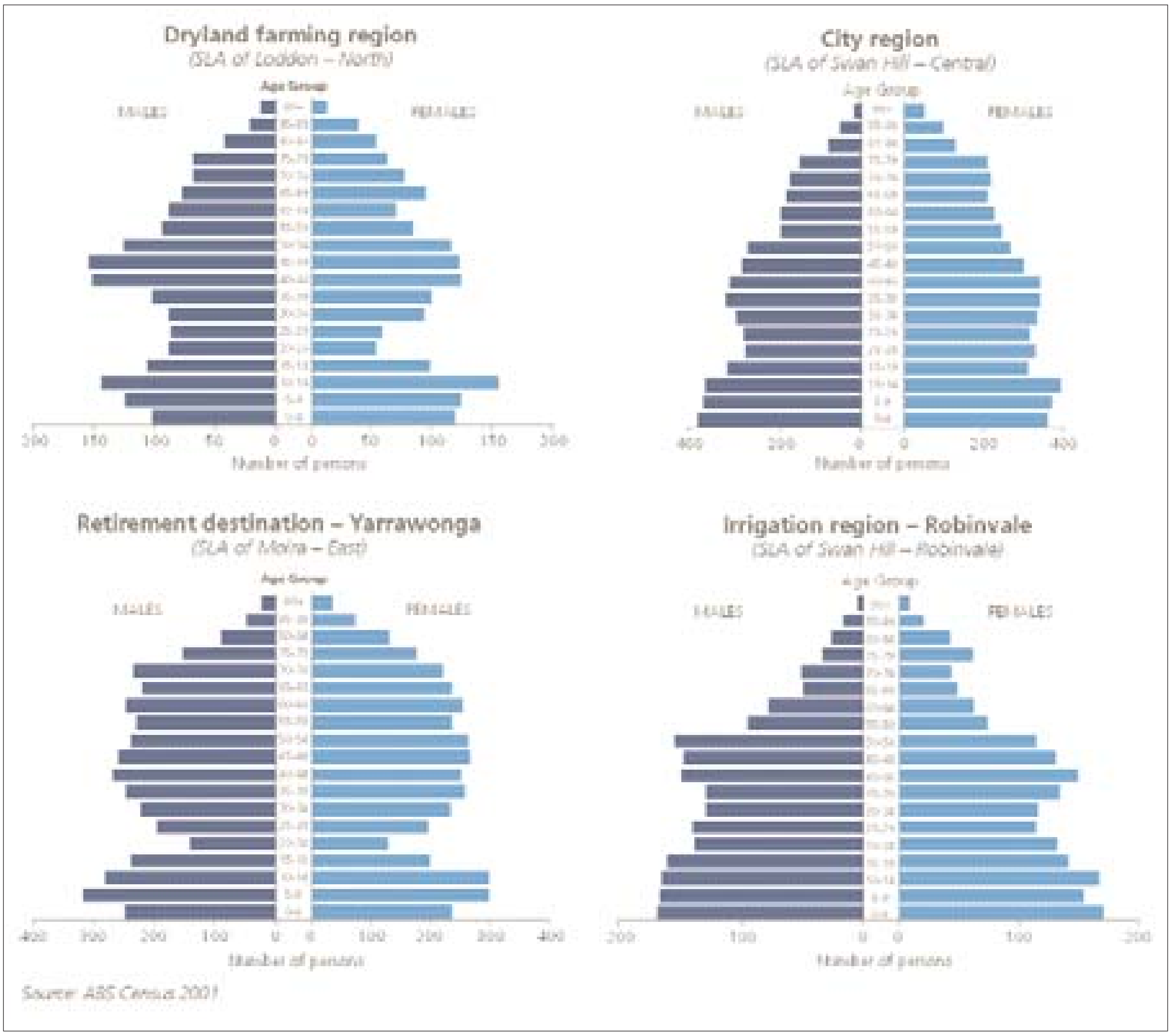


Figure 8.13 Employment by industry 2001 for Local Government Areas.

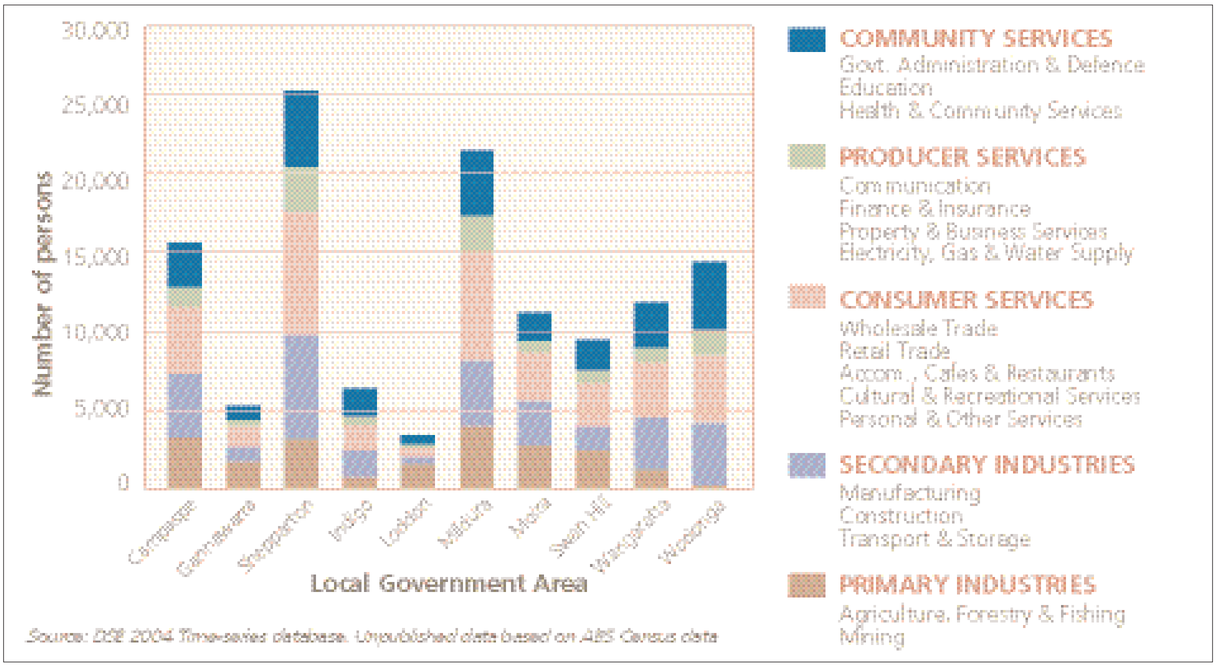


Figure 8.14 Estimates of tourism employment, 2001 for Statistical Local Areas.

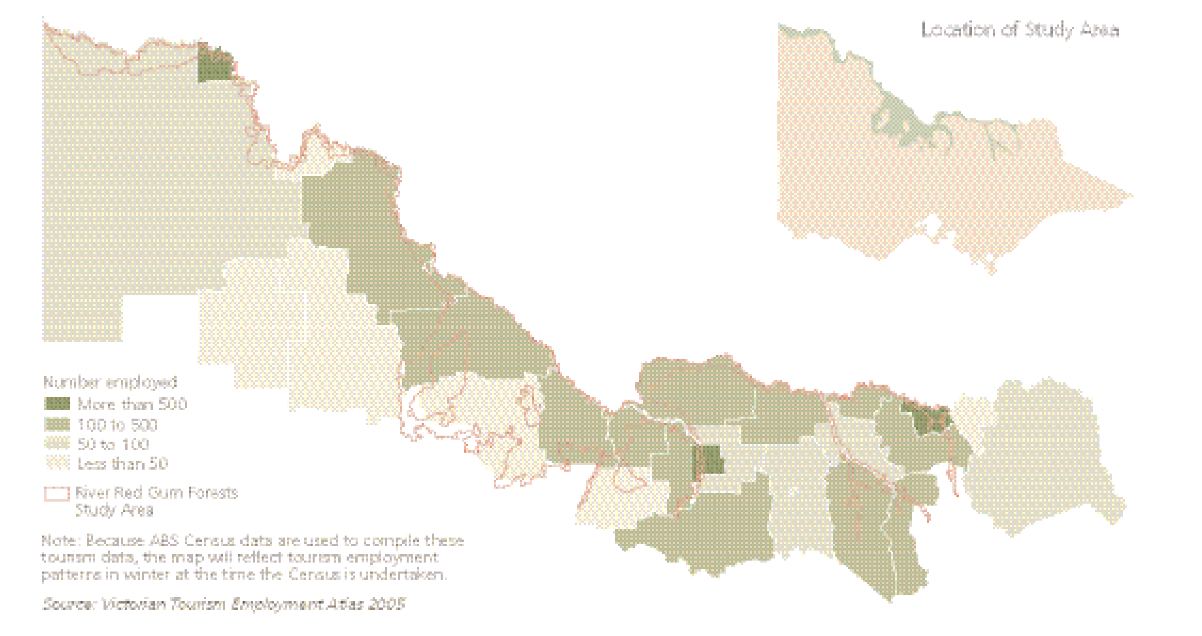
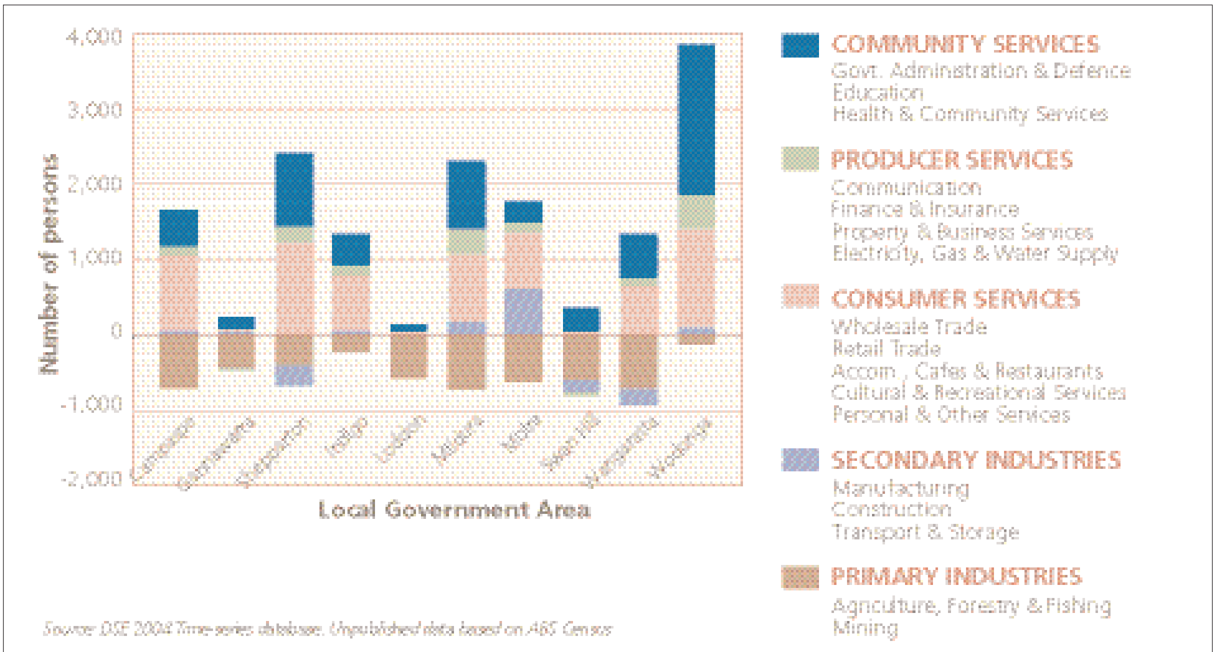


Figure 8.15 Change in employment by industry 2001 for Local Government Areas.



horticultural base are likely to have labour trained through vocational qualifications such as specialist diplomas or certificates.

In dryland farming areas, age structure is important in understanding the higher proportion of people with no post-school qualifications (Figure 8.17). Recent generations have higher levels of educational qualification—a result of increasing professionalisation of the workforce and requirements for training and qualification across most industries. Older generations have, on average, lower levels of tertiary qualifications. The age structure of farming communities in dryland regions of western Victoria is relatively old and hence a lower level of educational attainment would be expected.

The proportion of the population having no post-school qualifications is higher in regions downstream of Swan Hill. Despite having a relatively young age structure compared to other rural areas, this region has low levels of educational attainment. This may be partly explained by the fact that activities such as harvesting can be undertaken with relatively unskilled labour. There is also likely to be a greater degree of vocational or trade-related qualifications held by members of these communities rather than university qualifications.

Income

Income is an important indicator of socio-economic well-being. Low incomes indicate a lower capacity to access goods and services and may limit life choices. However, low income characteristics can be misleading in areas where residents are income-poor but asset-rich. Farmers and older people often fall into this category when land assets form a high proportion of their wealth (Figure 8.18).

Small numbers also confound income data in sparsely settled rural areas. Low income earners or unemployed tend to move out of such regions to access a wider range of employment opportunities. Unemployment figures for townships and rural areas also bear out this pattern of low unemployment rates in rural areas (Figure 8.19).

High incomes show some degree of dispersion across the study area although larger settlements show higher incomes reflecting more higher paid professionals (Figure 8.20). Around Mildura, Shepparton and Wodonga there is also evidence of higher incomes in the urban areas surrounding the city. In part this reflects the attraction of such areas for rural resident professionals, but in the case of Shepparton and Mildura it may also reflect high value agricultural production activities.

For public land management, the varying educational and income profiles of communities within the study

Figure 8.16 Proportion with people over 15 with a Bachelor degree or higher by Census Collection District.

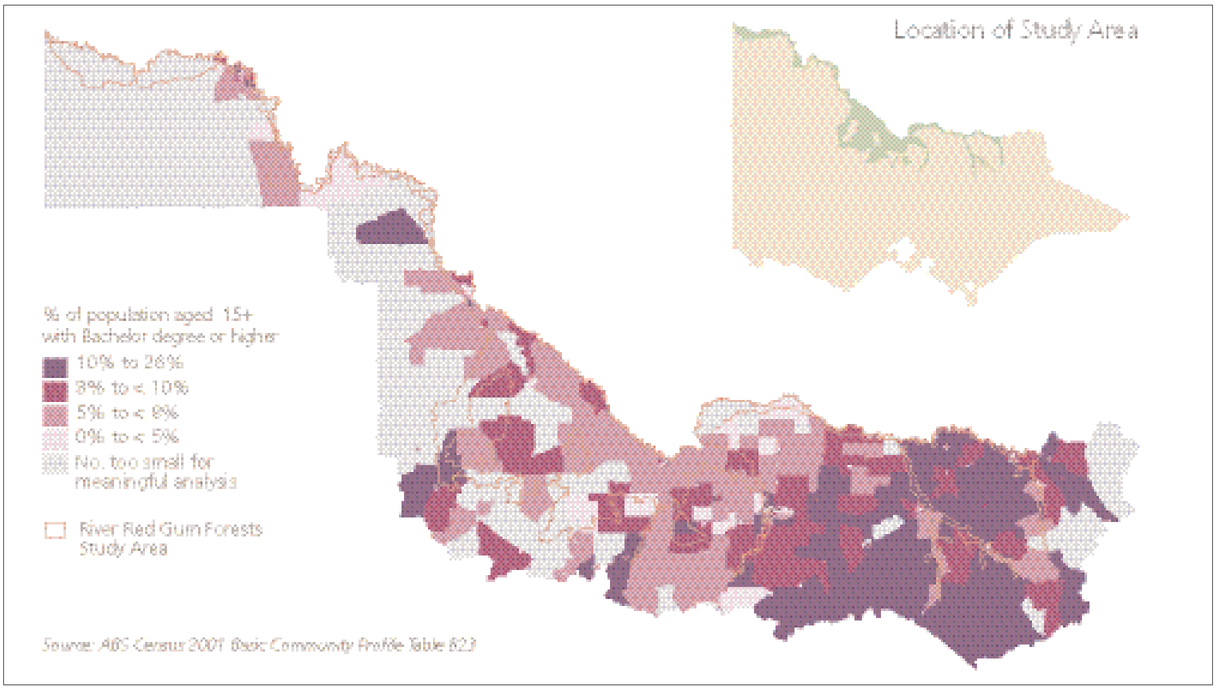


Figure 8.17 Proportion of people over 15 with no post-school qualifications by Census Collection District.

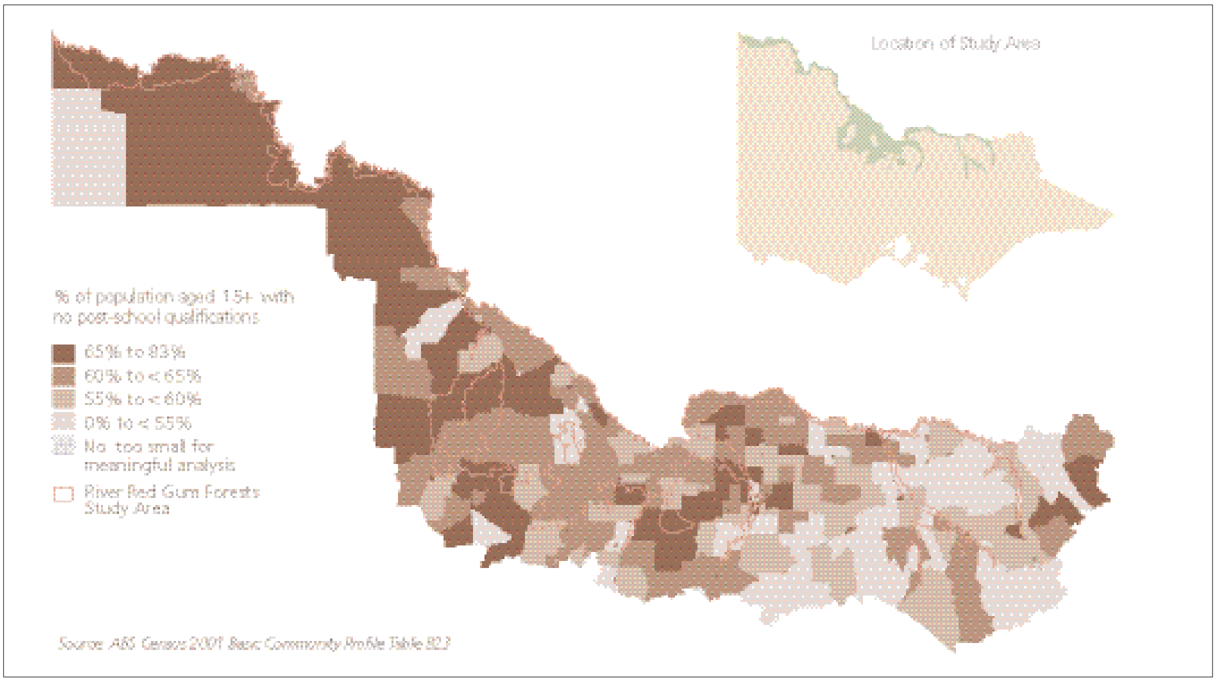


Figure 8.18 Proportion of households with gross income of less than $300 per week by Census Collection District.

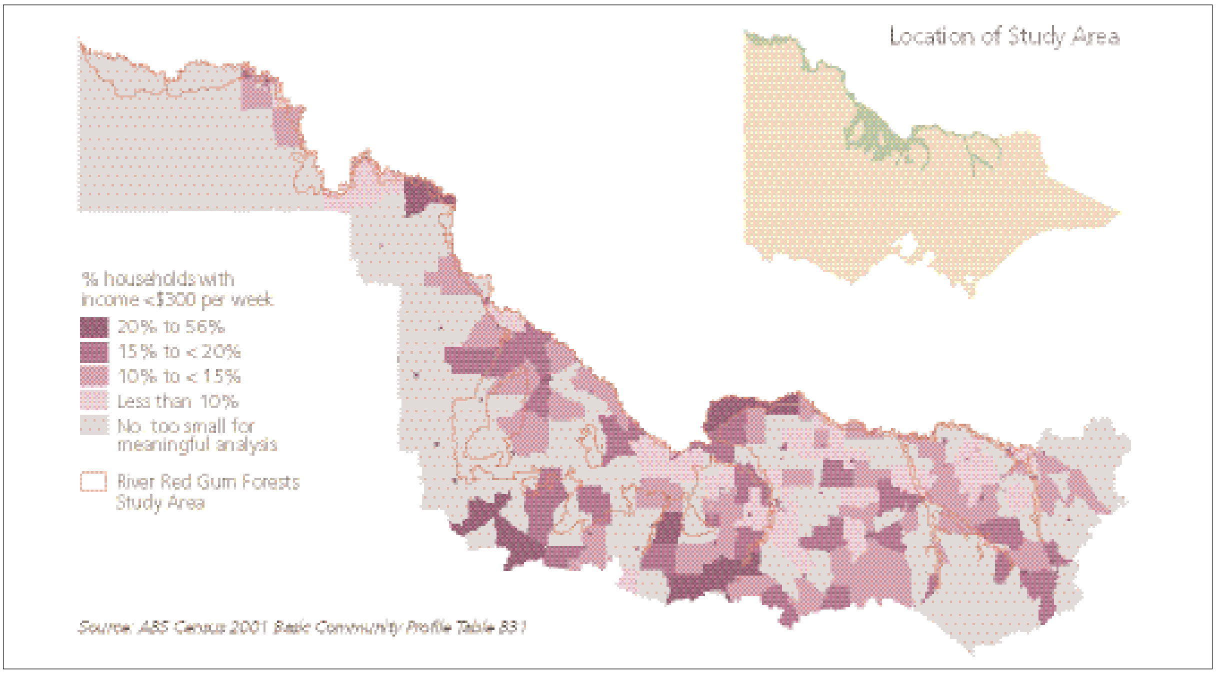
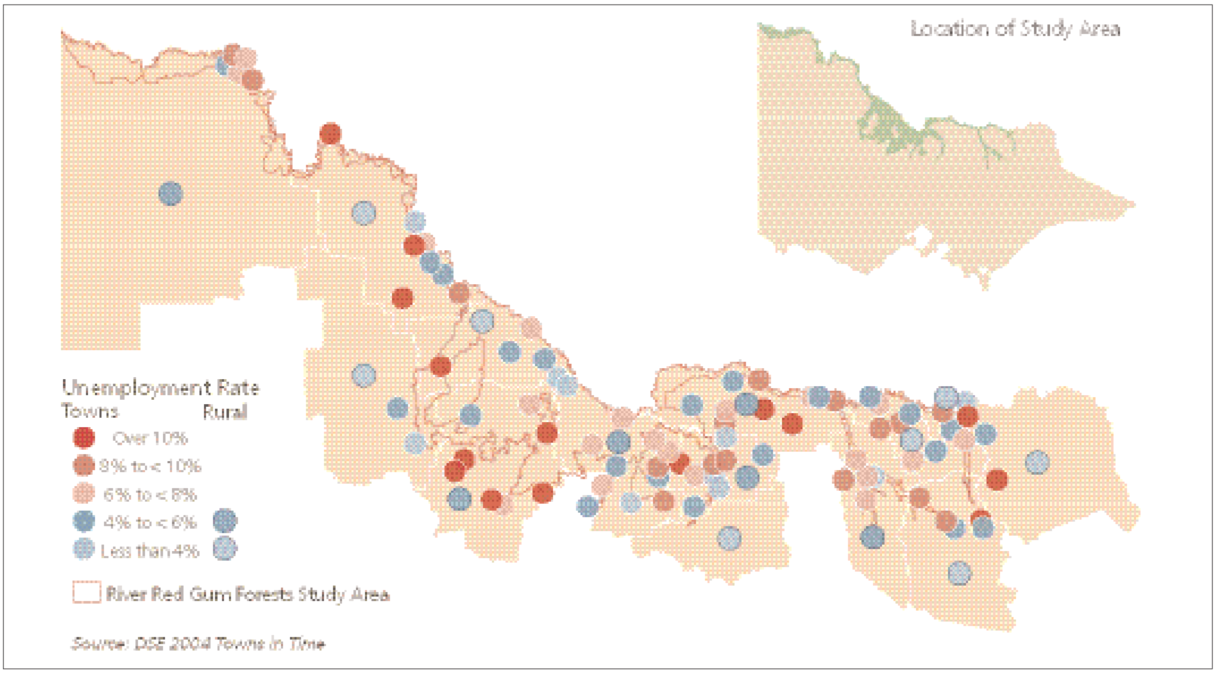


Figure 8.19 Unemployment rates for urban centres, rural localities and rural balances in the study area.



area may indicate a need for different communication and engagement strategies.

Summary

In socio-economic terms, a key challenge for public land management in the study area is community diversity. Public land in the south eastern part of the study area is closer to population centres. Even nearby rural areas house urban workers who commute to larger settlements. Communities can therefore be quite mixed in terms of urban and rural characteristics. In contrast, areas downstream from Echuca tend to have much more distinct differences between urban/irrigated areas and dryland rural areas. Dryland farming areas contain very dispersed, older and ethnically homogenous populations. Nearby irrigation areas along the Murray have younger population profiles, with more people who were born overseas, more Indigenous residents as well as high proportions of mobile or seasonal populations.

There are likely to be significant differences between communities in the study area in terms of: how long people have lived in the area, how well-connected they are and how much they wish to participate in their community. Some people are more mobile and have better access to transport. Some communities have strong levels of community activity and volunteering while others do not. Some communities have better familiarity with public land issues than others while income, education and culture also differ widely.

Such diversity is apparent when looking at an indicator such as involvement in volunteer activities (Figure 8.21). The Local Government Areas within the study area display a wide spectrum of volunteering levels from 31 percent (Shepparton) to more than 50 percent (Buloke, Loddon and Towong) (DVC 2005). These socio-economic differences between and within communities are challenges for communicating policy initiatives and management strategies for public land. Diverse communities challenge management agencies to identify all those who may have an interest in various public lands. Along the River Murray stakeholders are as diverse as tourists, recreational users, nearby residents and more distant communities, as well as upstream and downstream users of land and water resources. Recognition of this diversity within and across the regions is important when considering how public land is to be used in the future.

Figure 8.20 Proportion of households with a gross income of more than $1000 per week by Census Collection Districts.

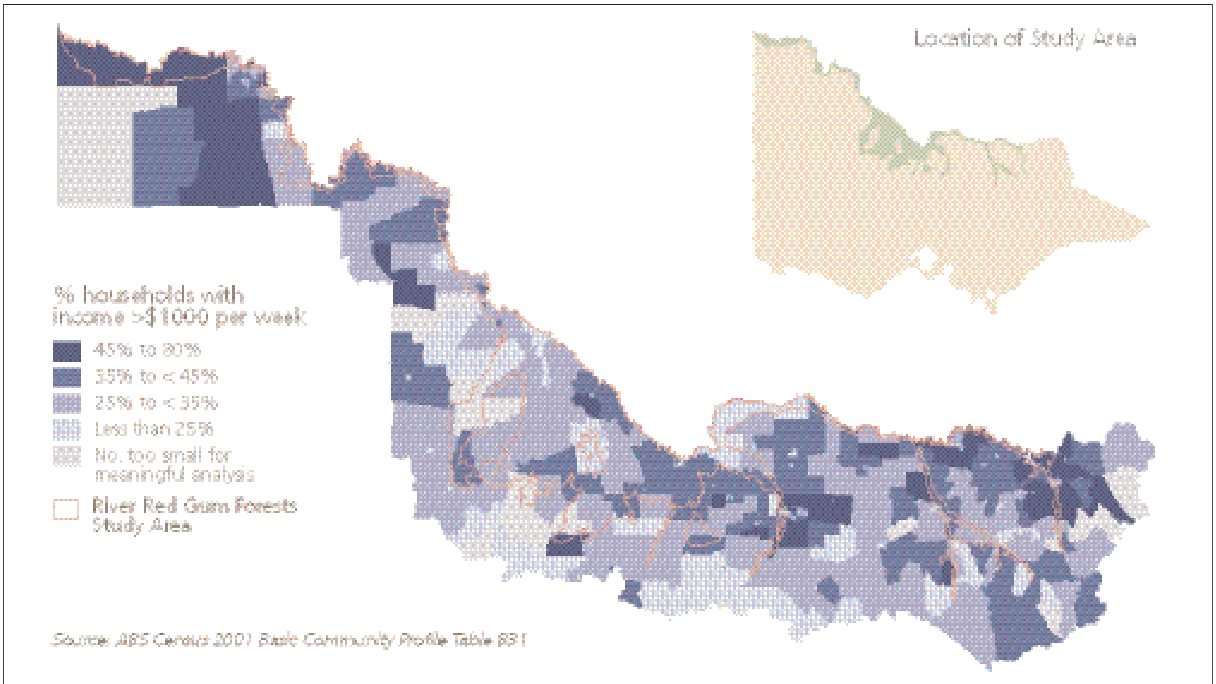
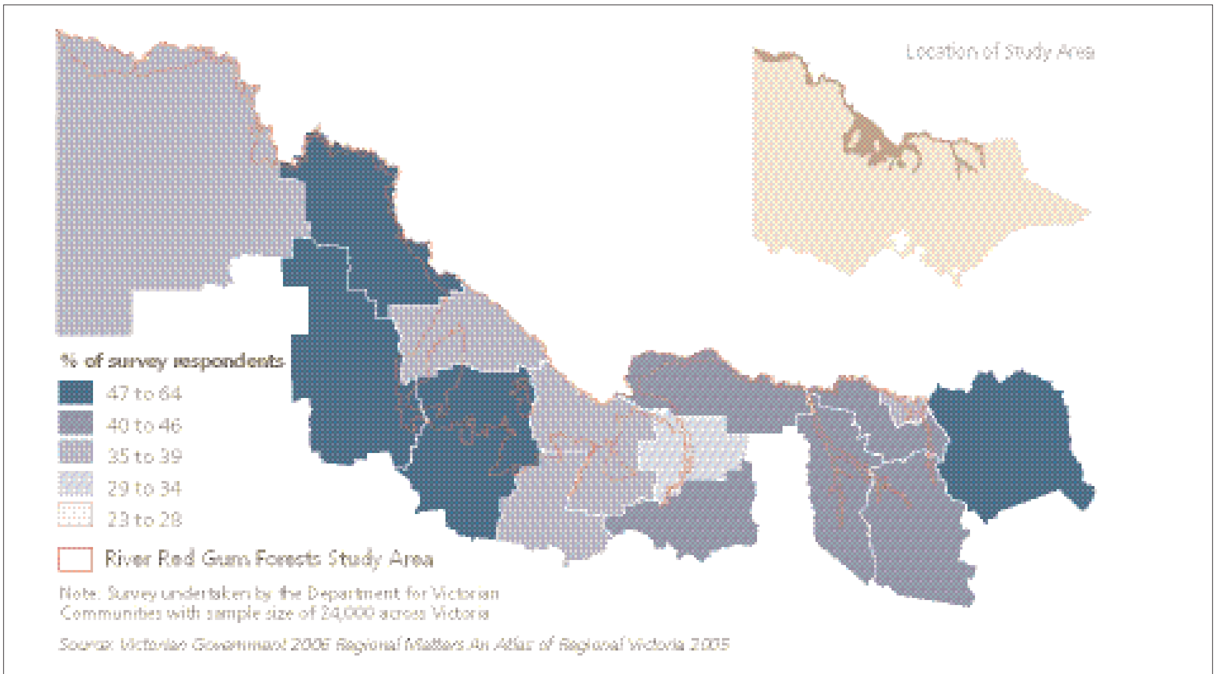
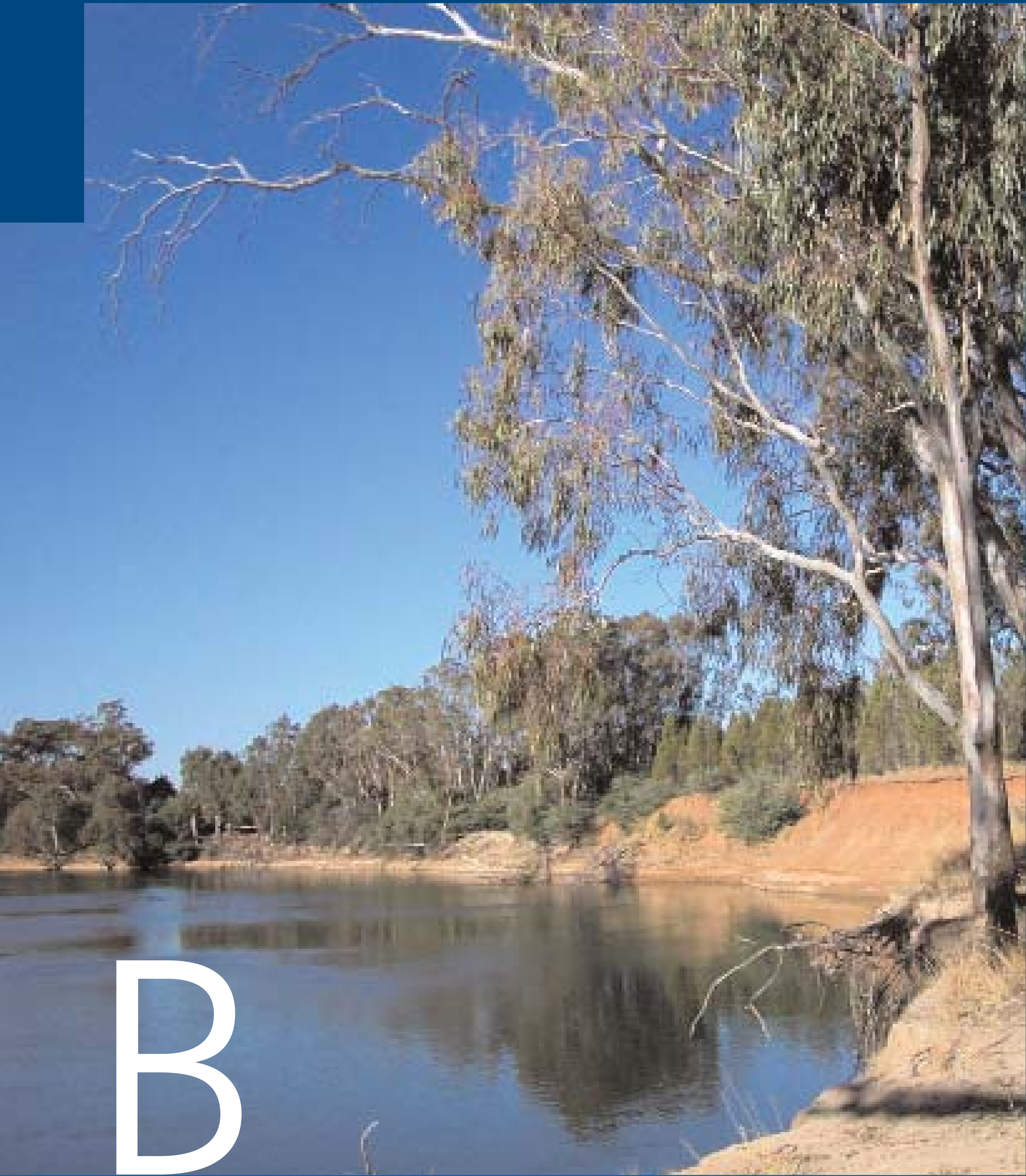


Figure 8.21 Proportion of residents who volunteer by Local Government Areas.





B

Public Land Use Framework

Part B explains in detail the public land use framework as it applies to the River Red Gum Forests study area. This includes the various public land use categories represented in the study area and the management arrangements associated with them. Chapter 9 is the only chapter in this part of the paper.

9 Public Land Use Categories and Management

This chapter provides an overview of the current public land use system in Victoria with a focus on those aspects most relevant to the study area. Victoria's public land use system is briefly compared with that in New South Wales and South Australia.

HISTORY OF PUBLIC LAND USE PLANNING

Three major stages have shaped the pattern of public land use in the study area as it is today: alienation of Crown lands (that is, transfer to freehold), protection of forest resources and strategic public land use planning. Each of these is considered in detail below.

Alienation of Crown Lands

Within a few years of explorer Mitchell's 1836 expedition through southwestern New South Wales and what was to become Victoria (see chapter 7), squatters began claiming large tracts of land for pastoral runs. Two decades later most of Victoria was occupied. Settlement patterns were strongly influenced by water supply, with the land closest to permanent water sources being settled first. The rich floodplains around Echuca were claimed early during settlement and most of the land between the Goulburn and Loddon Rivers was taken up by 1846. In 1846 Mildura was settled and, within 17 years, most of the Mallee was occupied by squatters. Several of the runs established in the Mallee during this time have remained public land with leases handed back after several years of drought and feral animal plagues which thwarted early agriculture (LCC 1987).

In 1851 a separate colonial government was established in Victoria and the annual Crown land pastoral leases were retained until a new land act was proclaimed in 1860 (LCC 1987). By that time, the imperative was to settle the land more densely and establish cultivated farmlands. Crown land was mostly alienated, or transferred to freehold, when surveyors (who acted as town planners) laid out and surveyed townships and farm allotments. Land was sold by way of selection, auction or ballot. A succession of Victorian Land Acts (1860, 1862 and 1865) heralded the end of the squatting era, with focus shifting toward more intensive agriculture. The *Land Act 1862* also changed the licensing system from annual to nine year licence periods. When licenses expired, the squatters were able to purchase portions of their runs and gain access to selections of land in recognition of their pre-emptive rights.

Agricultural settlement initially spread slowly along the Murray River, limited by the rate at which it could be surveyed. In 1869 selection before survey was permitted and the remaining land was quickly occupied. By the 1880s most land in the mid-Murray had been leased for agriculture and was converted to freehold once the lease conditions had been fulfilled (LCC 1983). Land rights were through land improvement which encouraged the clearing of vegetation and intensive irrigated agriculture (LCC 1987).

Pastoral and then agricultural settlement inevitably involved the clearing of the land; indeed, selectors were required to 'clear' their land as part of the terms of transfer of title. Trees were typically ringbarked or burnt. As land clearance spread, the loss of timber resources became a concern exacerbated by the opening up of the forests for selection after the best agricultural land had been sold (or leased with a view to sale) by the 1880s. Moreover, the taking of timber from unalienated Crown lands (permitted under licence) was poorly controlled, placing even greater pressure on timber resources. The area of Crown land in the rich agricultural areas of the alluvial floodplains rapidly diminished. The only large areas of Crown land remaining in the Murray Valley region were water frontages and flood-prone areas of river red gum forests, and these were under increasing pressure as a timber source and for stock watering access. The value of these areas as public water sources was recognised by the creation of frontage reserves on all permanent streams in 1881.

In areas of high density settlement such as the Campaspe River catchment, little water frontage reserve remains with most of the adjoining land sold in the 1860s prior to the introduction of water frontage reserves. As a result, very little public land on the Campaspe has been retained except the beds and banks of the river which were declared public land under the *Water Act 1905*. Water frontages were often an area of conflict, with settlers fencing in frontages adjoining their land for exclusive use, resulting in major problems in drier years when little common ground for grazing was available (LCC 1983).

Pastoral occupation in the Mallee rapidly increased after the proclamation of the *Land Act 1869*, which aimed to increase the number of smaller blocks and reduce the size of pastoral areas. However, without secure tenure, occupation soon dropped by a third by the 1880s. Clearance of the land and settlement was slow due to the difficulty in removing Mallee vegetation, droughts and soil erosion.

The extent of public land in the Mallee today is shaped by climate limitations on the expansion of wheat cultivation from the Wimmera into the Mallee, the limits of which were largely reached by World War II. Further settlement was attempted through soldier settlement schemes providing low interest long-term loans for returned WWI and WWII servicemen. Soldier settlements occur within the study area in the Goulburn Valley centred on Numurkah, Katandra and Stanhope, and in the Robinvale, Yungera and Red Cliffs area. Both Crown land and freehold land was purchased and sub-divided under these schemes, however, much of the Crown land made available was marginal. After periods of drought and the Great Depression, many leases were either consolidated into larger more profitable holdings or handed back to the Crown. In general, the current extent of public land in the Mallee today is much the same as what it was after WWII.

Protection of Forest Resources

The River Red Gum Forests study area supplied timber for the rapid expansion of European settlement in Victoria. Initial use was largely for fencing and building materials, but as the paddle-steamer trade route burgeoned along the River Murray, red gum and black box were cut without restriction from the river banks for fuel. The rapid expansion of agriculture on the irrigated floodplains and the discovery of gold in 1851 increased demand for infrastructure. River red gum was cut for harbours, locks and weirs along the river and to fuel irrigation pumping stations. Inland, trees were ringbarked to increase grazing area. The railway between Echuca and Melbourne was completed in the 1860s with sleepers harvested from river red gum forests along the Murray and major watercourses in northern Victoria.

Initially very few areas of public land were set aside for timber production and those large areas that have been retained are primarily on flood-prone land unsuitable for agriculture—such as Barmah forest and Gunbower Island—or areas less desirable for farming land due to climatic or soil condition. By the time settlement had expanded to the Mallee region in the northwest of the state, the need for controlled access to public resources such as timber was apparent, although extensive areas of cypress pine and belah were still cut for their durable and highly valued timber. Areas of river red gum and black box woodlands were retained west of Mildura (Walpolla, Lindsay, and Mulcra Islands) but these forests are of a more limited extent than those which formerly occupied the extensive floodplains in the central part of the study area. In places where squatters occupied and actively worked large land holdings, forests were cleared to the edge of the River Murray Reserve. Although agriculture, including dryland farming, increased with railway construction, several years of drought limited expansion and many areas of 'improved' farmland were returned to the Crown when unprofitable leases expired.

Local forest boards were established in the 1870s, but it was not until 1908 that an autonomous State Forests Department was established. This department controlled the production of timber from public land, reserved areas of forest, and collected royalties. In 1918 the Forest Commission was established and sought to repair the damage caused by a past lack of regulation that had resulted in immense wastage and over-cutting of preferred species significantly altering both forest structures and composition (LCC 1988). Drought and over grazing hampered attempts to re-establish forests in much of the western portion of the study area. The scarcity of multi-age and structurally diverse forests in the central and eastern part of the study area is a legacy of over use in the past (see chapter 14).

Balanced Public Land Use

For many years, the use and management of Victoria's public land and resources was driven by the demands of industry and 'development'. In 1970 the government established the Land Conservation Council (LCC), charged with conducting a more strategic assessment and making recommendations for the most appropriate use of public lands (Clode 2006). At that time only 2.8 percent of Crown land was reserved for conservation purposes as national parks or wildlife reserves, or 1 percent of the total area of the state (LCC 1988).

The LCC divided Victoria into 15 study areas, undertook regional investigations of these study areas and recommended that public lands be allocated to a balance of specified land use categories. The LCC's recommendations were made after the collection of scientific information and an extensive process of community consultation.

Most of the River Red Gum Forests study area has been investigated in one or more of several LCC studies (see Table 9.1). Three of these studies have also been reviewed as part of the strategic approach adopted by the LCC to revise recommendations at approximately 10 year intervals to accommodate the changing needs for public land use. The largest area covered in previous investigations is that overlapping with the LCC's Murray Valley Investigation (1985) and the Mallee Review (1989).

In addition to the broad-based public land use investigations, three thematic special investigations also overlap with the study area. The statewide LCC (1991) Rivers and Streams Special Investigation focussed on major watercourses with special values. Areas bordering the Ovens and Goulburn Rivers were recommended as Victorian Heritage Rivers, and more general recommendations were made regarding stream and public water frontages. Only a limited area of the Historic Places South-west Special Investigation (1997) is included within the study area near Charlton but there are a number of historic sites identified throughout the study area (see chapter 12). LCC's Statewide Assessment of Public Land Use (1988) included mapping of Victorian land systems, described in the joint LCC and Department of Conservation and Environment report by Rowan (1990), the results of which are explored in chapter 3. The LCC's successor body, the Environment Conservation Council (ECC) completed the Box-Ironbark Forests and Woodlands Investigation (2001) across extensive areas of central and western Victoria. Although this study area overlaps with the River Red Gum Forests study area, public land within the area of overlap was not considered in detail during the ECC study.

LCC and ECC recommendations subsequently adopted by government have largely been implemented. Since the Mallee Review study (1989), there have been relatively few changes to the land use allocations, mostly arising from subsequent special investigations (see Table 9.1). The boundaries of LCC and ECC investigations of relevance to the River Red Gum Forests Investigation are shown in Map 9.1.

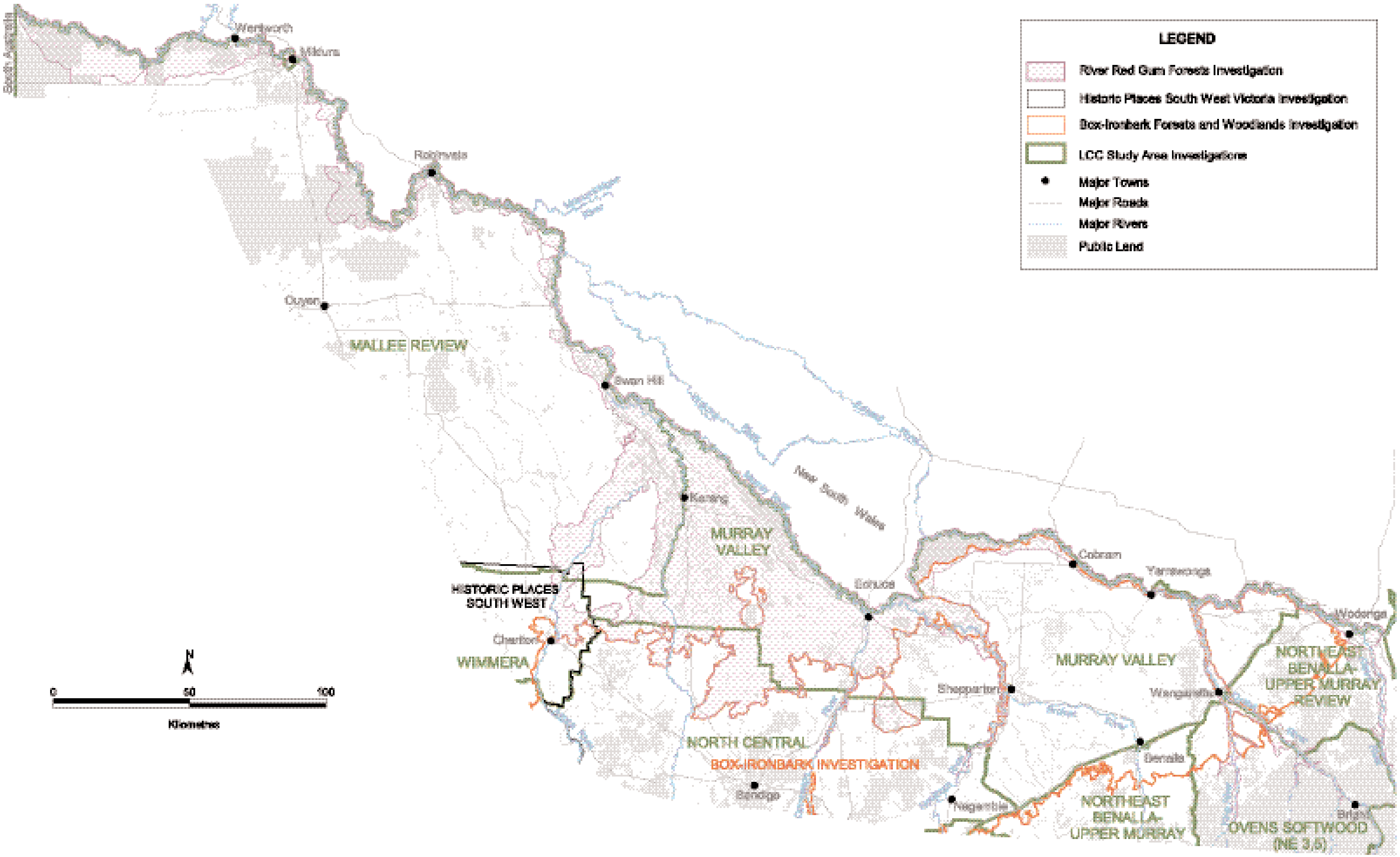
Table 9.1 Previous Land Conservation Council and Environment Conservation Council Investigations overlapping with the River Red Gum Forests study area.

Investigation	Date	Key Implications For Study Area
Regional Investigations		
Mallee Area	May 1977	Led to the creation of the Wyperfeld and Hattah–Kulkyne National Parks, and Murray–Kulkyne Park.
Mallee Review	August 1989	Existing parks enlarged and several new parks and reserves established including Murray–Sunset National Park and Leaghur State Park.
Murray Valley Area	May 1985	Barmah and Terrick Terrick State Parks and several conservation reserves were established, as were several regional parks and the River Murray Reserve along the Murray River.
North Central Area	February 1981	Relatively little overlap with River Red Gum Forests study area.
North East District 1	November 1973	Small areas of public land in the first two investigations are included in the current study.
North East District 2	July 1974	
North East District 3, 4 & 5	April 1977	Expansion of Mount Buffalo National Park.
North East (Benalla–Upper Murray) Review—Districts 1, 2 & 4	January 1986	Creation of Wodonga Regional Park (land in the rural city of Wodonga was included).
Wimmera Area	November 1986	Minor area of overlap with the River Red Gum Forests study area principally along the Avoca River.
Box-Ironbark Forests and Woodlands	June 2001	Areas overlap with the River Red Gum Forests study area principally along the Murray River from near Yarrawonga to Echuca and in the lower reaches of the Goulburn River.
Special Investigations		
Ovens Softwood Plantation Zone (NE 3, 5 Review)	November 1981	North East Districts 3 & 5 were reviewed as part of Ovens Softwood Zone Special Investigation. LCC recommendations were not accepted by government.
Rivers and Streams	June 1991	A statewide study that, amongst other things, led to the designation of heritage rivers including the Ovens and Goulburn Rivers in the River Red Gum Forests study area.
Historic Places—South-Western Victoria	January 1997	Led to the creation of historic and cultural features reserves in southwest Victoria, although very few in the River Red Gum Forests study area.
Land Systems of Victoria	June 1990	Statewide mapping of land systems undertaken at 1:250 000 scale.

Present Needs and Expectations

Over time there has been a significant shift in the expectation and needs placed upon public land, particularly in relation to biodiversity protection. Land management agencies have increasingly sophisticated management plans to promote sustainability and protect natural, economic and cultural values on public land. Private land owners also contribute to biodiversity protection through schemes such as ‘Land for Wildlife’. Similarly, timber plantations on private land reduce the pressure for timber resources on public land.

Map 9.1 LCC and ECC investigations overlapping with River Red Gum Forests study area.



Overview of Public Land Use Categories

Public lands are classified into the following major land use categories:

- parks—national, state and regional parks, wilderness parks, marine national parks
- nature conservation reserves—flora, flora and fauna, non-hunting wildlife reserves and marine sanctuaries
- historic and cultural feature reserves
- natural feature reserves—including bushland reserves, water frontages, streamside reserves and scenic reserves
- forest park
- state forest— including areas previously allocated specifically as hardwood production areas
- coastal reserves— coastal waters reserve and coast reserve
- community use areas—education areas, recreation reserves, parklands and gardens, schools, public halls and so forth
- water production areas—storage and distribution facilities
- plantations—softwood and hardwood plantations
- other categories—including alpine resorts, earth resources (stone reserves and coal production areas) and services and utility reserves.

Most land use categories define the primary purpose of the public land. For many of the land use categories a range of additional purposes is also defined. Each land use category is generally subject to particular legislation and management arrangements (see Table 9.2), although individual parks and reserves may also be subject to additional or alternative legislation and management arrangements.

Victoria's conservation reserve system mostly comprises national, state and wilderness parks and nature conservation reserves (see chapter 10). Other special features may be protected by specific reserves, such as historic and cultural feature reserves or natural feature reserves.

Special values of public land may be protected legally by overlays on the main land use category of an area. Such overlays include:

- reference areas
- wilderness zones
- remote and natural areas
- heritage rivers

Table 9.2 Summary of general land use categories, legislation and management arrangements.

LAND USE CATEGORY	LEGISLATION	MANAGER
national and state parks	*National Parks Act 1975*	Parks Victoria
regional parks	*National Parks Act 1975, Crown Land (Reserves) Act 1978 or Forests Act 1958*	Parks Victoria
nature conservation reserves	*Crown Land (Reserves) Act 1978*	Parks Victoria
historic and cultural features reserves	mostly *Crown Land (Reserves) Act 1978*	mostly Parks Victoria
natural features reserves	*Crown Land (Reserves) Act 1978*	Parks Victoria
forest park (Otways)	*Crown Land (Reserves) Act 1978*	DSE
state forest	*Forests Act 1958*	DSE
coastal reserves	*Crown Land (Reserves) Act 1978*	often committees of management (through DSE regions)
community use areas	*Crown Land (Reserves) Act 1978*	often committees of management (through DSE regions)
water production areas	various	water authorities
softwood production	*Victorian Plantations Corporation Act 1993*	private company as licensee
other reserves (e.g. services and utilities, stone reserves, coal production areas, etc.)	various	various (under DSE regions)

Note: Information in this table is a summary only. Any given park or reserve may be subject to additional or alternative legislation or management arrangement.

- representative rivers
- historic and cultural feature zones
- coastal protection and coastal recreation zones of coastal reserves
- scenic coast, and
- declared water supply catchments.

Special values of public land can also be specifically protected by zoning and prescriptions as defined in management plans, codes of practice and other management planning documents.

A public land use category is formally assigned to an area in a number of ways. Between 1970 and 1997 it was mostly undertaken through an Order in Council process, which directed government departments and public authorities to give effect to government-approved land use recommendations. The *Victorian Environmental Assessment Council Act 2001* retains the legal standing of such Orders in Council, which still define the approved public land use for an area unless it has been specifically amended or revoked by Governor in Council (s 28, *Victorian Environmental Assessment Council Act 2001*). Formal implementation of such Orders in Council can occur through amendment to legislation (for example, to the *National Parks Act 1975*), by changing the reservation of the land, or by administrative process. Current public land use categories in the River Red Gum Forests study area are described below.

In 1994 the LCC developed a revised and simplified system of public land use categories. Land uses from LCC studies before that date are shown on Map A as their equivalent in the revised public land categories. For example, areas approved by government as flora and fauna reserves are coloured as nature conservation reserves; approved bushland reserves and public land water frontages are shown as natural features reserves.

CURRENT PUBLIC LAND USE CATEGORIES

The extent of each major public land category in the study area is documented in Table 9.3. The study area boundary encompasses some 1,215,775 ha, of which approximately 262,915 ha is public land.

Table 9.3 The extent of major public land categories in the study area.

Category	Area (ha)
National Park	52,120
State Park	9920
Regional Park	7775
Nature Conservation Reserve	11,770
Natural Features Reserve (Murray River Reserve)	47,325 (16,060)
Water Production	10,800
Historic and Cultural Features Reserve	705
Community Use Area	3690
State Forest	106,710
Plantation	170
Earth Resources	125
Services and Utility	4760
Wildlife Co-operative Management Area	2520
Uncategorised Public Land	3845
Land not required for public purposes	680
Total Extent of public land included in the Investigation	**262,915**
Freehold	**952,860**
Total extent of study area (including all freehold and other land)	**1,215,775**
Overlays (areas included in the totals above)	
Reference Area (in various categories above)	3860
Heritage River (in various categories above)	16,450
Special Protection Zone (in state forest)	10,035

Note 1: The areas in this table are rounded-off to the nearest five hectares. The areas are mostly derived from spatial analysis of 1:25,000 or 1:100,000 mapping, and therefore may differ from other (generally less precise) area statements. For example, the area of Leaghur State Park according to Schedule 2 of the National Parks Act 1975 is '1583 ha more or less'. As a result, the areas in this table may not concur with those in other tables in this chapter which use the area statements from the official scheduling, proclamation, or reservation (whichever is appropriate) of lands in the various public land use categories.

Note 2: A number of larger blocks of public land are only partially included in the study area. This is particularly so for a number of larger national parks where only small sections of the parks are actually within the study area. e.g. Murray–Sunset, Hattah–Kulkyne and Terrick Terrick National Parks.

Parks

Until 1977 the only areas set aside for a park within the study area was the Hattah Lakes National Park. Initially about 16,800 ha in the Hattah area were set aside as a sanctuary for game in 1941 (Catrice 2002), but it was not until 1960 that the Hattah Lakes National Park (7200 ha) was declared after extensive lobbying from conservation groups throughout the 1950s. The LCC Mallee Study (1977b) recommended the enlargement of the pre-existing Hattah Lakes National Park (17,814 ha) and Hattah–Kulkyne National Park (46,160 ha) was created. The area of the Hattah–Kulkyne National Park was expanded to 46,500 ha in 1989 (LCC 1989a). At the same time the abutting Murray–Kulkyne Park was recommended to increase from 1600 ha with the addition of 1980 ha (LCC 1989a).

In the LCC Murray Valley Study (1985), no new national parks were recommended but Barmah State Park (7900 ha) and Terrick Terrick State Park (2500 ha) and several regional parks were recommended and later established. From the North-Eastern Area (Benalla–Upper Murray) Review (1986) several new regional parks were established. In the LCC Mallee Review (1989), a new national park, Murray–Sunset National Park (600,540 ha) was established covering large areas of mallee, river red gum and other vegetation types. Approximately 26,320 ha, of this parks falls within the study area, including the river red gum forests and associated vegetation communities on and adjoining Lindsay Island near the South Australian border. Under the same review, Leaghur State Park (1680 ha) was also created and the Murray–Kulkyne Park (1550 ha) enlarged. Prior to the ECC Box-Ironbark Investigation (2001), Terrick Terrick State Park (2493 ha) was established in 1988 and, with the addition of purchased private land (1277 ha), in 1999 Terrick Terrick National Park was established. The ECC Box-Ironbark Forests and Woodlands Investigation (2001) recommended Terrick Terrick Flora Reserve and some water frontages be added to the national park, resulting in an additional 110 ha to the park.

Details of the national, state and regional parks in the study area are provided in Table 9.4. Together, these parks protect a range of environments found in the study area and allow a variety of recreation activities in natural environments. While some parks include small relatively undisturbed areas, they nearly all include some areas with past disturbance, mostly by timber harvesting and grazing. The system of park and reserve classification in Victoria enables different classifications to meet differing land use needs, such as nature conservation, recreation, water supply, etc, to varying degrees. National and state parks primarily provide nature conservation, while regional parks have a focus on recreation. National and state park management plans generally apply a zoning scheme indicating the emphasis of management in specific parts of the park (see Table 9.5).

National Parks

National parks are generally substantial tracts of public land with outstanding natural features and diverse land types, primarily set aside to conserve and protect natural ecosystems. They also provide for public enjoyment, education and inspiration in natural environments. The three existing national parks in the study area, the Murray–Sunset National Park, Hattah–Kulkyne National Park and Terrick Terrick National Park, comprise about 19 percent of the public land of the study area.

DSE designates Murray–Sunset, Terrick Terrick and Hattah–Kulkyne National Parks as Category II (National Park) in the IUCN system of protected area management categories (see Box 10.1 in chapter 10). Protected areas in this category are managed primarily for ecosystem conservation and appropriate recreation.

Murray–Sunset National Park is the state's second largest national park (600,540 ha), and is one of the few remaining semi-arid regions that is relatively untouched. The park contains dunefields, groundwater discharge areas, grasslands, saltbush, river red gum and black box woodlands, a variety of rare and threatened flora and fauna, Aboriginal cultural heritage sites and historic sites relating to early pastoral activities and salt mining. There are also extensive opportunities for both passive and active recreation, with designated walking tracks, camping sites and four wheel drive tracks. The park covers several bioregions, 60 percent being in the Murray Mallee Bioregion, four percent in the Murray Scroll Belt Bioregion and the remaining 36 percent is in the Lowan Mallee Bioregion (see chapter 5 for Bioregion descriptions). Ten percent of the reserved public land within the Murray Mallee Bioregion and 88 percent in the Murray Scroll Belt Bioregion lie within the park. Although only about 4 percent (26,320 ha) of Murray–Sunset National Park is within the study area this subsection includes 25,770 ha (or 99 percent) of the protected Murray Scroll Belt bioregion compared to 546 ha (or only 0.14 percent) of the Murray Mallee Bioregion.

Hattah–Kulkyne National Park is typical of Mallee country with low scrub and open native pine woodlands. It also has riverine vegetation such as river red gum and black box woodlands, due to a network of freshwater lakes linked to the Murray River, known as the Hattah Lakes (see Figure 3.2). These lakes are largely included within the national park, and 48 percent (24,440 ha) of the park is within the study area. There are a variety of threatened flora and fauna species, Aboriginal cultural heritage sites, camping grounds, walking tracks and other facilities for recreational activities. The lakes are extensively used for water based recreational activities. Hattah–Kulkyne National Park is entirely within the Robinvale Plains bioregion. It is the only national park within this bioregion and comprises 64 percent of the reserved public land in this bioregion.

Lakes in Hattah–Kulkyne National Park are managed according to the Convention of Wetlands of International Importance, especially as waterfowl habitat, known as the Ramsar Convention (see chapter 5 Biodiversity). Australia is also a signatory to the Japanese Australian Migratory Bird Agreement (JAMBA) and Chinese Australian Migratory Bird Agreement (CAMBA), requiring land managers to protect habitat for listed birds, of which 11 species are found at Hattah–Kulkyne National Park. A strategic management plan has been prepared specifically to address conservation values of this wetland (DSE 2003e).

Terrick Terrick National Park near Mitiamo is the last remaining significant area containing the endangered northern plains grassland community—which is listed as a threatened community under the *Flora and Fauna Guarantee Act 1988*. The park also has the largest and most significant area of plains grassy woodland containing white cypress-pine, yellow box and grey box in Victoria. It contains threatened flora species such as annual buttons, pepper grass, slender darling-pea, red swainson-pea and threatened fauna species such as the plains-wanderer and hooded scaly-foot, a legless lizard species. It has imposing granite outcrops, a number of walking and vehicle tracks for a range of recreational pursuits and a significant number of Aboriginal archaeological sites. Past land uses such as timber harvesting, cropping, gravel and kaolin extraction remain evident in Terrick Terrick National Park.

Overall 27 percent (1055 ha) of Terrick Terrick National Park is within the River Red Gum Forests study area. Terrick Terrick National Park is the only national park to include the Victorian Riverina Bioregion (comprising 1212 ha or 31 percent of the park), the remainder being in the Northern Inland Slopes Bioregion. 87 percent of the protected area of Victorian Riverina Bioregion is in the study area. This national park also contains remnants of the listed northern plains grassland community, which has declined to a mere 0.5 percent of its original distribution.

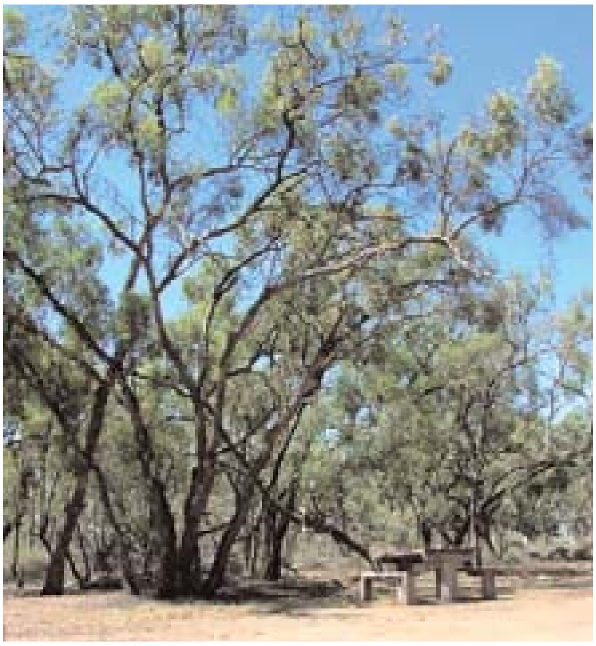
Mount Buffalo National Park abuts the northeast section of the River Red Gum Forests study area where the boundary follows a land parcel or cadastral boundary. Areas of river red gum forests occurring along the public water frontage to the Ovens River are included in the study.

State Parks

State parks are generally not as extensive as national parks and their natural features are usually less outstanding, but they are important contributors to Victoria's park system and enjoy a similar level of protection as national parks. They are primarily set aside to conserve and protect natural ecosystems and provide for public enjoyment, education and inspiration in natural environments.

Barmah State Park along with the adjoining Barmah State Forest on the Murray River floodplain is the largest river red gum forest in Victoria (DSE 2003b). Together with the adjacent Millewa forest in NSW, it forms the largest river red gum forest in the world (DSE 2003b). Barmah State Park contains wetlands of international significance listed under the RAMSAR Convention (1971). These wetlands, both temporary and permanent, are used as part of the river regulation and flood mitigation system for the Murray River and provide habitat and breeding sites for numerous bird species, many of which are rare and threatened. Barmah State Park contains many significant fauna species, including a range of aquatic species. The park vegetation consists of areas of river red gum with box forests in the drier areas. A large number of Aboriginal archaeological sites as well as historic sites related to early use and settlement, in particular timber production and grazing, are located in the park. DSE places Barmah State Park in Category VI of the IUCN list of protected area

Figure 9.1 National Parks provide protection for conservation values and opportunities for nature-based recreation.



management categories. The area is widely used for a range of water-based and land-based recreational activities, including swimming, canoeing, fishing, four wheel driving and camping.

Leaghur State Park, on the Loddon River floodplain, contains some of the state's most significant black box wetland and woodland communities. Regular—even if infrequent—flooding is essential for the black box woodlands and frequent flooding creates ephemeral wetlands and promotes generation of variable age class stands. River red gum stands are also present and also require specific flooding regimes. The park provides habitat for many threatened fauna species and contains a number of largely undisturbed undulating soil formations caused by seasonal shrinking and swelling. There are a number of cultural sites, both Aboriginal and from more recent European occupation. Leaghur State Park is placed in Category II of the IUCN system of protected area management categories. Visitors to this park generally undertake passive recreation, such as walking and bird-watching, in a semi-remote, largely treed environment surrounded by a cleared agricultural landscape.

Regional Parks

Regional parks allow for more intensive recreational activity in fairly natural surroundings. They are commonly located near major regional centres and offer opportunities for activities such as picnicking and walking in a forest environment. Minor resource use is often permitted in regional parks.

The network of regional parks recommended by the LCC Murray Valley Review (1985) along the Murray River was designed to provide for a wide range of recreational activities.

Cobram Regional Park, which includes River Murray frontage, is predominantly river red gum open forest and contains several billabongs and floodways. It is intensively used during summer, with many camp sites located along the river. There are also a number of sandy beaches which are extremely popular including Dead River, Big Toms, Little Toms, Thompsons, Scouts, Scotts and Horseshoe Lagoon. Major recreational activities include fishing, boating, swimming, walking, camping and picnicking.

Echuca Regional Park is located where the Goulburn River enters the Murray River, upstream of Echuca. It has a number of billabongs and floodways. Vegetation in this park consists of river red gum open forest, grey box open woodlands and some pockets of black box, and these woodlands provide habitat for the endangered squirrel glider. Recreational activities include camping, fishing, boating and walking.

Lower Ovens Regional Park is located at the confluence of the Ovens and Murray Rivers east of Yarrawonga. This park has a number of billabongs, river anabranches and islands created by water impounded behind the Yarrawonga weir. The vegetation is predominantly river red gum forest. The wetlands created by the weir provide valuable habitat for many water birds. It is a popular spot for fishing, boating, camping, swimming and bird-watching.

Murray–Kulkyne Park is located between the Murray River and Hattah–Kulkyne National Park. This park is listed under Schedule 3 of the *National Parks Act 1975* as 'Murray–Kulkyne Park' (hence the use of that name here), which is unusual for a regional park. Murray–Kulkyne Park is categorised as IUCN Category III (protected area managed mainly for conservation of specific natural features). This park has both floodplain vegetation and semi-arid vegetation communities which support several rare and threatened flora species. It also provides habitat for a number of key fauna species, including the near threatened tessellated gecko. Being adjacent to the Murray River, this park is used by many visitors and is popular for camping and access to water-based activities.

Tocumwal Regional Park consists of two discrete areas located along the Murray River west of Cobram. Only one of these two areas has frontage on the River Murray. The vegetation within this park is predominantly river red gum forest. There are a number of sandy beaches, including Apex, Mulberry, Pebbly, Finley, Carters and Labberts, which are popular and utilised for a range of recreational activities.

Wodonga Regional Park is located on a floodplain, near the confluence of the Murray and Kiewa Rivers. This park has continuous frontages to both rivers, and includes a network of billabongs, anabranches and seasonal wetlands. Vegetation consists of river red gum woodlands with a grassy understorey. The floodplains provide good habitat for many bird species. Attractive views of the surrounding landscape may be seen from the top of Huon Hill. Variable landscapes within the park provide for a wide variety of recreation opportunities, including four wheel driving, horse-riding, swimming, fishing and walking.

Much of the park is made up of land that was returned to Victoria after having been acquired by the Commonwealth-based former Albury-Wodonga Development Corporation (AWDC) in the 1970s. The park is currently managed by Parklands Albury Wodonga—a unique cross-border agency composed of government and community-based stakeholders with an interest in managing areas for recreational use in natural settings around Albury and Wodonga. Parklands Albury Wodonga manages some 4000 ha of parklands to this end—mostly as a Committee of Management. Other former AWDC lands have been returned to Victoria or are planned for disposal by the Corporation.

Yarrawonga Regional Park is located downstream of the Yarrawonga weir and is predominantly river red gum forest surrounding several billabongs and floodways. The Murray River frontage includes several sandy beaches, such as Green Bank, Chinamans Bend, Forges No.1 and No.2, Little Bruces and Zinettis No.1 and No.2. These beaches and Yarrawonga Common, as well as some open bushland within the park, are very popular for swimming, camping, and fishing.

One of the major issues considered by the LCC when recommending the original boundaries of these parks was the balance between nature conservation and timber production. As some areas had high capability for both nature conservation and timber production, this meant that some areas with park values were not included within the recommended parks system (and vice versa). Information on the flora and fauna distribution and values of the river red gum forests is now significantly greater than it was in the mid 1980s when most of the existing parks were defined. Usage of the parks has also increased significantly since their creation, particularly those areas along the major water courses including the River Murray.

Table 9.5 National and state park management plan zoning (figures for total area of each park).

National or State Park	Conservation (%)	Conservation and Recreation (%)	Recreation Development (%)	Reference (%)	Overlays (%)
Murray–Sunset	59.5	35.0	>1	4.5	Yes
Hattah–Kulkyne		95.4	>1	3.6	Yes
Terrick Terrick	24.6	72.8	0.1	2.6	
Barmah	88.0	8.4	0.1	3.6	
Leaghur		100	0.2		

Table 9.4 National, state and regional parks.

Name of Park	Area (ha)	Area (ha) in Study Area	Current Legal Status	Date of Creation	Primary Historic Land Uses	LCC Rec	Manage-ment Plan	Comments
Hattah–Kulkyne National Park	46,160	24,422	*National Parks Act 1975* – Schedule 2	1960, additions in 1980 and 1989.		A2—1977 A5—1989	1996	Includes one reference area within the study area
Murray–Sunset National Park	600,540	26,341	*National Parks Act 1975* – Schedule 2	1979, additions in 1991		A6	1996	Includes two reference areas within the study area
Terrick Terrick National Park	3770	1355	*National Parks Act 1975* – Schedule 2	1988, additions in 1999 and 2002		A3	2003	
Barmah State Park	8362	8362	*National Parks Act 1975* – Schedule 2B	1987	Extensive timber harvesting in the past and currently grazing	A2	1992	Includes two reference areas inside the study area
Leaghur State Park	1556	1556	*National Parks Act 1975* – Schedule 2B	1992	Some timber harvesting in the past	A7	1998	Original area was donated to the Crown
Cobram Regional Park	511	511	*Forests Act 1958*	1986		A7	—	
Echuca Regional Park	563	563	*Forests Act 1958*	1986		A4	—	
Lower Ovens Regional Park	1328	1328	*Crown Land (Reserves) Act 1978*	1986		A9	—	
Murray–Kullkyne Park	3999	3999	*National Parks Act 1975* – Schedule 3	1980 and additions in 1990		A5—1978; A10 and additional area A11—1989	1996	
Tocumwal Regional Park	483	483	*Forests Act 1958*	1986		A6	—	
Wodonga Regional Park	617	617	*Crown Land (Reserves) Act 1978*	Not Implemented		A21	—	
Yarrawonga Regional Park	311	311	*Crown Land (Reserves) Act 1978*	1986		A8	—	

Notes:The areas have been calculated from DSE spatial data and may vary from other published figures.

Nature Conservation Reserves

Together with national and state parks, nature conservation reserves comprise the state's core protected areas (see chapter 10). They encompass public lands of considerable value and are set aside to conserve species, communities and habitats of indigenous plants and animals of significance. The primary land use objective is nature conservation, although education, scientific study and passive recreation are permitted provided they do not damage the values of the particular reserve.

There are 38 nature conservation reserves in the study area (see Appendix 10), including fourteen wildlife reserves which have been designated as game refuges where hunting is not permitted—such areas are effectively nature conservation reserves and are managed as such. Where hunting is permitted in wildlife reserves, these are considered natural features reserves.

Many of the nature conservation reserves in the study area are small, eleven are under 50 ha, although five reserves are greater than 700 ha in size. Four of the reserves abut or are surrounded by state forest, six are adjacent to water frontage reserves and five abut or are surrounded by River Murray Reserve. One reserve is adjacent to the Goulburn River Heritage River. Unlike most national or state parks, the small size of nature conservation reserves means that they may be particularly prone to disturbance, both internally or from adjoining land.

Figure 9.2 Nature conservation reserves are an important part of Victoria's protected areas system.

Historic and Cultural Features Reserves

Historic and cultural features reserves are established primarily to protect places with highly significant historical remnants and features, such as buildings, structures, relics or other artefacts.

Throughout the study area there are a range of sites associated with Aboriginal history and European exploration, settlement, agriculture, timber production and gold exploration and mining. The historic and cultural features reserves within the study area are shown in Table 9.6. These reserves provide evidence of past land uses and their resultant effects on the landscape, and a means of interpreting current land uses. Other mechanisms, such as zoning, listing on heritage registers, and identification in planning schemes protect additional historic places on public land within the study area. Although in these cases the underlying land tenure or land use category does not specifically reflect the historic or cultural values, land managers see these sites as part of the overall public land values, and in some places a particular feature may be a key visitor attraction.

Natural Features Reserves

Natural features reserve is a general public land use grouping that includes several categories of land that have broadly similar land use objectives. They include:

- bushland reserves
- wildlife reserves (those that permit hunting)
- lake reserves
- scenic reserves
- geological and geomorphological features reserves
- streamside reserves
- water frontage reserves.

While the conservation values of such reserves are not generally as significant as the values of parks and nature conservation reserves, these areas nonetheless protect remnant vegetation, habitat, landscape character, natural and scenic features. They also provide opportunities for education and passive recreation. Details of natural feature reserves within the study area are provided in Appendix 11.

A majority of the bushland reserves in the study area are small isolated blocks of remnant vegetation remote from the Murray River. Thirty seven of the bushland reserves are smaller than 40 ha, while only five are greater than 100 ha. The Mystic Park Bushland Reserve (646 ha), located to the south of Swan Hill, was recommended by the LCC, but has yet to be formally reserved. This is the only bushland reserve in the study area larger than 200 ha.

There are thirty two wildlife reserves that permit hunting within the study area. Most of these are found on the floodplains of the Avoca and Loddon Rivers. Where hunting is not permitted in wildlife reserves, the public land use category is considered to be a nature conservation reserve, as described previously. Several wildlife reserves are also found along the Murray and Goulburn Rivers. Twelve of the wildlife reserves have an area less than 100 ha, but a majority are larger, with eight over 400 ha in size. Cullens Lake Wildlife Reserve (719 ha) and Lake Tutchewop Wildlife Reserve (509 ha)

Table 9.6 Historic and cultural features reserves.

Name of Reserve	Area (ha)	LCC Recommendations	Current Legal Status	Date of Creation	Manager	Comments
Bumbang Island Historic Area	566	V5—Mallee Review (1989)	Reserved for public purposes under *Crown Land (Reserves) Act 1978*	1990	Parks Victoria	Important site with evidence of Aboriginal occupation, over 600 scarred trees
Echuca & Waranga Trust Irrigation Pump & Channel Historic Area	5	E15—Box-Ironbark Investigation (2001)	Not implemented. Managed as if reserved.	2002	Parks Victoria	Oldest known irrigation pump housing in Victoria, of state significance
Happy Valley Creek Historic Area	1	No LCC Rec	Reserved for public purposes (historic purposes) under *Crown Land (Reserves) Act 1978*	1976	Parks Victoria	Also known as Myrtleford Jaycees Park
Kinipanial Creek Weir Historic Area	61	J24, then E1—North Central Study (1981) , then Box-Ironbark Investigation (2001)	Not implemented. Managed as if reserved.	1982	Parks Victoria	Weir built in 1885 by the Loddon United Water Trust. Some large river red gum woodland with large old hollow-bearing trees close to the Kinypanial Creek.
Major Mitchell Lagoon Historic Area	13	V4 Mallee Review (1989)	Not implemented. Managed as if reserved.	1990	Parks Victoria	Campsite of explorer Major Sir Thomas Mitchell. Relatively unchanged since then, with some important flora species present on the site.
Murchison Waterworks Trust Historic Area	1	J26 then E1—North Central Study (1981) , then Box-Ironbark Investigation (2001)	Not implemented. Managed as if reserved.	1982	Parks Victoria	Brick pumping cylinder and timber control gates erected by United Echuca and Waranga Waterworks Trust in 1882
Serpentine Creek Weir Historic Area	0.5	J28 then E1—North Central Study (1981), then Box-Ironbark Investigation (2001)	Not implemented. Managed as if reserved.	1982	Parks Victoria	Intact weir built by Loddon United Waterworks Trust to raise the level of Serpentine Creek
Woolshed Swamp Sheepwash Historic Reserve	13	I1—Murray Valley (1985)	Not implemented. Managed as if reserved.	1986	Parks Victoria	Adjacent to Woolshed Swamp NFR
Psyche Bend Pumps Historic Reserve	13	No LCC Rec	Reserved under the Crown Land *Reserves Act 1978*	1999	Parks Victoria	

are the two largest. Wildlife (hunting) reserves, or Victorian State Game reserves, permit hunting of game species during open season. The timing of the open season and setting of bag limits is determined by DSE based on environmental conditions. In 2006 the duck hunting season was from 18 March to 12 June. The bag limit was seven ducks per day, which includes a maximum of one Australasian shoveler, and all hunters must carry a valid Game Licence and Firearms Licence (see also chapter 11).

The majority of lake reserves in the study area are in the Kerang Lakes district and are typically surrounded by agricultural land. The exception is Lake Moodemere located adjacent to River Murray Reserve near Rutherglen in the northeast section of the study area. Streamside reserves generally include lands of nature conservation and recreation value along water frontages. The streamside reserves are mainly on the floodplains of the rivers that feed into the Murray River, and a majority are small, isolated blocks—only four are greater than 140 ha. There is approximately 17,690 ha of water frontage reserve in the study area. Additional values of water frontage reserves were identified during the LCC Rivers and Streams Special Investigation (1991).

Scenic reserves encompass areas of particular visitor interest such as waterfalls and lookouts. The only scenic reserve in the study area is below Kings Billabong, south of Mildura. It is surrounded by wildlife reserve and River Murray Reserve. The two highway parks within the River Red Gum Forests study area are isolated blocks located south of Echuca comprising about 33 ha in total. There are currently no geological and geomorphological features reserves in the study area.

River Murray Reserve

Public land in the immediate vicinity of the River Murray on both the Victorian and New South Wales sides has significant scenic, recreation, archaeological, historical, and conservation values. The river red gum forests, along with the many billabongs and floodways, provide feeding and breeding habitat for many species of native animals; they have particular significance in the conservation of species such as the regent parrot, which has specific nesting requirements. The state border along the River Murray is defined in Box 9.1.

The River Murray Reserve was established to conserve and protect many values and to maintain the riverine corridor. A comprehensive reservation of Crown land has been established along the entire length of the River Murray in Victoria, from Biggara near Corryong to the South Australian border. It includes the existing 60 m wide public purposes reserve, except where national parks, state parks, regional parks, and nature conservation reserves and wildlife reserves extend to the river. In some places additional areas of public land have been incorporated in the River Murray Reserve, which comprises more than 16,000 ha.

The Reserve follows the river as well as the major anabranches that are used as alternatives to the main river. In a number of sections, the reserve comprises only a relatively narrow strip (20–60 metres) of public land between private land and the River. Additional areas of Crown land have been included in the River Murray Reserve to maintain the scenic tree-scape and the river environment. Next to the Gunbower forest, the River Murray Reserve forms a narrow strip between the River Track and the Murray (state border), with scenic values in the adjoining state forest also protected. The only other areas abutting the Murray River not reserved are small areas alienated prior to the original public purposes reservation in 1881 (e.g. within Swan Hill township).

LCC (1985; 1989a) recommended that management of the River Murray Reserve be directed towards enhancing and protecting the following values:

- scenic
- nature conservation
- historical and archaeological features
- opportunities for a diversity of informal recreation activities in an essentially natural riverine environment.

The reserve is also coordinated with management of other specific reserves along the River such as the Murray–Kulkyne Park, Barmah State Park, Wodonga Regional Park and the Lindsay Island portion of the Murray–Sunset National Park.

Limited resource use is permitted within the River Murray Reserve at the discretion of the land manager and where it is compatible with the values described above. Uses include apiculture, grazing, hunting, limited extraction of timber products from specified areas (but not within the 60-metre public purposes reserve), water management or extraction, and operations for the maintenance of bank stability for public safety, flood mitigation or erosion control. Some facilities, such as those associated with water management (pump sites or regulators) have had a negative impact on scenic values in the River Murray Reserve and land managers are working towards consolidating these sites to improve visual amenity.

Adjoining private land owner encroachments, occupations, infrastructure and other restrictions upon pedestrian access occur in some places along the River Murray Reserve. Given the significant length of the reserve boundary, management of these encroachments is difficult and requires systematic and prolonged consultation with local communities to rectify.

Land in New South Wales that abuts the River Murray has characteristics, values, and uses similar to those of the River Murray Reserve in Victoria. Within New South Wales, there is substantially less public land adjoining the River Murray. The LCC suggested that it would be desirable if land on both sides of the River could be managed in a consistent way (LCC 1985; 1989a) especially where public land exists on both sides.

Forest Park

Forest parks are provided for under the *Forests Act 1958* but this category under the Act has been supplanted by other categories.

In its Angahook-Otway Investigation, VEAC recommended legislation to create an Otway Forest Park. The government has provided for the Otway Forest Park to be established under the *Crown Land (Reserves) Act 1978*, although it has not yet been formally reserved. The category was created to provide opportunities for informal recreation in natural surroundings, protect and conserve biodiversity and other natural values, whilst also allowing extraction of a limited range of natural resource products where compatible with recreation and natural values.

State Forest

State forests are usually large areas of forested land set aside to produce hardwood timber, conserve native plants and animals and protect water catchments. They also allow open-space recreation and education and protect sites of historic and Aboriginal cultural heritage significance. They may produce minerals, honey, gravel, sand, road-making materials, and other forest products. Like parks, the category of state forest is designed to achieve many objectives.

The land use category 'state forest' (as previously defined and used by the LCC) differs from the meaning of 'state forest' used in the *Forests Act 1958*. Under the *Forests Act 1958* the term 'state forest' describes reserved forest for the production of timber and other forest produce, and protected forest which brings the management of forest produce in proclaimed unoccupied Crown land, unused roads and water frontages under the jurisdiction of the *Forests Act 1958*. In this document, 'state forest' refers to the defined LCC land use category (LCC 1988).

State forest makes up well over half the public lands in the River Red Gum Forests study area. These areas include a range of vegetation types and natural features (such as floodplains, wetlands and islands) as well as many roads and facilities used by visitors. As well as hardwood sawlogs and their residual timber products, these forests also produce firewood, sleepers, posts and poles (see chapter 14). Details of some of the major state forest areas are provided in Table 9.7.

Figure 9.3 While primarily set aside to produce hardwood timber, state forests are also a source of other forest products and provide for a wide range of recreational activities and for nature conservation.

Management of these state forest areas is according to government-accepted recommendations of the LCC, forest management plans and regional forest agreements. Each of these aspects is summarised in Table 9.8 and discussed below.

Table 9.7 Major State Forest areas.

Name	Area (ha)	LCC Rec	Current Legal	Manager
Barmah State Forest	21,260	F1 Murray Valley (1985)	Reserved forest under the *Forests Act 1958*	DSE—Forests
Belsar Island State Forest	2415	S2 Mallee Review (1989)	Reserved forest under the *Forests Act 1958*	DSE—Forests
Gadsen Bend State Forest	1515	S2 Mallee Review (1989)	Reserved forest under the *Forests Act 1958*	DSE—Forests
Gunbower State Forest	17,490	F1 Murray Valley (1985)	Reserved forest under the *Forests Act 1958*	DSE—Forests
Nyah State Forest	835	S2 Mallee Review (1989)	Reserved forest under the *Forests Act 1958.*	DSE—Forests
Cobrawonga State Forest	2500	F1 Murray Valley (1985)	Reserved forest under the *Forests Act 1958*	DSE—Forests
Mulcra Island State Forest	2600	S2 Mallee Review (1989)	Reserved forest under the *Forests Act 1958*	DSE—Forests
Walpolla Island State Forest	9400	S2 Mallee Review (1989)	Reserved forest under the *Forests Act 1958*	DSE—Forests

Notes:These areas include softwood plantation lands that were never planted and have reverted to reserved forest.

Table 9.8 State forest land use categories and management zones.

Government accepted LCC recommendations (1985 & 1989)	Hardwood Production Area	Forest Area	Uncommitted Land
Land use category currently used for management purposes	State Forest		
Forest management area plan zoning (1992 & 2004)	Production Zone	Conservation Zone	
Forest management area plan sub-zones (1992 & 2004)	Hardwood Sawlog Production Domestic Water Supply A (sawlog harvesting) Domestic Water Supply B (no sawlog harvesting) Softwood Production Minor Forest Produce Green Firewood Production Zones	Rainforest Conservation Area Rainforest community and buffers Significant Floristic Area Wildlife Corridor and Native Fish Stream Reserve Geological Conservation Areas Water Supply Areas	
Regional Forest Agreement zones (2002)	General Management Zone	Special Management Zone	Special Protection Zone

Other Areas Managed as State Forest

Other areas currently managed as state forest within the study area arise from two different land use categories applied by the LCC in their regional investigations (LCC 1977a). These land use categories are:

a) forest areas—land set aside as buffer areas to pine plantations; and

b) uncommitted land—land without a primary land use managed to maintain future options.

During later LCC reviews, areas earlier classed as uncommitted were typically reallocated to other land use categories or placed in the then new category 'state forest' created to encompass hardwood production areas, 'forest areas' and much of the former uncommitted land. However, as the LCC's North-Eastern Victoria Ovens Softwood Plantation Zone Special Investigation (1981) recommendations were never accepted by government, such re-allocation did not occur for the uncommitted land in the study area. The study area includes 13 ha of such 'uncommitted' land currently managed as state forest.

Regional Forest Management Plans

Management plans are used for detailed planning and applying specific management priorities (within the multiple uses permitted) in different parts of the state forest. Within the study area, this planning was undertaken in the Forest Management Plans for the Mid-Murray Forest Management Area (FMA) (DNRE 2002), the floodplain state forests of the Mildura FMA (DSE 2004f) and the North East FMA (DNRE 2001).

Management planning incorporated new information on flora distribution and values with EVC data collected for the largest forest management areas in 2002 (Mid-Murray) and 2004 (Mildura). Additional flora surveys were carried out in the North East Forest Management Area in 1987 and 1992 as well as an EVC mapping project in 1998. Two main zones were applied across the forest management areas—a production zone and a conservation zone. The majority of land was included in production zones, mostly for hardwood sawlogs. Areas were also identified as for producing green fuelwood and minor forest produce. The conservation zones encompass a range of identified special values such as significant flora, wildlife corridors, native fish streams and geological features. Recreation was considered to be generally appropriate in all zones, although subject to some restrictions in conservation zones.

Regional Forest Agreement

In August 1999, the North East Victoria Regional Forest Agreement was signed by the State of Victoria and the Commonwealth of Australia. The agreement established a framework for managing state forests in northeast Victoria including some limited areas in the study area. The Agreement identified special protection zones (informal reserves) to complement the existing parks and nature conservation reserves (dedicated reserves) and established a reserve system consistent with the national comprehensive, adequate and representative conservation reserve system criteria for the region (see Map A and chapter 10 for details). Under the Agreement, the zones adopted supersede those of any earlier forest management plans.

Education Areas

Although most public land is available for passive (observational) education, education areas are specifically set aside as reserves where students can study the nature and functioning of natural ecosystems, observe and practice environmental analysis and field techniques and conduct simple long-term experiments. Education areas are usually selected to show areas that are undisturbed and disturbed (such as logging or agriculture). Appropriate facilities, including accommodation, may be established on-site or be located nearby. Environmental education is the long-term primary land use. The statewide network of education areas is intended to encompass examples of the state's major land systems and environments. The criteria used to select education areas are:

- Examples of major land types
- Maximum diversity of vegetation types, soils, geology
- Easy access
- Located to minimise the risk to users by wildfire
- Located close to other land types and land uses
- Large enough to prevent over use and include zoning to protect areas of special value
- Located to minimise erosion and pollution of the surrounding environment.

Three education areas have been designated within the study area, although only half of the Wemen Education Area is within the study area (Table 9.9). Each is accessible from a main road and together they encompass a range of the natural environments found within the River Red Gum Forests study area. The Wemen Education Area has been incorporated into Hattah–Kulkyne National Park. Wemen Education Area has only been used occasionally by school groups and there are no facilities available at the site. Spence Bridge Education Area, although not formally reserved, is managed as an education area, and has an established Scout camp—'Treetops'. This campsite is actively used by various groups and is booked most weekends. Visitors use both the education area and the surrounding forest for activities such as horse-riding and orienteering. Darling Junction Education Area has had minimal visitation, probably due to a lack of on-site facilities, however it is adjacent to Lock 10 on the River Murray where facilities are available. This education area abuts agricultural land providing a different range of environments compared with the other education areas in the study area.

Table 9.9 Education Areas.

Name of Education Area	Area (ha)	LCC Recom-mendation	Current Legal Status	Date of creation	Manager	Comments
Darling Junction Education Area	321	H5 Mallee Review (1989)	not formally reserved	1990	Parks Victoria	Adjacent to the River Murray, opposite the Darling River junction, contains quaternary alluvium of the present floodplain and adjacent higher terrace of the River Murray. Vegetation is river red gum forest, black box chenopod woodland, floodplain grassland and alluvial-rise shrubland. The billabong present is artificially high, due to being adjacent to Lock No 10, below the junction of the two rivers and the wetland has a diverse range of species. It abuts state forest.
Spence Bridge Education Area	228	M1 Murray Valley (1985)	not formally reserved	1986	Parks Victoria	Quaternary alluvium, floodplain with low sand dune. Vegetation is open river red gum forest (frequently flooded) and higher black box woodland, buloke woodland with associated grassland, lagoons and floodways. Surrounded by the Gunbower State Forest
Wemen Education Area (former)	426	H3 Mallee Review (1989)	Incorporated into Hattah–Kulkyne National Park under the *National Parks Act 1975*	1979	Parks Victoria	Murray River floodplain, lakes, red gum and black box woodland, sand dunes with slender cyprus pine woodland, mallee and hummock grass mallee. Close to agriculture, parks and irrigated areas.

Other Community Use Areas

Community use areas are primarily used for education, recreation or other specific community purposes. Many smaller blocks of public land have been set aside for particular community uses. The management of these reserves is often delegated to locally based committees of management. Some of these reserves contain small areas of remnant vegetation that contribute to local habitat and landscape values. Community use areas include:

- Recreation reserves—mostly small reserves close to townships with facilities for organised sports and informal recreation, e.g. sports ovals
- Parklands and gardens—small intensively used community parklands, playgrounds and ornamental gardens
- Buildings in public use—such as schools, public halls, court houses, police stations, etc.

Water Production Areas

Although water production includes harvesting, storing and distributing water (see chapter 15 Water use and Environmental Flows), the water production land use category only includes the actual water storage areas, diversion weirs, pump intakes and associated buffer areas. Separate land use provisions apply to the harvesting areas (see the section on declared water supply catchments below) and distribution facilities (which are usually within service and utility reserves).

There are also a large number of water reserves, storage tanks, bores, off-takes and water storages on public land which are reserved for water production. Pumps and weirs and some drainage basins on public land are included in water production areas. Drainage basins such as the Kanyapella flood protection area, are diversions for flood waters and therefore allocated to the services and utilities land use category. Some water storages in the Kerang lakes region are linked to other lakes reserved as wildlife reserves, e.g. Lake Tutchewop abuts Lake Tutchewop Wildlife Reserve.

A large number of water production areas were recognised by the LCC in the 1976 Mallee Study and subsequent Mallee Review (1989), Murray Valley (1985), North-Eastern Study 3,4 and 5, and the North-Eastern Area (Benalla-Upper Murray) Review (1986). In the Mallee, water is stored in elevated reservoirs before being pumped from earthen storages. Further upstream, water is pumped directly from the River Murray. In the Kerang region, water is drawn from Torrumbarry weir on the River Murray, and diverted to the Loddon River, where it then flows through a series of natural lakes connected by channels. These lakes include Reedy Lakes, Racecourse Lake, Lake Charm, Lake Tutchewop, Lake Kelly and Lake William.

The precise boundaries of the water production areas and, in particular, the buffer strips surrounding the defined facilities, are normally defined in detailed plans called special area plans (or pre-existing 'land use determinations') following the declaration of 'special water supply catchment areas' under the *Catchment and Land Protection Act 1994*.

From time to time, new facilities are required and old facilities decommissioned and areas allocated to water production require amendment. There have been many changes in the administration of water services since the 1980s, in particular the Water White Paper, *Our Water Our Future* (DSE 2004i). All former water authorities have been restructured and the total number significantly reduced. There are three rural water authorities in the study area, First Mildura Irrigation Trust, Lower Murray (Urban) and Rural Water and Goulburn–Murray Rural Water (trading as Goulburn Murray Water). Five water authorities maintain facilities for the storage and distribution of water (and management of sewage disposal) within the study area—Lower Murray Urban and Rural Water, Wimmera Mallee Water, Coliban Water, Goulburn Valley Water and North East Water (see chapter 15 for detailed discussion on water supply).

Plantations

Public land is used for both softwood (pine) and hardwood (eucalypt) plantations. Extensive plantations across the state occur on public and private land. School plantations have also been developed on small blocks of public land in some areas.

Softwood plantations have been established on both public land (mostly on land that was reserved forest under the *Forests Act 1958*) and private land. Plantations were established on areas of native forest as well as on reclaimed farmland, and may include remnant native forest forming small inliers, buffers, filter strips and landscape areas.

The LCC (1977a) North Eastern Investigation final recommendations covered existing and proposed plantations. By 1982, the state government made a policy decision to prohibit the further clearing of native forest on public land for softwood plantations. Some of the proposed plantation areas had been cleared and planted to pine, while other areas were never planted. The public land areas allocated for plantations by the LCC, but not planted for softwood production, remain reserved forest under the *Forests Act 1958*.

Most public land planted with pine was vested in the Victorian Plantations Corporation (under the provisions of the *Victorian Plantations Corporation Act 1993*), with perpetual licences over the timber resources granted to a private company in 1998. The two softwood plantations (Braithwaites and Junction) within the study area are both vested in the Victorian Plantations Corporation (VPC) and have subsequently been licensed to Hancock Victorian Plantations under the *Victorian Plantations Corporation Act (1993).* These pine plantations are located in the Ovens Valley, on the high rainfall foothills of Mt Buffalo. Under Section 27G of that Act, the vested lands remain public land, although the Act provides for possible sale of the land. The current legal status of public lands vested in the VPC is unreserved Crown land.

Other Land Use Categories

Other land use categories include earth resources, service and utility reserves, and uncategorised public land. These cover land uses such as quarries, cemeteries, municipal buildings, lighthouses, aerodromes, water towers and service basins, and water and sewage treatment facilities. Such reserves are mostly small isolated blocks, although some lie within larger areas of public land. Services and utilities occurring on broad-acre public lands are more generally under lease, licence or other authority.

Road Reserves

Road reserves are one type of service and utility reserve, the primary purpose of which is to provide for communication, transport and access. Vegetation along the road verges, however, can have particularly high conservation, recreation and landscape values, especially in agricultural districts where most of the native vegetation has been cleared. Geological features exposed in roadside cuttings are a resource for mapping the geology of an area and are often used for education. Management guidelines to protect roadside landscape, recreation and conservation values were developed by the LCC and adopted by government as were guidelines for unused road reserves.

Some small-scale soldier settlement schemes were established in the irrigation country on the northern plains. Some public land previously defined as 'land not required for public purposes' (often but not always associated with the soldier settlement areas) remains public land, although the majority has been sold for agricultural use. Freehold land which has been purchased by public authorities, is defined as public land for under the *VEAC Act 2001* (reflecting previous circumstances under the LCC and ECC).

Uncategorised public land is a broad category including land for which no specific recommendation or land use has been ascribed. Some uncategorised public land may include areas not subject to previous LCC recommendations, notably freehold land owned by water authorities used for drainage protection works, salt disposal and new water storages. The remaining uncategorised public land comprises small parcels previously designated 'other reserves and public land' and areas in townships that were specifically excluded from previous investigations.

Township Land

The Land Conservation Council recommended that unreserved Crown land in some townships might be required 'for township purposes in the future'. In practice Township Land sometimes includes stream frontages, sports grounds, halls, schools, courthouses, police stations, depots and other utility areas, and grazed paddocks, discussed public facilities and vacant Crown land. Most of these areas were only mapped at the time at a scale of 1:250,000. With the current availability of high quality 1:25,000 scale topographic and Crown parcel mapping means that land subject to old Township Land category can be replaced by appropriate categories reflecting actual land uses. In addition, where DSE has initiated conservation of a reserve in a township as an area of natural interest it effectively becomes a natural features reserve.

Uncategorised Public Land

Uncategorised public land applies to other areas in townships where the public land has no primary public use. In the context of this Investigation VEAC will address these on a case by case basis.

Former Cities, Rural Cities, Towns and Boroughs

Under the *Land Conservation Act 1970* (under which the LCC operated), all land within cities, rural cities, townships and boroughs was excluded from consideration by the LCC. This changed over time, as the *Land Conservation Act* definition was amended and municipalities changed status.

In the River Red Gum Forests study area, there are no formal LCC recommendations for the former Cities of Echuca, Mildura and Swan Hill, and parts of the former Cities of Shepparton and Wangaratta. For the former Borough of Kerang, there are only Rivers and Stream LCC recommendations. Crown land in these former cities, and around Kerang, is shown pale purple on Map A. A special Order in Council enabled LCC to make recommendations for public land in the former extent of the Rural City of Wodonga. These situations are not related to Township land category.

CURRENT PUBLIC LAND USE OVERLAYS

Three categories of land use overlay are defined by legislation: reference areas, heritage rivers and declared water supply catchments. A number of special values identified in public land use investigations of the LCC and ECC and recommended for specific protection have also been given legal standing—through Orders in Council requiring land managers to implement recommendations.

Reference Areas

Reference areas are relatively small areas of public land containing viable samples of one or more land types that are relatively undisturbed. Such areas are reserved in perpetuity as a scientific reference to compare modified and unmodified lands. Reference areas are proclaimed under the *Reference Areas Act 1978*. Each reference area management plan typically defines a surrounding buffer area in which restrictions are placed on land uses that may have a detrimental affect on the reference area.

No entry is permitted to these areas under ministerial management directives made under the Act (other than management personnel or those with ministerial approval). Approved research work may be permitted but grazing, mineral exploration, mining, harvesting of forest produce, quarrying, bee-keeping, educational use, recreational activities and all forms of harvesting (except for water harvesting) are all excluded activities. The management directive also requires compliance with approved Departmental management guidelines. Amongst other things, the guidelines provide for three-yearly assessments and define recommended buffer widths in which restrictions on activities apply outside the reference area. Depending on the activity, the buffer may extend from around 60 m (timber production) to 2 km (bee sites) or more. The *Mineral Resources Development Act 1990*, the *Extractive Industries Development Act 1995* and the Petroleum Act 1998 provide additional statutory protection from exploration and extraction of earth resources.

Six reference areas occur within the study area, all of which have been proclaimed under the *Reference Areas Act 1978*. Three are within national parks—two located in the Murray–Sunset National Park, and one within

Table 9.10 Reference Areas.

Name	Area (ha)	LCC Recommendation	Date of Creation	Manager Land	Use of Surrounding Land
Toupnein Creek	1664	C11 Mallee Review (1989)	1996	Parks Victoria	Murray–Sunset National Park
Lake Wallawalla	998	C2 Mallee Study (1977)	1998	Parks Victoria	Murray–Sunset National Park
Tarpaulin Bend	440	C19 Mallee Review (1989)	1998	DSE, Parks and Forests	State Forest
Chalka Creek	329	C4 Mallee Study (1977)	1998	Parks Victoria	Hattah–Kulkyne National Park
Top Island	177	B2 Murray Valley (1985)	1990	Parks Victoria	Barmah State Park
Top End	124	B3 Murray Valley (1985)	1990	Parks Victoria	Barmah State Park

Hattah–Kulkyne National Park. Two reference areas occur in Barmah State Park (Table 9.10). The remaining reference area is Tarpaulin Bend located within state forest and River Murray Reserve, east of Murray–Kulkyne Park.

Toupnein Creek Reference Area is located on a floodplain and higher alluvial plain besides the Murray River. Its vegetation consists of black box–chenopod woodland, floodplain grassland and some areas of lignum, river red gum forest and alluvial plain shrubland. This area is unique in that it supports floodplain vegetation in a semi-arid environment.

Lake Wallawalla Reference Area is located in red–brown duplex soils of the higher alluvial plains, but includes a lunette and portion of the River Murray floodplain. Representative vegetation types include black box chenopod woodland, alluvial plain and alluvial rise shrubland.

Tarpaulin Bend Reference Area is located on the grey clays of the present floodplain of the River Murray. It is predominantly river red gum forest and black box chenopod woodland, and is a good representation of the mid-mallee vegetation communities of the River Murray floodplain. However, the course of the Murray River in this area has changed in recent years and the main channel now separates Tarpaulin Bend from the rest of Victoria (see also Box 9.1 and Figure 3.2). There is nearly permanent access by dry land from adjacent freehold land in NSW, making it very difficult for land managers to maintain the integrity of the reference area (in particular, to exclude grazing by domestic stock).

Chalka Creek Reference Area is flat floodplain with shallow channels consisting of the Coonambidgal Formation; mainly clay, sand and sandy clay. Vegetation is red gum and black box woodland maintained by flooding from the Murray River.

Top Island Reference Area is located on a quaternary alluvial land system and its floodplains are subject to frequent flooding by the Murray River. Vegetation consists of an open river red gum forest with an understorey of Moira grass, warrego summer grass, swamp wallaby and common spike rush. Also present are tall closed grasslands of giant rush and grasslands dominated by Moira grass.

Top End Reference Area is also located on a floodplain on a Quaternary alluvial land system, subject to flooding by the River Murray. It is dominated by river red gum open forest with an understorey of terete culm-sedge, warrego summer grass and terete culm-sedge in association with a mosaic also including swamp wallaby grass, and grey box open forest.

Heritage Rivers

Victoria's Heritage Rivers were established to protect those rivers with outstanding values for current and future generations. The *Heritage Rivers Act 1992* followed government acceptance of the LCC (1991) Rivers and Streams Special Investigation recommendations. This systematic study focused on the biodiversity, recreational, cultural heritage and scenic values of Victorian rivers. The seventeen heritage rivers recommended were those rivers, or river reaches, that had at least four values of state or greater significance.

Several heritage rivers are to have no impoundment or other in-stream barriers constructed, retaining their free-flowing condition to protect native fish habitat, recreational canoeing or scenic values. Similarly, other recommended uses are related to the values being protected. The Goulburn and Ovens Rivers are the only designated heritage rivers in the study area (Table 9.11) and are listed on Schedule 1 of the *Heritage Rivers Act 1992*. Draft management plans for these rivers were released for comment in 1997.

The **Goulburn Heritage River** extends 430 km downstream of Lake Eildon to the Murray River near Echuca. This river supports significant river red gum communities, habitat for several threatened fauna species, high native fish diversity, Murray Cod habitat, high recreational fishing value, high scenic landscape

Table 9.11 Heritage Rivers.

Heritage River Name	Area (ha)	Area (ha) in Study Area	Length (km)	Date of Creation	Manager	Special Values to be Protected (LCC 1991) and Restricted Land and Water Uses (*Heritage Rivers Act 1992* – Schedule 3)
Ovens	3750	3750	57	1992	Parks Victoria, Forests	Scenic landscapes, threatened fauna and flora communities, fish habitat and diversity, recreational opportunities. No impoundments, artificial barriers or structures to be constructed, new water diversions not to significantly impair attributes.
Goulburn	19,310	16,657	430	1992	Parks Victoria, Forests	Catchment Management Authority Scenic landscapes, threatened fauna and flora communities, fish habitat and diversity, recreational opportunities. No impoundments, artificial barriers or structures to be constructed, new water diversions not to significantly impair attributes.

value and significant cultural heritage sites. The Goulburn River is a highly regulated river, with water stored at Lake Eildon and Goulburn weir and then diverted downstream for irrigation. A large proportion of the Goulburn River flows through a cleared landscape, with the public land water frontage generally less than 200 m wide, but below Toolamba, the river flows through the Lower Goulburn Riverine Forests which are up to 2 km wide. Below Murchison the river red gum open forests and woodlands are of state significance, as these communities are poorly represented in the reserve system. The understorey is a mosaic of rushes, grasses and sedges, although some areas have a shrubby or heathy understorey. The forest margins are often a mixture of red gum, yellow box and grey box, as this area is the boundary between the drier and the wetter red gum associations. The heritage river is important habitat for fauna species, including the squirrel glider, brush-tailed phascogale and barking owl. Below Shepparton the corridor is nationally significant as habitat for the squirrel glider, the southern myotis bat and the barking marsh frog. The Macquarie perch and Murray cod are both vulnerable species found also in the Heritage River (LCC 1991).

A 50-m wide Special Protection Zone (SPZ) has been established on both sides of the Goulburn River totalling 2050 ha. This corridor includes a 30-m public purposes reserve to protect the habitat of the endangered squirrel glider. Grazing practices and ecological burning strategies are also managed to protect the silver wattle understorey, which forms part of the squirrel glider habitat (DNRE 2002a). Grazing is permitted in the Goulburn Heritage River area and timber harvesting is permitted in a Special Management Zone (SMZ), with large old trees with hollows retained for habitat.

The **Ovens Heritage River** corridor extends from Killawarra to the River Murray confluence, including Lake Mulwala in the lower section. The alluvial floodplains along the Murray River and its tributaries are predominantly river red gum open forests and woodlands. Large areas of these forests have been cleared along the Ovens River, but significant forests and woodlands, with intact understoreys of silver wattle and river bottlebrush, still occur on the floodplain between Spring Creek and Lake Mulwala. The Ovens Heritage River also provides habitat for threatened fauna such as the southern myotis bat, Murray cod and golden perch. The river corridor is also home to other important fauna species and has a high native fish diversity. The Ovens River is the only totally unregulated river in the study area and has high recreational fishing and scenic landscape values.

The Mid-Murray FMA Management Plan established a 30 m public purposes corridor either side of the Ovens River which is treated as an Special Protection Zone where no logging or removal of forest products is permitted. All the remaining state forest falling within the Ovens Heritage River corridor is Special Management Zone and managed to maintain mature trees for squirrel gliders and barking owls. Limited timber harvesting occurs and firewood harvesting has recently increased in this forest. With the exception of several areas set aside for the protection of squirrel glider habitat, grazing is permitted across the Ovens Heritage River corridor.

Declared Water Supply Catchments

Currently all declared water supply catchments (previously known as 'proclaimed water supply catchments'), including the Ovens River upstream from Wangaratta's offtake, are listed on schedule 5 of the *Catchment and Land Protection Act 1994*. Declared water supply catchments are legislatively defined as a type of 'special area'. Additional water supply catchment areas can be declared by Order of the Governor in Council. A declared water supply catchment does not, in itself, directly affect existing land use, but alerts planners, landowners, managers, and the wider community to the importance of the area for water supply.

Table 9.12 Declared Water Supply Catchments.

Catchment (sub-catchments)	Total area (ha)	Date of Creation	Special Area Plan	Water Production Facility	Relevant Water Authority
Lake Hume Northern Section	688,388	1984	Yes	Lake Hume Dam	Goulburn–Murray Water
Ovens River (Wangaratta)	297,656	1988	No	Pump offtake on Ovens River Gravity offtake on Buffalo Creek Gravity offtake on Mush Gully Creek Pump offtakes on King River	Goulburn–Murray Water (supplies Wangaratta, Myrtleford, Whitfield, Moyhu, Oxley)

Of the 106,550 ha declared water supply catchments in the study area, about 60 percent is public land. Further details of the declared water supply catchments are provided in Table 9.12. Water supply authorities generally do not have direct management responsibility for all land within catchments (except in parts of Melbourne's catchment)—only for the storage and distribution areas in water production areas. The catchment from which water is harvested has generally been allocated to other primary land uses, with water production specified as an additional land use. Nonetheless, catchment land managers, water authorities and catchment management authorities coordinate action to protect water quality and quantity in all domestic and, as appropriate, other water supply catchments.

Provision for detailed planning is made under the *Catchment and Land Protection Act 1994*, by way of 'special area plans' (or a pre-existing 'land use determination'). These plans are binding on public land managers and may recommend planning scheme amendments, which are binding on private landholders as well. An appropriate use in one catchment may not be appropriate in another due to differences in climate, geology, soils, topography, and vegetation, as well as the level of water treatment provided. In the end, appropriate use balances desired activities and treatment cost to ensure that harvested water meets accepted community standards.

Water yield and quality are key aspects of harvesting. Managing water yield and quality may involve many different approaches ranging from 'closed' catchments (e.g. most of those supplying Melbourne) to multi-use style catchments. In recent years some sources of town water have provided relatively poor water quality and supplies are now piped from higher quality sources.

PUBLIC LAND MANAGEMENT ACROSS CATEGORIES

Road Management

The road network in Victoria is managed by a number of authorities. Statewide there is approximately 196,000 km of roads (from major arterial roads to forest tracks). Roads can be divided into five main types, freeways (790 km), arterial urban (21,500 km), arterial non-urban (21,500 km), municipal (134,000 km—includes 40,000 km of roads in parks and forests) and Freeway tollways (22 km).

The *Road Management Act 2004* coordinates management for all public roads in Victoria. The Act allocates road ownership, management and accountably for policy, performance standards and liability. Responsibility has been allocated to VicRoads for freeways and arterial roads (not in built up areas), to local municipal councils for arterial roads in urban areas and local roads and to the relevant state agency, for example the Department of Sustainability and Environment for non-arterial State roads (i.e. forest roads).

The Act provides for several Codes of Practice outlining practical guidance for road authorities, works and infrastructure managers to perform their functions and duties. Codes have been developed through a process of stakeholder and public consultation, for the following areas:

- operational responsibility for public roads;
- clearways on declared arterial roads;
- road management plans;
- management of utility and road infrastructure in road reserves; and
- worksite safety—traffic management.

Management Objectives

Road reserves provide communication, transport and access. Roadsides are managed to maintain road functionality, and may involve vegetation removal or trimming, however, protection of conservation, visual, landscape and recreation values along roadsides is also important. This is particularly the case where roadsides provide habitat for threatened plants or animals, or is an important visual element in the landscape (i.e. adjoining major tourist routes or in largely cleared landscapes).

Road management agencies have developed management plans and detailed roadside vegetation mapping and survey in many places. Roadside management plans allow sites with significant biodiversity and cultural heritage values to be identified and guide roadside maintenance and treatments. They also prioritise a schedule of works and a framework for communicating with interested and affected parties and evaluating the achievement of strategic management objectives and statutory responsibilities.

Road management largely falls into either maintenance or development. Maintenance includes the continuing safe passage of vehicles along a roadway by maintaining and ensuring:

- sight distance to junctions, signs and around curves;
- vegetation near the road is not posing a potential danger to life or property of road users e.g. trees that are structurally unsound or large trees close to the carriageway;
- adequate drainage including waterway clearance; and
- environmental assets within roadsides.

Development focuses on improving the efficiency of the existing road network through new roads, road widening and duplication. Flora and fauna and cultural heritage investigations are undertaken for most projects, except for sites where such values are unlikely to be present. Community consultation is part of many large-scale road management projects (e.g. Albury–Wodonga Bypass). During planning, a number of specialist studies are typically carried out to enable a full assessment of the potential impacts of the options under consideration and to develop appropriate management plans to minimise these impacts. This includes an Environment Effects Statement (EES) which then provides the basis for the preparation of a detailed Environmental Management Plan, which is required before construction commences.

Box 9.1 Victoria and New South Wales state border

The 1842 Act of the British Parliament defined the Port Phillip District—which was to become Victoria—of the colony of New South Wales as lying south of a line extending west from Cape Howe to the source of the nearest tributary of the Murray and thence downstream to the South Australian border.

The South Australia *Colonization Act 1834* passed by the British Parliament established the boundaries of the colony of South Australia with the eastern boundary being set at 141°E. When this boundary was surveyed between 1846 and 1850 the southern part of the line was set 2 minutes of longitude too far west. This caused a dispute with Victoria, when NSW and SA were drawing up the boundary north of the Murray, along the intended position of the meridian. The dispute continued until 1914 when the Privy Council ruled to maintain the status quo.

In 1851, Victoria ceded from NSW and the state border was defined as the top of the left bank (taken as high water mark) looking downstream. In 1855 it was decreed that Victoria's northern boundary should not run mid stream, but on the south bank of the Murray River.

In 1881 (May 27) (Government Gazette p1389) land along the River Murray and its tributaries were permanently reserved from sale. Crown land consisting of the bed and banks of a defined list of watercourses, together with adjoining lands (generally of a width of 20 metres on both sides of the watercourse) that had not been previously alienated, were permanently reserved for public purposes.

This permanent reservation notionally falls between the official state border (top of the left bank) and the winter river level. The land that forms the popular beaches when water levels are lower than the top of the southern bank is officially in NSW, but is managed informally by Parks Victoria as it is largely accessed via the Murray River Reserve along the Victorian bank of the River. In those parts of the study area alienated prior to 1881 there are few water frontage reserves. However, under provision of the Water Act 1905, the beds and banks of all watercourses (that form the boundary of freehold allotments) were deemed to be Crown land.

The changing course of the River Murray has gradually changed both the border and the Crown land reserves along it. When the river changes its course completely, however, and meanders are cut-off or bypassed, the state border remains along the original channel.

In 1982 the High Court settled a dispute of the border concerning the location of the border in relation to Beveridge Island, which was first arose in 1873. It was found that more water flowed through the northern channel of the island than the southern, so this was decreed as the state border. Guidelines were also established in relation to the border, and that only slow and imperceptible change in the river will alter the border. Flood events, which alter the course of the river, do not change the state border location, which will remain at the southern bank of the old river channel, even if water no longer flows along that course (LCC 1987).

In some places the waterfront reserves have disappeared due to the gradual change in course of the river, and now the river potentially adjoins either other public land or freehold land. Changes to the permanent reservations, require surveying and amending legislation.

Road Improvement and New Roads

Specific road improvements projects within the study area include the Hume Freeway Albury–Wodonga Bypass (under construction), Murray River crossing bridge works at Corowa, Cobram and Robinvale, and Goulburn Valley Highway works at Arcadia with bypasses in development at Shepparton, Strathmerton and Nagambie.

The 17.4 km four lane Hume Freeway upgrade project through Albury–Wodonga is a largely federally-funded project with a total cost in excess of $500 million. The project includes a second Murray River crossing, to provide an additional link between Albury and Wodonga, and twenty-six new bridges. The project is expected to be completed by mid 2007. The upgrade is designed to reduce congestion and travel times between Albury and Wodonga (35,000 vehicles per day will be removed from the Lincoln Causeway), eliminate six railway level crossings on roads adjacent to the new highway, bypass 17 sets of traffic lights and 5 right-angled bends (such as 'rollover corner') on the Hume Freeway.

Replacement of the existing truss bridge crossing the Murray River between Cobram and Barooga is to be completed in 2006. This $12 million project is jointly funded by the New South Wales and Victorian Governments, and will provide for the rehabilitation of the existing structure for future use as a combined cycle and pedestrian path after the completion of the new bridge.

The Goulburn Valley Highway is a vital transport link connecting the fruit growing and food processing industries around Shepparton, with markets in Melbourne and Brisbane. The Goulburn Valley Highway is fully funded under the Australian Government's Auslink Transport Plan. The strategy for the development of the Goulburn Valley Highway is to:

- provide a divided highway between the Hume Freeway and Victorian/NSW Border at Tocumwal;
- provide bypasses of Nagambie, Shepparton and Strathmerton; and
- duplicate the highway at Arcadia.

Dual carriageway and duplication has been completed for two section of the Goulburn Valley Highway. The duplication from the junction with the Hume Freeway, near Seymour, to south of Nagambie was opened in March 2001 at a cost of $49 million. The Murchison East Deviation, involving 18 km of dual carriageways from Wahring to Moorilim, was opened in February 2003 at a cost of $88 million.

Planning studies are progressing on the Nagambie, Strathmerton and Shepparton bypasses. The planning study to determine the alignment for the future Goulburn Valley Highway bypass of Shepparton commenced in 1995. The Shepparton study developed options for constructing a dual carriageway of approximately 36 km in length, with a deviation to the west of the township the preferred alignment. Construction of the Shepparton, Strathmerton and Nagambie bypasses is yet to be agreed upon under the federal Auslink Transport Plan.

Funding for the $40.5 million Arcadia section duplication project linking the northern limit of the Murchison East Deviation and the southern limit of the proposed Shepparton Bypass to the preferred western alignment, was announced in February 2006.

A future project for consideration is the re-alignment of traffic movements west of Strathmerton and Tocumwal along the Goulburn Valley Highway. This project has the potential to save 9 km of travel compared with the current route and enhance road safety by eliminating a number of curves and narrow bridges near the border with NSW and the Murray River.

Another area of road improvement is the state government's 'Run Off the Road Program'. VicRoads is mid-way through implementing this $80 million program as part of the government's Safer Road Infrastructure Program. Despite there importance as vegetation, large roadside trees pose a serious potential hazard in many areas. VicRoads have assessed the value of the vegetation and consultation with DSE and local municipal councils. Environmentally significant trees are cordoned off with wire rope barrier or guard rails, where feasible. Rigid barriers such as guard rails requires minimal vegetation removal, whereas wire-rope barrier may require some clearance of vegetation behind the barrier of about 1–2 metres to allow for the flexible nature of the barrier. However, wire-rope barriers reduce crashes by 90 percent, whereas rigid barriers only reduce crashes by 45 percent.

The state government announced $4.7 million per annum on-going, in the 2005–06 budget, towards the maintenance of roads in state forest.

Railways

Historically, railways have played a critical role in the expansion of the state's economy. In particular agriculture has benefited infrastructure for transporting goods to markets and the wider community. Rail networks decreased the reliance on paddle-steamers, and the River Murray as a trade route and created opportunities for the expansion of the Port of Melbourne. Today, rail routes still transport both goods and people throughout Victoria, but as road transport increased, some railways were closed and decommissioned. Many of these decommissioned lines have been transferred to 'rail trails' for recreational use or bushland reserves with outstanding natural values. For example, the Bonegilla Station Bushland Reserve, east of Wodonga was reserved partly to protect the threatened purple diuris orchid species. In other places, rail reserves have been sold to adjoining land owners. This alienation of public land was initially conducted in an ad hoc manner, but in the late 1980s a systematic review of rail reserves was undertaken. Where outstanding natural or recreational values were identified, the land was set aside to protect these values.

Victorian rail reserves are the repositories of some of Victoria's most threatened species and communities, largely due to their management history. Regular burning for fuel reduction was an essential part of management of rail reserves for over a century. This management regime resembled, at least in part, the pre-European ecology. Rail reserves that have not been grazed, ploughed, graded or sprayed with herbicides contain of some of the most endangered communities and plant species in Australia. Examples are the nationally endangered turnip copperburr, and mountain swainson-pea, and critically endangered spiny rice-flower. Some of the best examples of Northern Plains Grassland community, listed under the Victorian *Flora and Fauna Guarantee Act 1988*, occur on rail reserves within the River Red Gum Forests study area.

Appropriate management of these sites is essential for the conservation and protection of threatened species and communities in Victoria. The Victorian Rail Industry Environment Forum (consisting of DSE, DPI, Country Fire Authority, VicTrack, Pacific National, Australian Rail Track Corporation, Connex, and Municipal Association of Victoria) is currently developing Vegetation Management Guidelines for Rail Corridors (due to be released in 2006). These guidelines will provide a framework for land managers and rail lessees to encourage changes to works practice addressing biodiversity conservation, prevention and reduction of weeds, fire management and efficient rail operations.

Fire Management

Victoria is a fire-prone landscape and has been for many thousands of years. Archaeological and historical evidence indicates that Aboriginal people used fire to manipulate the growth of forests and grasslands and to encourage animals dependent upon these environments (see chapter 4). Fire management requires both an understanding of the role fire plays in biodiversity maintenance and the threat to life and property.

Fire Management on Public Land

Approximately one third of Victoria is public land consisting of mostly parks and state forests. The Department of Sustainability and Environment (DSE) is responsible for fire management and suppression on all Victorian public land. DSE (and Parks Victoria as the service agency managing conservation reserves and parks) must be prepared for both bushfire and the planned use of fire for asset protection and ecological purposes. Within DSE the Fire Management branch has responsibility for providing authoritative advice on wildfire prevention and suppression, planned fire, fire monitoring on public land, response coordination, specialist fire equipment, training and research.

The Code of Practice for Fire Management on Public Land (DCNR 1995) provides a framework for efficient, effective, and integrated management of fire and fire-related activities on all public land in Victoria by DSE. Key objectives are to protect human life, property, assets and environmental values. The Code establishes a framework for wildfire prevention and suppression activities on public land. Under the Code, these activities are to be conducted in an effective, operationally safe, environmentally sensitive and cost-effective manner. The existing Code is currently being reviewed by DSE in line with the 10 year cycle enabling public comment and consultation and incorporation of the most up to date fire management science. The adoption of a new Code is expected in 2006 (DSE in prep).

A strategic or regional Fire Protection Plan is also prepared for each fire district (Map 9.2). These plans specifically aim to ensure that wildfire prevention and suppression occurs on public land within each fire district, whilst also protecting environmental values of public land. Extensive consultation is undertaken with managers of public land and fire authorities as well as the community prior to completion of each plan.

In addition, each year DSE prepares a Fire Operations Plan for every fire district across Victoria. These plans are prepared in consultation with the community and education programs for fire preparedness and fire prevention. Each plan provides a schedule of proposed wildfire prevention and suppression activities for public land including prescribed burns and road and track maintenance for a three year planning period, but is reviewed annually. These plans have four main strategies for wildfire: prevention, preparedness, suppression and recovery. The fire protection strategies and practices are designed to meet both fire protection and environmental objectives.

The River Red Gum Forests study area encompasses parts of five fire districts: Mildura, Bendigo, Shepparton, Ovens, and Upper Murray.

Wildfire Occurrence on Public Land and Causes

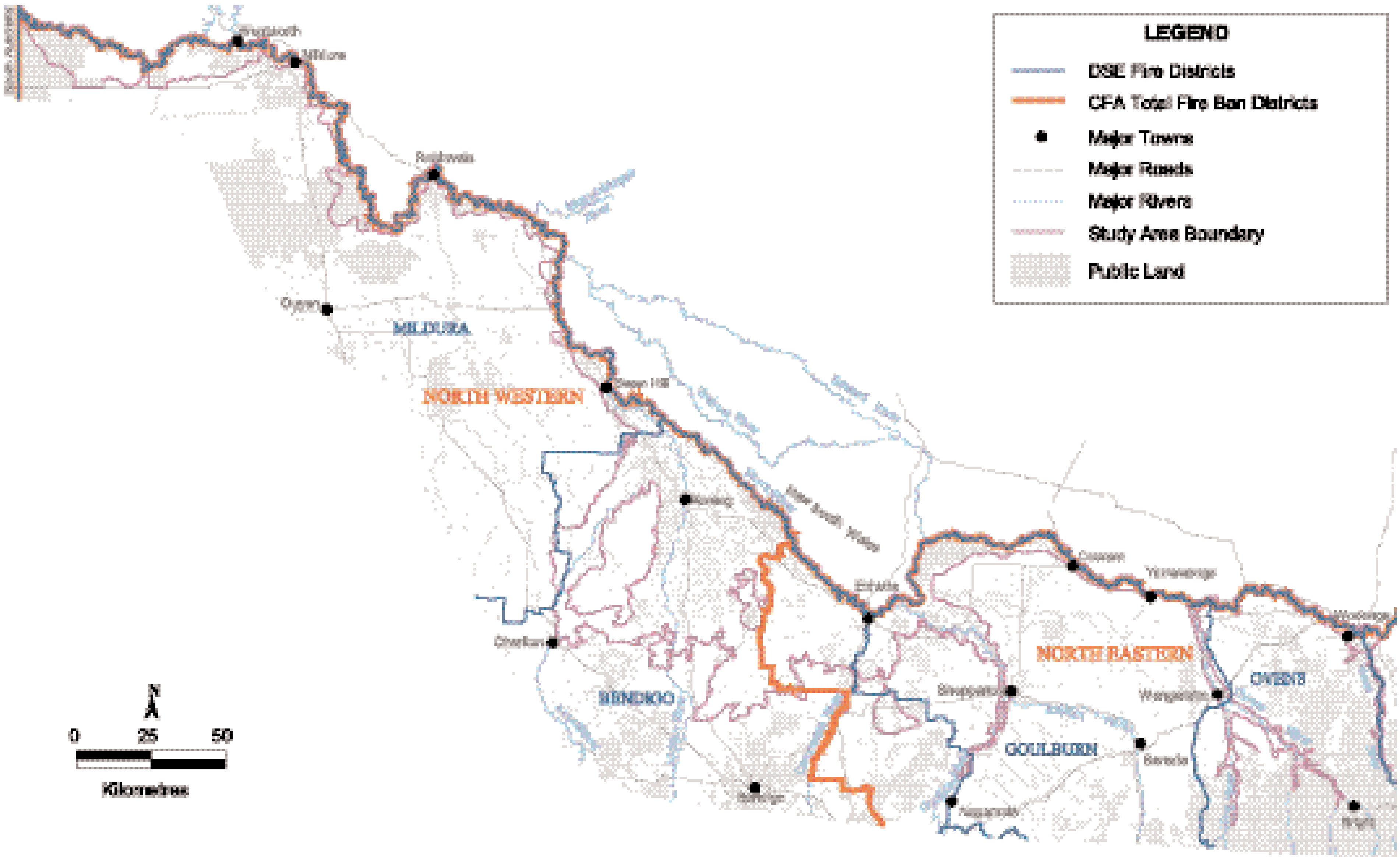
DSE estimates that on average 620 fires occur within Victorian public land each year (Wareing & Flinn 2003). These fires are caused either naturally or by human activities. Virtually all wildfires of natural origin are caused by lightning strikes. These fires often occur when thunderstorms roll across Victoria and can light large numbers of fires rapidly. For example, on 8 January 2003 over 80 fires were ignited by lightning in eastern Victoria (Wareing & Flinn 2003). Approximately 26 percent of all bushfires on public land are started by lightning strikes.

All other bushfires on public land are a direct result of human activity including both deliberate and accidental ignitions. On average, campfires left unattended or not properly extinguished cause 10 percent of these fires. Within NSW, solid fuel fires are banned in state forests of the Riverina region throughout summer because of the increased risk of campfires escaping and starting fires (NSW Department of Primary Industries 2005a).

Agricultural burns on private land are lit by farmers to control weeds, burn crop debris and removal of rubbish. The fires, particularly unattended burns, can 'escape' and become wildfires spreading on to public land. These fires cause over 15 percent of wildfires on average each year and burn approximately 8000 ha of public land each year. By comparison, prescribed burn escapes constitute approximately 2 percent of bushfires on public land. Equipment or machinery that generates heat or sparks such as chainsaws, slashers, welders, grinders, and exhaust from vehicles, ignite about 3 percent of public land fires and burn approximately 2500 ha of public land.

Malicious or deliberate fires include children playing with matches or experimenting with fire, farmers deliberately lighting fires without necessary permits or authority, or fires lit with intent to damage or destroy property as an act of vandalism. Deliberate lighting is the second highest cause of all bushfires on public land (25 percent) after lightning (26 percent). In an average year, people

Map 9.2 Fire Districts for public land fire management purposes.



cause up to two thirds of wildfires on public land, either deliberately or accidentally.

Controlling Wildfires on Public Land

A public inquiry conducted by the Emergency Services Commissioner was established following the 2003 Alpine fires which burnt some 1.1 million hectares in Victoria over a period of nearly 60 days (Esplin 2003). This was the fifth major inquiry resulting from large or significant bushfire events in Victoria and is typical of high community concern following major bushfires events.

Both the Victorian Bushfire Inquiry (VBI) (Esplin 2003) and a Commonwealth select committee investigation (House of Representatives Select Committee into the Recent Australian Bushfires 2003) received public submissions on the fire season 2002–03. Criticisms voiced by the community regarding fire management during these inquiries and issues regarding management of fire on public land is discussed in chapter 19.

Use of Traditional Aboriginal Burning Strategies

Traditional burning strategies or regimes are sometimes raised as a method of fuel and hazard reduction on public land. However details of these practices and how they should be applied to a fragmented landscape with changed climatic conditions are harder to obtain. The arrival of Europeans has dramatically changed Australian environment and the lives of Aboriginal people. Although some knowledge remains of traditional burning strategies, most has been lost, or is fragmentary. With only a partial understanding, and applied only to public land, this re-creation would not be comparable to traditional practices. Following detailed investigations, Esplin (2003) concluded:

> *"While it would be advantageous to have Aboriginal knowledge added to the decision-making process – as is now done for Kakadu and Uluru-Kata Tjuta National Parks in the Northern Territory (Langton 2000) – any use of a 'traditional Aboriginal burning regime' within a park or State Forest in southern Australia would be an experiment in land management, rather than a re-creation of Aboriginal fire regimes, and should be recognised as such" Esplin (2003).*

PUBLIC LAND USE CATEGORIES IN NEW SOUTH WALES AND SOUTH AUSTRALIA

Public land adjoining the study area in New South Wales (NSW) and South Australia is shown on Map A to provide context, particularly in terms of conservation and resource management. A brief description of conservation reserves and state forests in these states is provided below.

New South Wales

Conservation Reserve Categories

In NSW, there are 751 parks and reserves which cover 8.1 percent (6.5 million ha) of the state. The different categories of conservation reserves in NSW are outlined below.

- National parks are similar to Victoria in that they are large areas protected for their landscapes, and flora and fauna values. They are widely used and often have visitor facilities.
- Nature reserves are areas of special scientific interest, predominantly established to conserve native plant and animal communities.
- State conservation areas are parks with some important landscape features, set aside mainly used for recreational activities.
- Regional parks are located near large population centres and are used mainly for recreational and cultural activities; they are often located in altered landscapes.
- Marine parks are areas with unique and outstanding marine flora and fauna, zoned for recreational or commercial activities.
- Aboriginal areas are places culturally significant to Aboriginal people and are managed in accordance with the area's cultural values.
- Historic sites are sites of national cultural importance, including buildings, monuments and landscapes.
- Wilderness areas are usually an 'overlay' on national parks and reserves. They are large areas, remote and essentially unchanged by human activity, managed so that native flora and fauna communities are disturbed as little as possible (NSW NPWS).

Of these protected areas in NSW, 143 are national parks, which comprise 4,172,308 ha (5.2 percent of the state area). The second largest category of parks and reserves are nature reserves 724,650 ha (0.9 percent). The remaining reserves make up the remaining 0.1 percent of the state's protected areas.

On the NSW side of the River Murray, the only park or reserve adjoining the river, is Kemendok Nature Reserve (1043 ha) near Colignan. It consists mainly of river red gum forests, black box woodlands, old-man saltbush shrublands, cane grass, lignum swamps and eumong thickets. This reserve is important for protection of regent parrots with over half the known nesting sites in NSW located here. It is also important for other fauna species including several bat species (NSW National Parks and Wildlife Service).

State Forest

Twenty-two state forest blocks in NSW have frontage to the River Murray. The area of state forest blocks with river red gum forest vegetation types is approximately 110,400 ha. All of these state forests are managed as native forests. The Koondrook–Perricoota (31,150 ha), Millewa (20,969 ha) and Mallee Cliff (10,136 ha) state forests comprise a substantial proportion of the river red gum forests in NSW.

South Australia

Conservation Reserve Categories

South Australia has 20,968,720 ha of land within the parks and reserves system, which are reserved under various acts including the *National Parks and Wildlife Act 1972 (SA), Crown Lands Act 1929 (SA),* and the *Wilderness Protection Act 1992 (SA)*. In total 21.3 percent of the state is reserved for conservation purposes encompassing 333 parks and reserves (see Table 9.13) divided into the following seven categories:

- National Parks are areas considered to be of national importance due to wildlife, landscape features, or Aboriginal or European cultural heritage.
- Conservation Parks are areas for conserving wildlife or the natural or historic landscape features.
- Wilderness Protection Areas (WPAs) protect areas that are natural or remote under the *Wilderness Protection Act 1992*.
- Games Reserves are set aside to protect wildlife and for the management of game for seasonal hunting.
- Regional Reserves were established to conserve wildlife or natural or historic features, while allowing responsible resource utilisation.
- Recreation Parks are areas managed for public recreation and enjoyment in a natural landscape.
- Conservation Reserves are areas reserved for conservation of natural and cultural features under the *Crown Lands Act 1929*.

The different types of parks and reserves are shown in Table 9.13. Of the public land reserved, over 50 percent (9,712,348 ha) is regional reserves, which comprises 9.9 percent of the total area of South Australia. Conservation parks make up 5.9 percent (5,851,673 ha), and national parks comprise 4.6 percent (4,546,663 ha) of the total area of the state. In total, 20.4 percent of the state is protected under the *National Parks and Wildlife Act 1972 (SA)*. In comparison, only 0.14 percent (139,621 ha) of the state's reserves are managed under the *Crown Lands Act 1929 (SA)*.

In the Riverland near the Victorian and South Australian border, there are three game reserves located on the Murray River, Chowilla (18,082 ha) which abuts the border with NSW and Victoria, Moorook (1248 ha) and Loch Luna (2070 ha) further downstream. North of Chowilla Game Reserve is Chowilla Regional Reserve (75,036 ha) and Dangalli Conservation Park (252,079 ha). The Murray River National Park (13,023 ha) is located within the Murray River corridor and consist of three discrete blocks, as well as the Pike River Conservation Park (227 ha), and Maize Island Lagoon Conservation Park (215 ha).

State Forest

Within South Australia, there are some blocks of state forest along the River Murray near the Victorian border. These are Murtho, Lyrup and Mundic blocks, comprising a total area of 2625 ha. South Australia has virtually no areas of native forest managed for timber production. There are however significant areas of softwood plantations in the southeast of the state.

Table 9.13 South Australian protected area system.

Reserve type	No. of reserves	Total area (ha)	Percent of state (%)
National Parks and Wildlife Act 1972			
National Park	21	4,546,663	4.62
Conservation Park	232	5,851,673	5.94
Recreation Park	14	3171	<0.01
Game Reserve	10	25,794	0.03
Regional Reserve	7	9,712,348	9.86
Wilderness Protection Act 1992			
Wilderness Protection Area	9	689,451	0.70
Crown Lands Act 1929			
Conservation Reserve	40	139,621	0.14
Total (State total area 99,515,752 ha)	**333**	**20,968,721**	**21.28**

C

Uses of Public Land

Part C of the Discussion Paper provides details on the various uses of land within the study area and the implications of these uses on the values and attributes of the River Red Gum Forests as a whole. It covers chapters 10 to 17.

10 Nature Conservation

Nature conservation is a significant use of public land in Victoria and includes the protection of flora and fauna species, their habitat and significant environmental characteristics. Features of geological, geomorphological and scenic significance are part of nature conservation as well as the preservation of processes necessary to conserve species, such as fire and flood regimes. This chapter provides an explanation of the contribution of public land—and in particular the reserve system—to nature conservation.

As discussed in chapter 5 a great deal of Victoria's biodiversity has been lost, largely due to land clearing and the introduction of exotic species. This decline continues in many areas. As a result, the maintenance, protection and enhancement of biodiversity have become important priorities for many communities as well as local, state and Commonwealth governments. Many people appreciate biodiversity for its own sake and for the chance to experience it—and many believe it is important to preserve species for future generations. Some also believe that all life forms have an inherent right to exist. In addition to its intrinsic value, biodiversity is essential to maintain the health of natural systems more broadly, such as healthy soil and waterways—the term "ecosystem services" has been coined recently to recognise the importance of this role.

The conservation of biodiversity is achieved using many different methods on both public and private land. These methods depend upon how many species are present, how intact the ecological processes are and how much human habitation and use there is in an area. Biodiversity conservation can take many forms, ranging from conservation reserves, to the sympathetic management of natural areas used for resource extraction (such as state forests) or utilities (such as road reserves), to improved management of remnant vegetation on private land through incentives and support.

Nature conservation encompasses the protection of both the living and the non-living parts of the environment, including geological and geomorphological features and scenic natural landscapes.

CONSERVATION RESERVE SYSTEMS FOR BIODIVERSITY CONSERVATION

Protecting natural areas in conservation reserves is a cornerstone of biodiversity preservation (Gaston et al. 2006). The need for conservation reserves is recognised worldwide and both the Australian and Victorian governments are committed, through the Convention on Biological Diversity, to establishing a representative conservation reserve system.

Habitat protection within conservation reserves is considered to be one of the most efficient means of conserving biodiversity and reducing extinction rates (Lawler et al. 2003). Protecting biodiversity in natural areas (*in situ* conservation) is more likely to maintain natural evolution and broader ecological processes than focusing on a single species outside of its natural environment. Deforestation and habitat fragmentation are generally much higher outside conservation reserves than inside (Sanchez-Azofeifa et al. 1999). Other human-induced threatening processes such as hunting and grazing are also reduced in conservation reserves (Bruner et al. 2001) and this can improve conservation of

threatened species in these areas (McKinney 2002).

In situ conservation is usually the cheapest and most effective long-term option. *In situ* conservation of threatened species in reserves is cheaper than *ex situ* conservation (Balmford et al. 1995; Lindsey et al. 2005). Numerous studies have compared (on a global scale) the costs of conserving biodiversity in conservation reserves with the costs of conserving biodiversity in the general landscape. James et al. (1999) estimated that a global network of conservation reserves would cost $27.5 billion per year while the conservation and remediation of biodiversity in the agricultural, forestry, coastal and aquatic landscapes would be nearly ten times as great (approximately $290 billion per year). Retaining an intact area of biodiversity may also have greater economic benefits than converting the land for production. Balmford et al. (2002) reviewed studies that included the benefits of recreation and ecosystem services (see chapter 5) such as carbon sequestration, water supply and regulation, and storm protection, and consistently found that retaining the area as intact habitat was more cost effective than clearing it for production. The cost of managing the conservation reserve system is estimated at 0.1–1% of the value of ecosystem services provide (James et al. 2001; Pimm et al. 2001).

DESIGN CRITERIA AND SETTING GOALS FOR RESERVE SYSTEMS

The conservation reserve system began early in Victoria's European history with the first national park declared in 1898 although early reserve declarations tended to be ad hoc and favoured sites that were scenically spectacular or of little use for agriculture, timber or mining. This pattern is common across the world (Margules & Pressey 2000). From 1971 to the mid 1990s, the Land Conservation Council conducted systematic regional studies of public land across Victoria. These studies recommended parks and reserves that included parts of each major land system found in the state. Most of Victoria's existing conservation reserve system result from these recommendations (see chapter 9). However, many of the recommendations were made with the limited ecological information available at the time. More recent research has changed scientific thinking on bioregional approaches (see chapter 5) or the appropriate size and configuration for reserve systems. In the 1990s, more sophisticated and systematic considerations of reserve systems were developed in recognition of their central role in biodiversity conservation.

Recent developments in terrestrial reserve systems in Australia have largely come under the auspices of the National Reserve System (NRS) and the Regional Forest Agreement (RFA) processes, both of which have been consistently supported by all state and Commonwealth Governments since the inception of each process in 1992. The Regional Forest Agreement process aims to balance sustainable forest production (largely through timber resource commitments to industry) and conservation (largely through reserves and sustainable forest management outside reserves). As the name suggests, this process involved a series of regional agreements (between the Commonwealth and state governments). In Victoria, five RFAs were signed but only the North East RFA (Commonwealth of Australia & State of Victoria 1999) overlaps with the River Red Gum Forests study area—the area of overlap being the current North East Forest Management Area (Map 14.1 in chapter 14 shows the boundaries of Forest Management Areas overlapping with the study area).

The Commonwealth funding program for the National Reserve System mainly focuses on terrestrial ecosystems other than forests, with particular emphasis on adding poorly reserved environments to the national conservation reserve system, using a bioregional approach.

Comprehensive, Adequate and Representative (CAR) reserve systems

Both the National Reserve System and the Regional Forest Agreement processes incorporate the need for a comprehensive, adequate and representative (CAR) conservation reserve system. In the context of the study area, these terms are defined as:

> **Comprehensive:** includes examples of the full range of ecosystems within each Victorian bioregion within the study area;
>
> **Adequate:** of sufficient size and number, and of appropriate shape to ensure the maintenance of ecological viability and integrity of biological populations, species and communities;
>
> **Representative:** areas selected for inclusion in reserves should reflect the diversity of the flora and fauna within each of the protected habitats and biological communities.

In summary, the conservation reserve system should contain examples of all types of ecosystems to be comprehensive. For each ecosystem, the reserved areas should be of sufficient size and configuration to maintain the integrity of its biodiversity (adequacy). Also, each ecosystem should be represented within each bioregion to cover the range of biological variation (representativeness). Bioregions are the broadscale mapping units for biodiversity planning in Victoria and capture the patterns and ecological characteristics in the landscape (for a full description of bioregions, see chapter 5).

Biodiversity may be defined in terms of species, genetic variation, habitats and/or ecosystems (see Ricotta 2005). The CAR criteria describe biodiversity at the level of "ecosystem" and assume that other levels of biodiversity are protected if coverage of ecosystems is comprehensive, adequate and representative.

However, ecosystems may also be difficult to map and thus, Ecological Vegetation Classes (EVCs) have been used as ecosystem surrogates to measure comprehensiveness, adequacy and representativeness for a number of years (Woodgate et al. 1996; Parkes et al. 2003) (see chapter 5 for further details). EVCs are the principal unit for vegetation circumscription and mapping for land-use planning and management in Victoria.

EVCs may not be the most suitable indicators for the distribution of all components of biodiversity (e.g. Mac Nally et al. 2002) and additional measures may be

needed to identify the conservation requirements of these components. For example, restricted colonial nesting species such as pelicans and egrets may not be well represented with the EVC approach. The vulnerability of particular EVCs (or ecosystems), species or other components of biodiversity to further loss or decline needs to be incorporated into the priorities for reservation.

Setting Goals to achieve CAR: The JANIS Criteria

A number of goals have been set to help establish a conservation reserve system that is representative, adequate and comprehensive. The Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia is widely known as the JANIS criteria (after the acronym for the group that developed the criteria) (JANIS 1997). Through successive Regional Forest Agreements, these criteria have been the benchmark for region-based assessments and establishment of forest reserve systems. The Terms of Reference for the River Red Gum Forests Investigation require VEAC to have regard to these nationally agreed criteria.

The JANIS biodiversity criteria specify appropriate minimum representation for ecosystems in each bioregion according to the status of each ecosystem. Typically, areas most intensely subject to human use are poorly represented in conservation reserve systems and consequently are often in most need of protection. More threatened or depleted ecosystems require higher levels of conservation reserve system representation. The JANIS definitions of threatened ecosystems—what constitutes endangered, vulnerable etc—are similar to more recent definitions of bioregional conservation status in Victoria's Native Vegetation Framework, see Appendix 6 (DNRE 2002i). The targets for reservation of each ecosystem are broadly:

1. 15 percent of the pre-1750 distribution of each vegetation type.
2. At least 60 percent of the remaining extent of vulnerable ecosystems. A vulnerable ecosystem is one which is i) has been reduced by around 70 percent within a bioregional context and which remains subject to threatening processes; or ii) is not depleted but subject to continuing and significant threatening processes.
3. All remaining rare and endangered forest ecosystems. A rare ecosystem appears within a small range of less than 10,000 ha, occupying a total combined area of generally less than 1000 ha or in isolated patches of generally less than 100 ha. An endangered ecosystem has contracted to less than 10 percent of its former range or former total area, or where 90 percent of its area is in small threatened patches.

Although drawn from a limited literature, the minimum 15 percent target was based on best advice from scientific experts and exceeds the targeted 10 percent protection of current forest area set internationally (Kanowski et al. 1999; Kirkpatrick 1999). Others suggest that the targets should be evidence-based (based on the conservation requirements of species and communities) rather than policy-based (Svancara et al. 2005) and that higher levels of reservation are therefore required in some Australian landscapes (e.g. 30 percent: Freudenberger et al. 1997). An over-reliance on broad-scale attributes and an emphasis on 'representation' in reserve system establishment has been criticised by some scientists who suggest that unique areas and hotspots for biodiversity may be being missed (e.g. Brooks et al. 2004). Thus identifying 'key biodiversity areas' may be an important complementary process in selecting reserves (Eken et al. 2004). In Victoria, 'Biosites' (see chapter 5) may provide a framework for identifying important elements of biodiversity not accounted for using the JANIS criteria.

The recently-released Directions for the National Reserve System—a Partnership Approach sets a number of time-lines for achieving CAR outcomes (NRMMC 2005a).

JANIS Criteria for Conservation Reserves

Recognising that the conservation reserve system should first be selected from public land, the JANIS criteria identified three public land components of the reserve system, in decreasing order of preference:

Dedicated reserves: reserves established by legislation for conservation purposes and for which a Parliamentary decision is required to revoke their status;

Informal reserves: areas reserved under other secure tenure or management arrangements, where it is not possible or practical to include conservation values in dedicated reserves; and

Protection by prescription: values protected by prescription where protection in reserves is impracticable because of the nature of the value.

'Dedicated reserves' are equivalent to those reserves meeting the World Conservation Union definition of 'protected area' (see below). Informal reserves, mostly Special Protection Zones (SPZs) in state forest, result from forest management planning undertaken by DSE (see chapter 14). Other measures taken by DSE, such as Special Management Zones and prescriptions for timber harvesting, give a level of protection to natural values and complement the conservation reserve system but are not considered as part of the system.

There are two key points to take into account in interpreting the JANIS criteria for River Red Gum Forests and associated ecosystems:

Flexibility: the need for flexibility in the application of the criteria to ensure that the CAR reserve system delivers optimal nature conservation outcomes as well as acceptable social and economic outcomes is specifically mentioned in the JANIS criteria and is aligned with Section 18 of the *Victorian Environmental Assessment Council Act* 2001 which specifies that Council is to have regard to "the potential environmental, social and economic consequences of implementing" its recommendations.

Context: in the Regional Forest Agreement process, the JANIS criteria were applied to forested landscapes with a relatively large proportion of off-reserve areas supporting substantially intact tracts of indigenous vegetation. In contrast, much of the vegetation in the River Red Gum Forest study area has been cleared or degraded. In some areas, only small, highly degraded areas may be available for reservation. Such blocks are generally very expensive to manage, often with little reason to expect a significant contribution to the conservation of biodiversity. This may make it very difficult to meet some JANIS targets.

When the JANIS criteria were applied in the North East Regional Forest Agreement, some red gum areas were protected through the establishment of Special Protection Zoness, although no new dedicated reserves were created. The JANIS criteria were also used as a basis for Special Protection Zone establishment in the Forest Management Plans for the Mid-Murray and Mildura Forest Management Plans (DNRE 2002a; DSE 2004f), although at that time EVC mapping was inadequate even to quantify representation targets.

VICTORIA'S PROTECTED AREA SYSTEM AND THE NATIONAL RESERVE SYSTEM

A protected area is a park or reserve with a primary aim of biodiversity conservation. International thinking has been led by the World Conservation Union (IUCN), which has developed definitions and classifications for protected areas (see Box 10.1). In Victoria, protected areas include reference areas; national, state, wilderness and some regional parks; nature conservation reserves; heritage rivers and some natural features reserves (see below for details). Some other categories of land known as 'parks' or 'reserves' are not considered protected areas as their primary purpose is not biodiversity conservation (e.g. most regional parks, historic reserves, lake reserves, highway parks).

The National Reserve System (NRS) represents the collective efforts of the States, Territories, Commonwealth Government, non-government organisations and indigenous landholders to achieve a system of terrestrial protected areas that samples all regional ecosystems in a comprehensive, adequate and representative manner. It includes all protected areas throughout Australia, including securely protected private land[1].

In Victoria, those public land use categories that meet the definition of protected area (see below) are included in the National Reserve System. The existing conservation reserve system is largely a product of the work of the LCC, ECC and VEAC who sought to represent all land systems or vegetation types in dedicated reserves. DSE, through Parks Victoria, is responsible for management of most dedicated reserves on public land in Victoria.

Dedicated reserve status of land in the categories included in the reserve system is conferred by one of four Parliamentary Acts. Broadly speaking, national, state and some other parks are scheduled and managed under the *National Parks Act 1975*, nature conservation reserves and natural features reserves are reserved and managed under the *Crown Land (Reserves) Act 1978*, reference areas are proclaimed and managed under the *Reference Areas Act 1978*, and heritage rivers are proclaimed and managed under the *Heritage Rivers Act 1992*.

Recognising that the National Reserve System cannot achieve the CAR goals of being comprehensive, adequate and representative from public land alone, the Commonwealth's National Reserve System Program has a key role in enhancing the reservation of some of Australia's most under-represented ecosystems, mainly through the provision of funds for land purchase. Within Victoria, this is complemented by DSE's Conservation Land Purchase Program which acquires, on a voluntary basis, freehold land supporting high-quality examples of key ecosystems to enhance the conservation reserve system. Within the study area, most of the focus for land purchase has been on native grasslands and grassy woodlands, specifically in the Patho Plains region near Mitiamo. Since 2000, six properties containing endangered Northern Plains Grasslands have been purchased in this region totalling almost 1500 ha. Elsewhere, buloke grassy woodlands near Lake Moodemere, cane grass wetlands at Wanalta and saltbush shrublands at Winlaton have been purchased and declared as nature conservation reserves (Fitzsimons & Ashe 2003; Fitzsimons et al. 2004; Fitzsimons et al. 2006).

[1]Note that land purchased by private organisations through the National Reserve System Program meets protected area criteria and thus contribute towards CAR targets. The status of various other conservation agreements over private land is currently being evaluated by DSE.

Box 10.1 Protected Areas: Definition and Management Categories.

The definition of a protected area adopted by World Conservation Union (formerly known as the IUCN) 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".

Although all protected areas meet the general purposes contained in this definition, in practice the precise purposes for which protected areas are managed differ greatly. Thus the IUCN defined a series of six protected area management categories, based on primary management objective (IUCN 1994). Note that in Victoria, each reserve qualifying as a protected area is assigned an IUCN category. In summary, these are:

CATEGORY Ia:	Strict Nature Reserve: protected area managed mainly for science
Definition	Area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.
CATEGORY Ib	Wilderness Area: protected area managed mainly for wilderness protection
Definition	Large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.
CATEGORY II	National Park: protected area managed mainly for ecosystem protection and recreation
Definition	Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.
CATEGORY III	Natural Monument: protected area managed mainly for conservation of specific natural features
Definition	Area containing one, or more, specific natural or natural/cultural feature which is of outstanding or unique value because of its inherent rarity, representative or aesthetic qualities or cultural significance.
CATEGORY IV	Habitat/Species Management Area: protected area managed mainly for conservation through management intervention
Definition	Area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.
CATEGORY V	Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation
Definition	Area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural value, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.
CATEGORY VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems
Definition	Area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs.

Protected Areas within the Study Area: Focus on Conservation

The following section describes various public land use categories that generally are protected areas and contribute to the National Reserve System. More comprehensive descriptions of all public land use categories are provided in chapter 9.

National and State Parks

National and state parks provide the highest level of protection for natural features such as flora and fauna and landscapes, and for Aboriginal cultural sites and places and historic sites. Accordingly, harvesting of forest products, grazing by domestic stock, and hunting and firearms are normally not permitted, and national and state parks are exempt (in most circumstances) from exploration and mining under the *Mineral Resources Development Act 1990*. There are many forms of recreation that are compatible with nature conservation and these are generally encouraged in national and state parks. Management plans are legislatively required for all national and state parks, and all parks in the study area currently have management plans in place. Careful management planning and zoning is required to minimise potential conflicts between human use and the protection of natural features.

Regional Parks

Although most regional parks are usually not considered to be protected areas, the Murray–Kulkyne Park is a potential exception because it is listed on Schedule 3 of the *National Parks Act 1975* (most regional parks are listed under the *Crown Land (Reserves) Act 1978*), which has objectives that meet the criteria for protected areas. Murray–Kulkyne Park is managed in conjunction with Hattah–Kulkyne National Park.

Nature Conservation Reserves

Nature conservation reserves (including flora reserves, flora and fauna reserves and wildlife reserves where hunting is excluded) have a primary purpose of biodiversity conservation. They are generally smaller than national and state parks and declared over areas with important ecological significance or areas sensitive to human use. Generally provision for public use is limited to passive recreation such as nature observation. Timber removal, grazing by domestic stock, and hunting and firearms are generally not permitted.

In heavily cleared and fragmented landscapes, such as the Victorian Riverina, nature conservation reserves are the primary mechanism for high-level conservation of biodiversity. Management planning in these reserves is important, particularly for those ecosystems requiring more intensive management, such as native grasslands. Management statements have been prepared for some nature conservation reserves, while for others, overarching management directions are provided in the *Conservation Reserves Management Strategy* (Parks Victoria 2003).

Natural Features Reserves

Some natural features reserves qualify as protected areas, particularly those with a strong emphasis on the conservation of species, ecosystems or natural features—bushland areas, scenic areas, geological and geomorphological features areas, streamside areas, natural features reserves and the River Murray Reserve (DNRE 1996b). As with nature conservation reserves, natural features reserves are often small, and usually contain features of less ecological significance. Nonetheless, most retain native vegetation that provides habitat for native species, often within fragmented landscapes, as well as scenic values. A greater range of recreational or other activities are usually allowed for in natural features reserves.

Generally natural features reserves receive a lower management priority than the preceding categories, although at certain times of the year, they may be heavily utilised (e.g. the River Murray Reserve during summer holidays). Few reserves are the subject of management plans, but overarching management directions are provided in the *Conservation Reserves Management Strategy* (Parks Victoria 2003).

Reference Areas

Reference areas are generally small areas of land set aside as representations of different land systems or ecosystems for use as a reference for scientific comparison with similar land under other uses and to maintain natural ecosystems into the future. Reference areas exclude entry by all persons (other than management personnel or those with Ministerial approval), provide for approved research work and prohibit grazing, mineral exploration, mining, harvesting of forest produce, quarrying, bee-keeping, educational use, recreational activities and all forms of harvesting (except water harvesting). Reference areas are usually embedded within other much larger public land blocks, typically parks or state forest. Not all land systems can be represented in reference areas, as for many land systems, no suitable public land exists that can be managed for scientific reference.

Heritage Rivers

Heritage River are a public land use overlay that sets aside stretches of rivers and streams to protect natural heritage, cultural heritage, recreational, and/or scenic values. The *Heritage Rivers Act 1992* commits managing authorities to ensure any heritage river is maintained without further interference to its free-flowing state, which includes new impoundments and dams and diversion of water. It also commits managers to 'take all reasonable steps to ensure that the significant nature conservation, recreation, scenic or cultural heritage attributes of the area are protected'. The management objectives for other uses in heritage rivers vary according to the underlying tenure. For example, in both heritage rivers occurring in the study area (the Ovens and the Goulburn), timber harvesting is allowed in areas of overlap with state forest, but not in nature conservation reserves.

Other Public Land Use Categories with some Conservation Focus

The following public land categories are not considered as protected areas (with exceptions) and are not part of the National Reserve System. However, many have native vegetation and thus contribute in some part to the conservation of biodiversity.

Regional Parks

A regional park is an area of public land, readily accessible from urban centres or a major tourist route, set aside primarily to provide recreation for large numbers of people in natural or semi-natural surroundings. Regional parks are generally in excess of 1000 ha and managed by Parks Victoria. Timber extraction and grazing is often permitted in regional parks but the ECC Box-Ironbark Investigation recommended the proclamation of regional parks where these activities were not permitted and where nature conservation is a major objective. Accordingly, these parks may be considered to be protected areas and thus part of the National Reserve System (ECC 2001).

Natural Features Reserves

Those natural features reserves that are generally not considered protected areas place a stronger emphasis on recreation or other uses than on the conservation of natural features. These categories are public land water frontages, lake reserves and highway parks (DNRE 1996b). Despite their management emphasis, most retain native vegetation that provides habitat for native species, often within fragmented landscapes, as well as scenic values. Lake reserves allow for the seasonal hunting of duck species. Generally natural features reserves receive a lower management priority than the preceding categories, although at certain times of the year, they may be heavily utilised (e.g. lake reserves which allow intensive water-based recreation). Few of these natural features reserves are the subject of management plans, but overarching management directions are provided in the *Conservation Reserves Management Strategy* (Parks Victoria 2003).

Historic and Cultural Features Reserves

Historic and cultural features reserves are established to primarily protect places with highly significant historical values, including remnant historical features such as buildings, structures, relics or other artefacts. In some instances these reserves contain important natural or semi-natural vegetation. As they are mainly small in area, their contribution to nature conservation is generally small.

Special Protection Zones in State Forest

Special protection zones within state forest are designated by Regional Forest Agreements or Forest Management Plans in order to protect sites of ecological significance, aesthetic areas, streams and wetlands, known sites for certain important flora or fauna species, and to meet CAR objectives. As Special Protection Zones exclude the removal of timber and in some cases can be quite large, they potentially play an important role in nature conservation. However other uses permitted in Special Protection Zones (e.g. cattle grazing) may compromise their protected area status. The zones have no legislative basis and can be altered through administrative processes.

Conservation on Other Public Land

The majority of other public land in the study area retains some indigenous vegetation and consequently plays an important role in nature conservation. State forest in particular provides extensive areas of natural habitat.

NATURE CONSERVATION ON PRIVATE LAND

Trust for Nature (Victoria)

The Trust for Nature (Victoria) is a statutory body corporate constituted under its own Act of Parliament, the *Victorian Conservation Trust Act 1972*. The Trust accepts bequeathed land or money for conservation and as well as purchasing properties with high nature conservation values. The Trust can also enter into voluntary conservation covenants with private landowners on their land, permanently protecting significant areas of natural habitat. More recently, the development of a Revolving Fund has enabled the Trust to acquire land for the purpose of conservation and on-sell it with a conservation covenant as a condition of sale. The proceeds of the sale are then returned to the Trust, which acquires another property for the same purpose.

The Trust has purchased a number of properties in the study area with part funding from the National Reserve System Program (i.e. Neds Corner, Korrak Korrak Grassland, Glassons Grassland, and Kinypanial Grasslands). These private reserves increase the representation of some of the State's most endangered or under-represented ecosystems.

Market-based approaches

In recent years, market-based approaches to increasing protection and improving management of native vegetation and other natural assets have been trialed in Victoria. The best-known of these is BushTender, an auction-based approach where landholders competitively tender for contracts to improve native vegetation on their land. Successful bids are those that offer the best value for money, with successful landholders receiving periodic payments for their management actions under agreements signed with DSE. These actions are based on management commitments over and above those required by current obligations and legislation (DSE 2005b). Within the study area the North East BushTender trial was completed in 2002.

Other initiatives currently operating within the study area are Cornella EcoTender project (a tender-based system to allocate funds in a way that delivers multiple environmental benefits for landholders at both the local and catchment scale), the North East RiverTender, as well as initiatives with emphasis on the re-establishment of native vegetation (e.g. CarbonTender, Bush Returns).

Land for Wildlife

The Land for Wildlife scheme provides assistance for landholders who register under the program to manage all or part of their properties for nature conservation. These agreements are non-binding and either party can withdraw from the agreement at any time.

Landcare

Landcare is a major, joint government-community initiative to promote sustainable land use. Under various sub-programs, local Landcare groups receive government support for appropriate activities, many of which have nature conservation as a primary or subsidiary aim.

Environmental Overlays in Local Government Planning Schemes

Planning schemes provide opportunities to protect nature conservation values on private land. The placement of Environmental Significance Overlays on particular areas of private land can limit use of those sites for activities that may impact negatively on their specific values.

COORDINATING NATURE CONSERVATION ACROSS PUBLIC AND PRIVATE LAND

The coordination of nature conservation activities over public and private land is increasingly recognised as an essential element of effectively and efficiently managing biodiversity at a landscape scale. Within Australia, such models are characterised by Conservation Management Networks (CMNs) and Biosphere Reserves. In Victoria, Catchment Management Authorities also play a large role in conservation across public and private land tenures.

A CMN is a network of remnants managed for conservation, their managers and other interested parties. The CMN model essentially coordinates, or helps coordinate, the protection and management of fragmented ecological communities across a range of tenures and with a variety of protection mechanisms (Thiele & Prober 1999, 2000). While originally designed for a ‘whole of ecosystem’ approach, Conservation Management Networks have been developed at a more regional scale in Victoria (Fitzsimons 2004). Within the study area, the Northern Plains Conservation Management Network, centred on the Patho Plains near Mitiamo, seeks to coordinate the management of native grasslands on both public and private land.

Biosphere Reserves are concerned primarily with integrating biodiversity conservation with ecologically sustainable development across a variety of land tenures and uses. The theoretical Biosphere Reserve model revolves around a ‘core’ protected area managed primarily for nature conservation, a ‘buffer’ zone where activities that impact on the biodiversity of the core are minimised, and a ‘transition’ zone, where the sustainable use of natural resources is encouraged (UNESCO 1995; Brunckhorst et al. 1997). The international ‘Man and the Biosphere Program’ is coordinated by UNESCO.

Two biosphere reserves currently adjoin the study area in New South Wales and South Australia. The Riverland Biosphere Reserve (formerly the Bookmark Biosphere

Reserve) incorporates public and private land along the South Australian Murray River corridor and large former pastoral properties in the South Olary Plains. The recently declared Barkindji Biosphere Reserve is located in the southwest of New South Wales, and incorporates the Australian Inland Botanic Gardens, a number of pastoral properties and smaller blocks of public and private land. Although the Hattah–Kulkyne National Park is a listed biosphere reserve, its boundary does not currently extend beyond the national park.

Cooperative tri-state conservation initiatives already exist between Victorian, New South Wales and South Australia through programs such as the Murray Mallee partnership and The Living Murray program.

PROTECTION OF OTHER IMPORTANT NATURAL, SCENIC, GEOLOGICAL AND GEOMORPHOLOGICAL VALUES

Although EVCs are the main surrogate for landscape-scale conservation planning in Victoria, particular elements of biodiversity, or significant features or sites require particular attention. These are outlined below.

Large Old Tree Sites

Sites with a relatively high abundance of large old trees can be a significant factor in reserve system planning in regions where the original abundance of such trees has been greatly reduced (see chapter 5 for more details). They are important for many reasons including the following (not all of which are related only to biodiversity conservation) their:

- Contribution to biodiversity by providing habitat—including hollows, a distinctive forest structure, and abundant bark and fallen timber—for many threatened species. For example, Barking Owls, which are endangered in Victoria, can only breed in large tree hollows. In addition, many of their prey species use tree hollows. Loss of hollow-bearing trees is one of the factors contributing to the decline of this species in Victoria.
- Importance as places of scientific and management, providing unique insights into the ecological functioning of what may once have been the dominant forest age-class in the River Red Gum Forests.
- Irreplaceable in the short-term, taking hundreds of years to re-establish if lost.
- Scenic landscape values, provide landscape diversity and aesthetic appeal—people boating along the rivers, for example, enjoy the picturesque views of large old trees along the riverbanks.
- Represention of places of great antiquity and reminders of another age, producing strong emotional reactions.
- Cultural element to both Indigenous and non-Indigenous people. Large old trees provide a link to people's ancestors and their uses of and affinity with the forests.

Freshwater Ecosystems

Freshwater ecosystems include rivers, anabranches, floodplains, wetlands, and ephemeral lake systems. The conservation of freshwater ecosystems poses unique challenges due to the hydrological connectivity of freshwater habitats. Partial reservation of individual freshwater habitats may not ensure the long-term sustainability of those sections of rivers, wetlands, and other freshwater ecosystems that are considered 'protected'. For example, by only reserving a portion or even most of a river or wetland, it is likely that any degrading processes occurring in unprotected areas will ultimately affect the reserved portion of the same system (Fitzsimons & Robertson 2005). Within the study area, of those wetlands with at least some form of reservation, 51 percent are not completely reserved (Robertson & Fitzsimons 2005g). The variation in hydrological processes between riverine, wetland and groundwater ecosystems means that a variety of different strategies are required.

Recent reviews suggest that Australia does not have a comprehensive freshwater reserve system (Georges & Cottingham 2001; Nevill & Phillips 2004; Kingsford & Nevill 2006) and the Directions for the National Reserve System paper highlights the need for increased emphasis on this issue (NRMMC 2005a). As part of the Intergovernmental Agreement on the National Water Initiative (Council of Australian Governments 2004), the Parties' water management framework also stated that they will "identify and acknowledge surface and ground water systems of high conservation values, and manage these systems to protect and enhance those values" (s25.x.).

Three important indices in the assessment of wetland reservation have been identified for assessing wetland reservation in Victoria: 1) reservation status (area of different wetland types in reserves, relative to pre-European and current extent); 2) reserve design (percentage of wetland area included in a reserve); and 3) reservation categories (type of reserves which protect wetlands) (Fitzsimons & Robertson 2005).

Wetlands listed under the Ramsar Convention area are not considered protected areas in their own right and have no specific legislative protection in Victoria. Ramsar sites are however considered under the *Environment Protection and Biodiversity Conservation Act 1999* as a 'matter of national environmental significance'. The Barmah Forest Ramsar site is mainly state park and state forest, Gunbower is mainly state forest, Kerang Lakes a mix of natural features reserves and other public land, while Hattah Lakes are totally

contained within the Hattah–Kulkyne National Park. The NSW Central Murray State Forests Ramsar sites adjoins the Barmah and Gunbower sites in New South Wales, while the Riverland Ramsar site in South Australia adjoins the Victorian border.

The Directory of Important Wetlands in Australia (Environment Australia 2001) is a national inventory of significant wetlands. While not providing any increased legal protection, the Directory provides information for use in planning decisions including identifying new Ramsar sites and sites of importance for particular species, including threatened or migratory species. Numerous Directory wetlands occur in the study area, including the Corop Lakes, Wallpolla Island and Lindsay Island.

The recently established Living Murray Initiative, coordinated through the Murray–Darling Basin Ministerial Council, aims to improve the health of the Murray River and adjoining ecosystems through the provision of additional water for the environment. An initial focus for action is on maximising environmental benefits for six 'significant ecological assets'. Five of these sites are at least partially within the study area: Barmah–Millewa Forest, Gunbower and Koondrook–Perricoota Forests, Hattah Lakes, Chowilla Floodplain (including Lindsay and Wallpolla Islands), and the River Murray Channel (MDBC 2005b).

Threatened Species and Communities

The recovery of threatened species and communities is important in the conservation of biodiversity (see chapter 5). This is reflected by legislation at the state (*Flora and Fauna Guarantee Act 1988* (FFG Act)) and federal (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) levels. This legislation calls for the development of Action Statements and Recovery Plans

for individual species and communities. The plans outline a range of actions required for the conservation and recovery of these species or communities, including the management of public land. The amelioration of listed potentially threatening processes, for example, "degradation of native riparian vegetation along Victorian rivers and streams", is also essential for the maintenance of biodiversity and often for the recovery of threatened species and is covered under this legislation. The distribution and abundance of threatened species and communities, and potentially threatening processes requires special consideration during the process of conservation reserve system design.

Scenic Landscapes

Scenic landscapes focus on the natural beauty and appeal of the landscape which, while essentially subjective, typically have in common features appreciated by many people. These include natural-looking landscapes with focal points such as waterfalls and rivers, towering mountain ranges with spectacular

Table 10.1 High scenic quality rivers and streams within the River Red Gum Forests study area.

River	Section(s)
Ovens River	Killawarra to Lake Mulwala
Goulburn River	
Loddon River	
Murray River	Wodonga west to the Ovens River junction
	abutting Barmah State Forest and State Park
	abutting Gunbower State Forest
	Mildura area
	Wentworth west to the SA border

Source: LCC (1989b).

rock formations, or vast forests interrupted by fast-flowing rivers and sheer cliffs. Scenic landscapes allow people to enjoy nature and often provide a sense of pleasure and well-being. They also provide opportunities for recreation and tourism and hence contribute to local economies.

The Murray River largely determines the scenic qualities of the study area. The importance of water in this dry, and sometimes arid, landscape provides inspiration and rejuvenation for many visitors and residents, as it has for thousands of years. In places, the major rivers form tight meanders and steep cliffs, while other areas have popular sandy beaches with large river red gums overhanging the watercourse.

With such a dominance of water-related features across the study area, the broad alluvial plains extending from the Bendigo area to Swan Hill and Echuca may be easily overlooked. These flat alluvial floodplain areas, now largely cleared of native vegetation, are utilised for extensive and intensive agriculture. The broad expanses have their own appeal, punctuated by chains of lakes and swamps in shallow depressions, and by elevated hills of bedrock such as in the Mt Hope–Terrick Terrick area.

Formal scenic landscape quality was assessed for the great majority of Victoria's larger rivers and streams by the Land Conservation Council (LCC 1989b). A number of river reaches in the study area were assessed as high scenic quality areas (Table 10.1). The other high scenic areas are located in farm-forest or mixed agricultural and natural areas, agricultural and small town or suburban river settings (LCC 1989b). In addition, particular reference was made to the outstanding values adjoining the Victorian banks of the Murray River.

Much of the Victorian landscape has been significantly modified by human intervention over the last 200 years and while changes such as historic homesteads or railway bridges may enhance scenic qualities, others such as powerlines or communications towers generally detract and have a negative visual impact.

Scenic landscapes are often protected in national parks, e.g. the Twelve Apostles in Port Campbell National Park. Scenic values are specifically protected as Victorian Heritage Rivers for the river corridors in Table 10.1, with the exception of the Loddon River (LCC 1991). Smaller scenic areas such as Red Cliffs Scenic Reserve near Mildura have been set aside as scenic reserves under the *Crown Land (Reserves) Act 1978* for the conservation of areas of natural beauty or interest (LCC 1977b). Other areas may be set aside as Section 50 reserves under the *Forests Act 1958* to protect scenic areas from inappropriate resource extraction or other threatening processes.

In some places local governments have strived to protect current values and control the change of character or inappropriate development through Environmental Significance overlays under the *Planning and Environment Act 1987*. For example, the Significant Landscape overlay listed under the Moira Shire Planning Scheme for Lake Mulwala water and shoreline environs is designed to preserve and enhance the special landscape and natural attributes of the area from inappropriate development or visual intrusion. However the planning scheme process is limited to a role that is only triggered by new applications and does not have ongoing influence on land management practices.

Register of the National Estate

The Register of the National Estate is a national inventory of natural and cultural heritage places maintained by the Australian Heritage Council. Although not directly applicable to conservation reserve system design, the Register provides relevant information on some areas of high nature conservation value. Areas such as the Barmah–Millewa Forests and Terrick Terrick National Park are listed on the Register of the National Estate. Cultural heritage values are discussed extensively in chapter 12.

Sites of Geological and Geomorphological Significance

Many localities in the study area display geological and landform features of interest for educational, research or conservation purposes. Some sites show rare or unusual minerals, fossils or landforms. These features vary widely and include natural outcrops or landforms, as well as exposures in road and railway cuttings, quarries or other excavated sites. Geological sites generally display features developed in earlier times, such as an outcrop with sediments and fossils. Many geomorphological sites are important for displaying active land forming processes, such as dune development or stream erosion and deposition.

Sites or features may be rated according to a defined scale of significance. Significance is often ascribed to features because they are outstanding in some way or rare. Outstanding sites are excellent examples of a feature, either in the region or on a wider scale. Rare features are uncommon or unique, either regionally or further afield. However, recognition of only outstanding or rare sites is insufficient to identify all important geological elements or values. Representative sites are examples of features typical of a region and compliment high significance features.

A geographic scale is also necessary to compare significance, for example whether the site is of local, state, national or international significance. These ratings may be applied in combination, for example a representative feature for a region may also be an outstanding or rare example on a state or national level.

Significance ratings contain a degree of subjectivity determined partly by what is known about the specific site, but also the level of knowledge of similar sites elsewhere. Geological and geomorphological significance are not necessarily the most aesthetic features of a landscape (see scenic landscapes above). Some sites of very high significance may not be at all aesthetic, e.g. quarry faces or road cuttings, whereas aesthetically pleasing views may have no geological significance.

To be considered for assessment, sites consist of at least one of the following:

- type section (reference location) or type example of a geological unit
- important fossil locality
- exposures of a range of characteristic or unusual features of the rock unit, or boundary relationships between units
- unusual or rare occurrence of a particular geological feature, rock type or mineral
- illustration of tectonic and/or volcanic processes
- attributes which enable palaeoclimatic reconstructions
- demonstration of the effects of weathering, erosion and/or deposition, or geomorphological process (active or relict) such as landform evolution
- representative example of a landform type.

For this Investigation, geological and geomorphological features within the River Red Gum Forests study area have been assessed as outstanding, rare and/or representative and rated as of local, regional, state, national or international significance as described by White et al. (2003). The assessment of significance was undertaken by an expert volunteer panel of the Geological Society of Australia Inc. (Victoria Division), Geological Heritage subcommittee. Sites are identified using an alphanumeric system conforming with that used by the Geological Heritage subcommittee referring to the relevant 1:250,000 geological map sheet (BD Balranald and Deniliquin; BN Bendigo; SH Swan Hill; SR St Arnaud; MD Mildura; TL Tallangatta and WN Wangaratta and part of Jerilderie) and an assigned unique number as described in Joyce and King (1980).

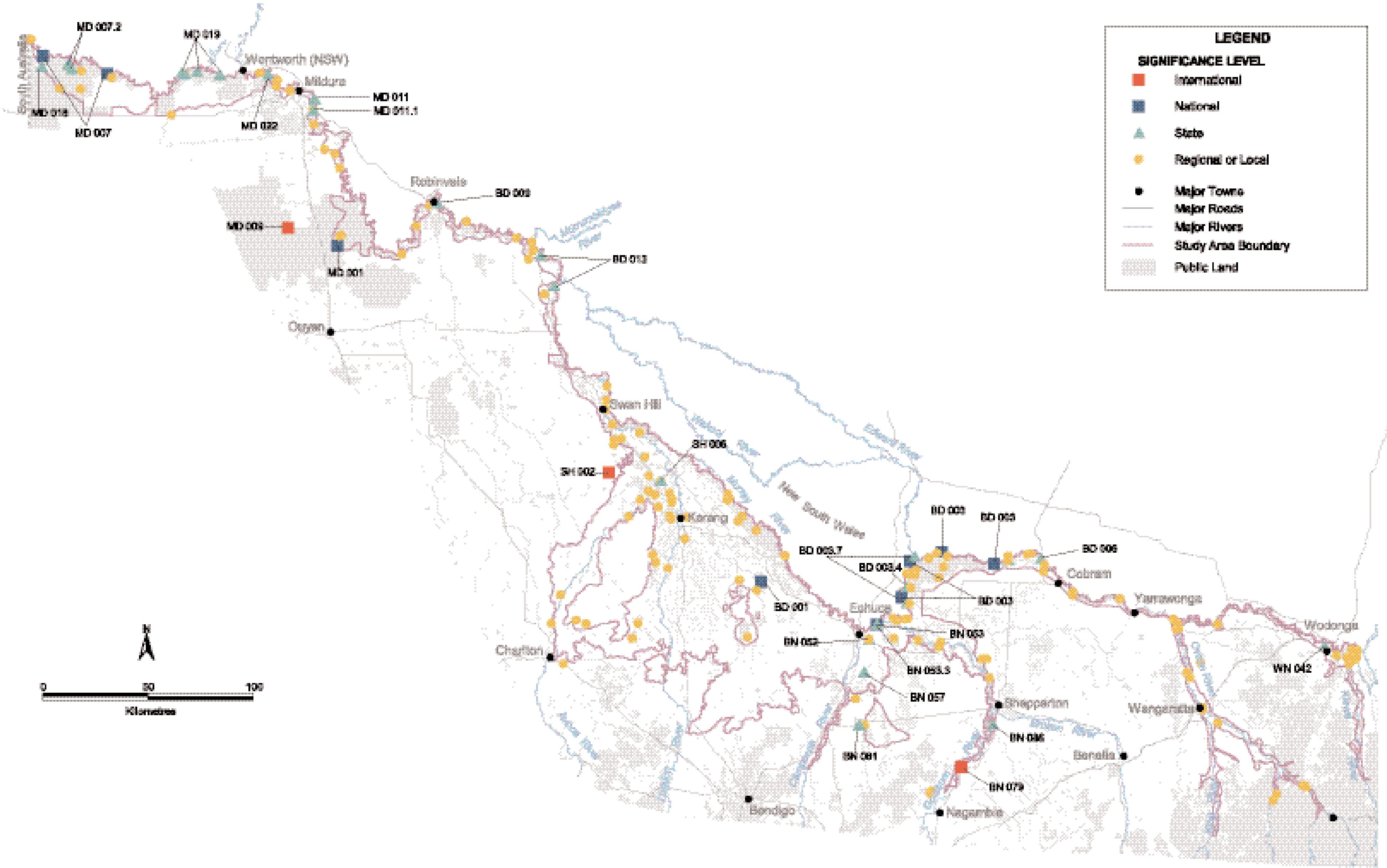
The study area

Significant geological and geomorphological sites of the river red gum forests of northern Victoria are generally Cainozoic rather from the earlier Mesozoic or Palaeozoic periods (see chapter 2). A few isolated sites of older rocks are identified but the geology of the riverine plains is dominated by sedimentary, tectonic and geomorphological processes of the last 30 million years.

Significant geological features in the region include rock units and structures visible as natural outcrops and in exposures created by mining and quarrying operations, road and railway cuttings and water bores. Important geomorphological features include those related to the complex hydrology of the River Murray and its tributaries: the Kiewa, Ovens, King, Goulburn, Campaspe, and Loddon Rivers. The extensive lunette lakes of the Murray Basin and their distinctive crescent shaped dunes are significant parts of the landscape. Sites where hydrological and hydrogeological processes are important are the most common geological sites identified.

A list of all 145 sites of geological and geomorphological significance identified in the study area is provided in Appendix 13, derived from field investigations, scientific literature and personal accounts related by earth science professionals. Sites of high significance (international, national and state) both within and near the study area are presented in Table 10.2. Important sites located near the study area have been included in these lists to provide context. Specific sites are represented as point locations on Map 10.1.

Map 10.1 Sites of high geological and geomorphological significance in and near the study area.



Sites of high significance

Currently, three sites of international significance have been identified which lie just outside the study area boundaries: the Murchison Meteorite fall site (BN 079), Raak Plain boinka (MD 009) and Lake Boga granite quarry mineral type locality (SH 002) (Joyce & King 1980; King 1988; White et al. 2003).

The Murchison Meteorite is rare in a worldwide context — by the nature of its scale, state of preservation and display, and is comparable with examples known internationally. The Murchison Meteorite Shower was observed on September 28, 1969. The meteorite fragments found are of the rare carbonaceous chondrite (CM2) type and many are housed with the Museum of Victoria meteorite and tektite collection. The largest piece in the collection is 1.3 kg in and the entire collection weighs 11 kg although it is estimated that at least 100 kg has been recovered in total. This meteorite has been widely studied as it contains organic compounds such as simple amino acids, important for understanding the origins of life (Henry & Lyle 2003).

Lake Boga granite quarry located to the south of the town contains an unusual suite of minerals. This working quarry is the locality for the mineral ulrichite which was first discovered there in the mid-1980s (and has not been found anywhere else) and bleasdaleite found in 1995. Most of the 50 mineral species that have been identified from this site comprise secondary phosphates of copper, calcium and uranium. Other new minerals are being investigated from this rich deposit (Birch 2003).

The Raak Plain is a boinka (a large saline groundwater discharge lake) landform complex, and consists of a variety of features including sandplains, salt pans, saltbush flats gypsum flats, gypsite hills, and salinas (ephemeral lakes). The boinkas occupy a broad flat depression within a linear dunefield. The Raak Plain is the largest of the Murray Basin boinka (~500 km sq) and is an excellent example of a feature which is unusual on a world scale. This area is also an example of natural salinisation processes, as opposed to salinisation resulting from human activity.

Five sites of national significance have been identified within and near the study area. The extremely complex hydrological system where the Goulburn River and Broken Creek enter the River Murray (BN 053) is of national significance (Bama-Goulburn drainage complex BN 053). In times of high flow from the Goulburn, the Murray is 'dammed' and 'flows backwards' or in reverse. This hydrological complexity is rare in Australia and results in the flooding of the Barmah forest area (BD 003). The other nationally significant site is Hattah Lakes system comprising the natural anabranch lakes, channels, lunettes and dunes (MD 001) and the Lindsay Island floodplain, scroll bars, active and abandoned channel complex (MD 007). The significance of the Kow Swamp (BD 001) is largely related to the cultural heritage sites in a low lunette on the eastern margin of a former lake depression. The site is now used for water storage. A description of the archaeological significance of the site is provided in chapter 12 Cultural Heritage.

Eighteen sites of state significance have been identified (Table 10.2). These sites are important in defining the geology and geomorphology of Victoria. They vary from type-sections of rock types restricted to Victoria e.g. Shepparton Formation type-section (BN 086) at Kialla West, to major tectonic features e.g. Tawonga Fault (TL 139). Other state level sites include Cainozoic climatic and hydrological sites such as Palaeolake Kanyapella at Echuca (BN 052), and complex modern hydrological or geomorphological sites such as Bumbang Bend recent meander cut-off (avulsion) near Robinvale (BD 009) and Cowanna Bend neck meander and potential avulsion site (MD 022) Redgrove, where the River Murray is currently modifying the landscape.

Sites of low significance

Sixty-five sites of regional significance have been currently identified (see Appendix 13). These sites include landforms or geological features representative of regions of about 60-km radius. Examples include the Rochester shire quarry (BN 006) where underlying Palaeozoic bedrock is exposed and is one of the few examples of accessible bedrock in the study area or Tyntynder choke (SH 016.1) near Vinifera where the River Murray is narrow compared to nearby reaches.

Although not of high value, the fifty-six sites have been identified as locally significant for educational purposes and should not be disregarded just because other more highly significant features exist. Documentation of these features may also be important particularly if a feature of higher significance is destroyed or its values reduced in some other way. Features of local significance are typically representative of smaller areas within a region, e.g. Bullock Creek palaeo-drainage, Leitchville (BD 001.2). Such sites are typically related to either a local municipality or an area with a radius of 20 km.

Significance assessments are not regarded as fixed or permanent as sites are reassessed periodically often when new sites, research or information comes to light.

SUMMARY

Systems of protected areas are the cornerstone of nature conservation. A number of criteria and goals have been developed in Australia to ensure the conservation reserves network is comprehensive, adequate and representative and thus gives a level of protection to biodiversity and other natural values including scenic values. Ecological vegetation classes are used as a measure of biodiversity to achieve the CAR goals but other values are also considered important when designing the conservation reserve system. In addition, it is recognised that examples of all environments cannot always be protected on public land and consequently many complementary conservation programs have been initiated on private land. However, the protection of other natural values such as sites of geological or geomorphological significance are not documented in such a rigorous way, and as a consequence are largely represented in the reserve system based upon a coincidence with biodiversity, scenic or recreation values.

Table 10.2 Geological or geomorphological sites of high significance.

Site number	Site name and Location	Land status	Significance
BN 079	Murchison Meteorite fall site, Murchison East	Mostly freehold	International
MD 009	Raak Plain boinka, 16 km NW of Hattah	Mixed freehold/ public land	International
SH 002	Lake Boga granite quarry mineral type locality, Lake Boga	Public land	International
BD 001	Kow Swamp lake and lunette, 3 km S of Leitchville	Public land	National
BD 003	Barmah forest alluvial fan and anabranch network, Barmah	Public land	National
BN 053	Bama–Goulburn drainage complex , Murray / Goulburn rivers confluence area, E of Echuca	Public land	National
MD 001	Hattah lakes overflow lake and anabranch systems, Hattah	Public land	National
MD 007	Lindsay Island floodplain, scroll bars, active and abandoned channel complex, W of Neds Corner	Public land	National
BD 003.4	Moira and Barmah lakes digitate delta and silt jetty, Barmah	Public land	State
BD 003.7	Barmah Choke River Murray constriction, Picnic Point to Barmah	Public land	State
BD 006	Ulupna Creek and Island floodplain complex, ~ 10 km N of Strathmerton	Public land	State
BD 009	Bumbang Bend recent meander cutoff (avulsion), Robinvale	Public land	State
BD 013	Wakool Junction abandoned channels and plains, Kenley	Public land	State
BN 052	Palaeolake Kanyapella area, E of Echuca	Mixed freehold/ public land	State
BN 053.3	Murray and Goulburn confluence area, E of Echuca	Public land	State
BN 057	Cadell Fault, Kanyapella South to NSW	Mixed freehold/ public land	State
BN 081	Lake Cooper quarry mineral locality, Colbinabbin	Public land	State
BN 086	Shepparton Formation Type-section, Kialla West	Public land	State
MD 007.2	Websters Lagoon and Websters Island Reference Area disrupted drainage and scroll plain	Public land	State
MD 011	Kings Billabong and the floodplain between Butlers and Psyche Bends, Irymple	Public land	State
MD 018	Olney Bore Eocene to Miocene Olney Formation Type-section, SW of Pollard Island	Public land	State
MD 019	Wallpolla Island and Creek anabranch and floodplain, W of Mildura	Public land	State
MD 022	Cowanna Bend neck meander and potential avulsion site, Redgrove	Public land	State
SH 006	Kerang groundwater discharge area, Kerang to Lake Boga public land	Mixed freehold/ State	
TL 139	Tawonga Fault, Kiewa Valley Highway public land	Mixed freehold/ State	
WN 042	Wodonga Quarry outwash fans, 6 km W of Huon Hill	Public land	State

11 Recreation and Tourism

The study area is a major destination for recreation and tourism. It is valued for its warm, sunny weather, sandy beaches, grand river red gums and natural surroundings. The River Murray and its tributaries provide for tranquility and water activities prized by millions of annual visitors. Recreation and tourism in the River Murray region are important for people living both in and outside of the study area. The first section of this chapter discusses the key recreational activities in the area. The second looks at the importance of tourism to Victoria and to local communities as well as exploring more detail about tourism activities in the study area.

RECREATION

Recreation is an important part of modern life. As our lives become busier, the chance to take a break becomes more valuable. There are many opportunities for recreational activities in parks and reserves and state forests within the study area. Visitors to the region enjoy the feeling of remoteness and the unstructured activities. The most popular activities for people visiting the River Murray parks and reserves are camping, fishing, water-skiing, swimming, motor boating, cycling and having a meal (such as a picnic). However, priorities differ slightly between people from Melbourne and people from regional Victoria. People from Melbourne are most likely to have water-skied on their previous visit whereas people from regional Victoria are most likely to have gone fishing on their previous visit (Newspoll 2005).

Activities range from passive activities where there is little discernible effect on the social (including quality of life) and biological environment, to activities that have large and varied impacts on an area. Each of these activities also contains a spectrum of impact from minimal to a large impact on the surrounding environment.

Land managers report a long-term trend of increasing popularity for recreation and associated developments in the study area, however with no fee or booking system for many activities, it is very difficult to get accurate data on visitor numbers, reasons for visits, expenditure and preferences. Consequently, some of the data reported in this chapter is for only parts of the study area.

Camping

Camping within the study area is focused on the rivers and adjacent lakes (Figure 11.1). There is no fee for camping on public land in the study area except in the various caravan parks on public land and at Hattah-Kulkyne National Park. Campers are not required to notify anyone or use booking systems which are used in other areas of Victoria. People camp on beaches, in the forest, on riverbanks, on the banks of tributaries and beside billabongs. Campsites are generally accessed by car but a number of sites can only be reached by walking or by boat.

Figure 11.1 Camping at Hincheys beach on the River Murray.

There are 76 sandy beaches with camping areas between Yarrawonga and Tocumwal, which become very crowded in the peak season (Figure 11.2). Facilities are generally limited at campsites in state forests and parks, reserves along the River Murray and tributaries, often consisting of only picnic tables and signs or simply a cleared spot. People also camp at commercially operated caravan parks where there are more facilities such as hot showers and flushing toilets. There are 14 caravan parks between Lake Hume and Robinvale with a total of 4480 sites and 3624 cabins (Hassall & Associates & Gillespie Economics 2004). The caravan park at Torrumbarry Weir operates under a lease managed by Goulburn Murray Water (Figure 11.3).

Figure 11.2 Crowded camping and boating area on the banks of the River Murray near Yarrawonga.

Figure 11.3 Caravan park at Torrumbarry Weir.

Parks Victoria surveyed people visiting five parks over the Easter weekend in 1998 and found that the main reason people came to the area was "relaxing/getting away from it all" (Peacock & Reed 1998). The main reasons for choosing the specific location were tradition or familiarity, relaxing or peaceful location, or social reasons such as being with friends. Camping with friends may require a specific location that provides sufficient space, facilities or particular qualities such as a shallow beach or deep section of a river for a boat. Visitors were also asked about park management. In general, they thought positively about the area as a cheap holiday, the sense of being in the "wilderness" and the quality of the beaches. In contrast, they thought negatively about the lack of information on natural and cultural/historical features of the park, ranger availability, litter control and access to toilets and other facilities. People like to camp in relatively large groups (the average group size was ten people) and most groups described themselves as families with kids. Fifty percent of these groups had dogs with them.

The Easter survey found that 44 percent of visitors were from Melbourne and 43 percent were from country Victoria. Of those surveyed, 50 percent of visitors were on their first visit to the Murray parks and reserves in the last 12 months, and about 12 percent were from other states. About half the campers stayed four to seven nights (Peacock & Reed 1998).

Because there are no fees, bookings or access control, detailed information on the numbers of people camping in the study area and how this is changing over time is difficult to establish. However, rough estimates of camper numbers (based on counts of cars) in the area between Yarrawonga and Tocumwal are shown in Table 11.1. The most popular times for camping in the study area are Christmas and Easter (see below Figure 11.15 for the peak in tourism in March-April). While fewer people visited the area over Christmas compared with Easter, the longer school holiday break over Christmas means the number of visitor nights was greater at Christmas than Easter. Indications are that the Melbourne Cup weekend is also increasing in popularity (Parks Victoria, unpublished data). This part of the river is probably the most popular area for camping given the sandy beaches and proximity to Melbourne. However, it is likely that other river frontage in the study area has similar numbers.

People participate in numerous activities whilst camping. These include the many activities described in the remainder of this chapter as well as swimming, day walks, picnicking and having a meal, drinking and socialising with friends and family, touring local towns, participating in local festivals and events, travelling to local towns to shop, going to the local hotel for a drink and a meal. Many of these activities bring money into the towns and although this is highly seasonal, it contributes greatly to local economies.

Camping Issues

Campfires

Many campers enjoy having a campfire. In fact, they may choose their camping location partly based on whether or not wood fires are permitted (compared with areas that only allow gas units). Campers use fire for many purposes including cooking, keeping warm and heating water as well as for social enjoyment and ambience.

However, in some popular camping areas, such as along the Murray at Hattah-Kulkyne National Park, the Lower Ovens, and near Yarrawonga, Cobram and Tocumwal, the current rate of use of firewood is unsustainable, with firewood becoming very scarce. Roadsides around Yarrawonga have been stripped of their fallen timber, affecting flora and fauna that require the fallen timber for habitat (as discussed in chapter 5). It is not only the small, easily handled wood that is taken (Figure 11.4). Some campers attach very large logs to their four-wheel-

Table 11.1 Estimated Numbers of Campers between Yarrawonga and Tocumwal.

Time of year	Approx. no. vehicles	Average stay	Average /vehicle	Visitor nights
Christmas/New Year 2003/4	2080	8 nights	3 people	49,920
Easter 2005	3320	3 nights	3 people	29,880

Source: Estimates were made by Parks Victoria rangers on patrol and based on counts of cars in reserves managed by Parks Victoria (Parks Victoria, unpublished data).

drives and drag them through the forest causing soil disturbance and erosion. Campers have also been known to ring-bark standing living trees to use for firewood the following season, despite the possibility of prosecution and heavy penalties (Figure 11.5). In some Victorian parks, such as Wilsons Promontory National Park, rangers supply firewood over the periods fires are permitted in established fireplaces. Campers and day visitors are not allowed to gather their own supplies.

Figure 11.4 Large amounts of firewood are collected from the river red gum forests by campers.

Many wildfires are started by unattended and abandoned campfires. In response to this issue, the Department of Primary Industries in New South Wales first introduced a ban on solid fuel fires in State Forests in 1990. This ban extends along the Murray River from Howlong (west of Albury) to Tooleybuc (north of Swan Hill) during the summer high fire danger period (NSW Department of Primary Industries 2004). Fire managers report that this ban appears to have reduced the number of wildfires caused by summer campfire escapes but appears to have increased camping and firewood pressures on the Victorian side of the Murray. A ban on summer campfires similar to that in New South Wales was proposed a couple of years ago by the River Murray Users/Water Watch Committee but has not been introduced for public land along the Murray in Victoria.

Figure 11.5 Ring-barked tree in the Lower Ovens Regional Park.

Toilets

Permanent long-drop or pit toilets are provided at several beaches. These toilets are pumped out regularly at times of high visitor use and before floods so the faecal matter does not get washed through the forest. However, at beaches and campsites without permanent toilets and at those with toilets but high visitor demand, campers must either bring their own toilets or make other arrangements. Portable chemical toilets are recommended but pit toilets can be acceptable if well maintained. Pit toilets must be at least 100 m away from any waterway or from the high bank of the river (Parks Victoria 2004a). Some campers do not bury their faecal waste and the bush becomes littered with toilet paper and waste. At the start of the recent summer holiday periods, Parks Victoria published "The Murray River Guardian", a newspaper distributed free to campers and visitors, in an attempt to reduce environmentally damaging practices. The risk campers' waste—buried or left at the surface—poses to water quality and the health of water consumers downstream, remains unclear.

Rubbish

Campers leaving rubbish in the bush is a major issue for public land managers who previously provided bins for campers and collected large amounts of rubbish. For instance, from Christmas 2003 to the beginning of February 2004, Parks Victoria collected 1114 cubic metres (an average car trailer is about one cubic metre) of rubbish between the Lower Ovens and Ulupna Island (Figure 11.6).

As part of the "Don't waste the Murray" campaign promoted by Parks Victoria and local shires, Easter 2005 was the final year in which bins were provided at the main entry points to riverine public lands in the Moira and Campaspe shires. Thereafter, signs were erected to direct campers to transfer stations for which hours were extended to meet campers' needs. Campers can leave rubbish at transfer stations for $2 per bag and recyclables are free of charge. This initiative is intended to encourage campers to take their rubbish home or to a transfer station, reducing the amount of rubbish left in the bush.

Figure 11.6 Rubbish dumped illegally in a park.

Long-term Campers

Itinerant workers in the horticultural industries sometimes camp for long periods on public land in the study area—particularly in the Yarrawonga, Cobram and Mildura regions. The itinerant workers stay in these areas at no charge and are relatively close to seasonal work locations. However, when people camp in one place for extended periods firewood typically becomes scarce and human waste, including faecal material, accumulates. Vegetation under tents and caravans becomes degraded and trampled. Additionally, there is an equity issue, as other people are denied access to the public land.

Campers cannot stay on Crown land for more than 21 days without a valid permit, lease or licence (*Land Act 1958*). Dealing with long-term camping requires considerable management resources and land managers report difficulties in evicting long-term campers.

Figure 11.7 Campsite of an itinerant worker.

Boating

Boating is a common recreational activity in Victoria. It was estimated that in 2000 there were over 170,000 boats (including jet skis, canoes, sailing boats, row boats and power craft) owned in Victoria with an estimated value of $620 million (Henry & Lyle 2003). Figures are not available for boat usage in the study area. Although issues of boating on the River Murray are reviewed in this section, the River Murray is actually in New South Wales and therefore the ability of Victorian government agencies to address some of these issues is limited.

Canoeing, kayaking and other rowing are activities that are unlikely to cause pollution or physical damage to the river and lake systems. Canoeing is a popular way to access shallow areas during flooding and provides good transport for birdwatching (Figure 11.8). There is a canoe trail on and around Gunbower Island. The Murray Marathon is the longest flat-water canoe race in the world, extending 404 km from Yarrawonga to Swan Hill. It has been run each year since 1969 and is a fundraiser for the Red Cross. The Marathon is a major event and thousands of people associated with the event (competitors, organisers, and support crews) camp in football grounds in major towns.

Figure 11.8 Canoeing on Barmah Lake.

The major rivers within the study area are popular water-skiing spots because the surface of the water is often flat throughout the day (unlike lakes where the wind and thermals create waves on a long reach of water) and the water level does not change significantly (Figure 11.9). Some places within the study area specifically cater for water-skiers and water-skiing clubs with permanent slalom courses and jump ramps set up (e.g. Lake Moodemere near Rutherglen). Water-skiing is particularly popular in the Lower Ovens River. Some areas of the Murray do not have sufficient water and have too many snags for safe water-skiing (e.g. around Hattah-Kulkyne National Park).

Figure 11.9 Water-skiing and other water sports are popular activities on the River Murray.

The "Southern 80" is an annual high-speed 80 km ski race between Torrumbarry and Echuca. It is organised by the Moama Water Sports Club and attracts up to 350 competitors in several classes and over 40,000 spectators. The event attracts many campers, many of whom stay in reserves and parks along the River Murray. Whilst many of the campers are environmentally and socially conscious, the combination of groups of spectators and alcohol requires considerable Police and Parks Victoria resources to retain a pleasant atmosphere for all. In 2006, 30 cubic metres of rubbish was picked up by Parks Victoria following the Southern 80. Other races include the Mildura 100 held over Easter while several ski schools and ski clubs are located along the River Murray, on Lake Mulwala and on Lake Hume.

Wake-boarding has risen in popularity over the past ten years. Like skiing, wake-boarders are towed behind a powerboat, but unlike skiing, participants favour a very large wake from which they can jump and perform tricks. Wake-boarders often put a plastic bladder of water or other ballast into the stern of the boat to achieve this large wake. Unfortunately, this wake also affects other river users. The large wakes cause bank erosion in rivers (Shoalhaven City Council 2005) although it is also likely that rising and falling water levels for irrigation contribute to bank erosion in the River Murray. Placing bans or restrictions on wake-boarders on some sections of the River Murray (particularly around Yarrawonga) has been discussed by the River Users/Water Watch Committee (convened by NSW Maritime which has responsibility for River Murray waters) and other stakeholders, but these are yet to be instituted.

Jet skis and other personal watercrafts are also commonly found on the Murray River and can be hired from a number of locations. Riders of these craft typically like to jump waves and "do donuts" rather than travelling long distances in a straight line. This potentially creates noise pollution and contributes to bank destabilisation.

Houseboats are a popular means to relax and explore rivers (Figure 11.10). Houseboats can be hired at most major centres along the River Murray including Wentworth, Mildura, Swan Hill and Echuca, however, mooring places along the River Murray are limited and can be costly. There are approximately 50 houseboats for hire and 250 private houseboats just in the area between Robinvale and the South Australian border (Hassall & Associates & Gillespie Economics 2004).

Figure 11.10 Houseboat moored nearing sunset on the River Murray at Mildura.

Houseboats on the River Murray are required to have onboard wastewater treatment systems connected to a holding tank, which must be discharged to an approved sewage pumpout facility. Grey water is also a potential problem with houseboats. This may contain solid and liquid foods, soaps, washing powders, detergents, skin, hair, and microbial pathogens such as bacteria and viruses (Laginestra undated). In the past grey water from houseboat showers and sinks was disposed of directly into the river carrying with it the soaps and detergents that contribute to pollution and possible eutrophication. Recently, regulations have been introduced that require grey water to be stored in a holding tank and then disposed of away from the River (Section 120 under the NSW *Protection of the Environment Operations Act 1997)*. Companies and individuals risk fines of up to $1M and $250 000, respectively, for polluting New South Wales waters. This section of the legislation is enforced by New South Wales Maritime. In Victoria, the *Water Act 1989, Lake Eildon Houseboat Regulations: Houseboat Regulations 2001, Schedule 2* provides the requirements for sewage disposal from houseboats.

Paddlesteamers are a major tourist attraction in the Echuca–Moama area, which was once the biggest inland port in Australia (see also chapter 12), but are also located at Mildura, Swan Hill and Albury-Wodonga. Historically, paddlesteamers transported produce, timber, mail and passengers up and down the River and today they provide a link back to early European settlement. Several boats, badly damaged over time, have been fully restored at Echuca. Some paddlesteamers can be chartered for private functions or overnight stays.

Other tour and cruise boats also provide opportunities for visitors to explore the rivers of the study area and socialise. These include the *Kingfisher* at Barmah, the *Paradise Queen* and the *Lady Murray* at Yarrawonga, the *Kookaburra* at Swan Hill and the *Mundoo* at Mildura. The commercial cruise boats at Lake Mulwala require an occupational licence arrangement with Goulburn-Murray Water although the authority for this water is NSW Maritime.

At Lake Mulwala there are six public boat ramp facilities. Each has rubbish removal and three have public toilets. Goulburn-Murray Water licences about 175 private jetties and concrete boat ramps along the shore of Lake Mulwala. The annual licence fee is currently set at $165 per annum and each licence holder is required to have their own public liability insurance policy. There has not been a formal study to determine the environmental impact of these structures but the numbers have been capped since 2002.

Boat licences are required to drive all powered recreational vessels (including hire boats but excluding houseboats) and personal watercraft (e.g. jet skis) in Victorian (regulated by Marine Safety Victoria) and New South Wales waters (regulated by NSW Maritime Authority). The Victorian General Boat Operator Licence is recognised on the River Murray but boat operators must understand and obey the New South Wales regulations as the Murray falls under the jurisdiction of New South Wales (through NSW Maritime). Goulburn-Murray Water is the boating authority for Greens Lake and Loch Garry.

Fishing

Recreational fishing is a popular recreational activity in Victoria. It is promoted as a healthy and fun family activity (Fisheries Victoria 2000). The fish species of the study area are described in chapter 5. This section describes recreational fishing habits in Australia, Victoria and the study area.

A 2000-2001 study of recreational fishing (Henry & Lyle 2003) found that 550,000 (12.7 percent) of Victorians (aged five years and older) went fishing at least once in the 12 months prior to the survey period and there were approximately 2.6 million fisher days/year in Victoria. Just over 40 percent of Victorian's fishing effort was spent at rivers, lakes and dams (compared with estuaries, offshore and coastal locations). In dollar terms, Victorian fishers spent an estimated $396 million on fishing per year. This equates to approximately $721 per Victorian fisher per year. An earlier study estimated that approximately $200 is spent per kilogram of fish caught and kept (National Institute of Economic and Industry Research 1997).

Fishing was more popular with males than females and the main method was line fishing (over 85 percent of fishing effort in Victoria). The most popular primary motivation for going fishing was "to relax and unwind" (37 percent of respondents), with the second most popular being "sport". "Fishing for food" as a primary motivation was only listed by 7.5 percent of respondents (DAFFA 2003).

The Department of Agriculture Fisheries and Forestry Australia Recreational and Indigenous Fishing Survey asked respondents about the numbers of fish taken annually by recreational fishers (Table 11.2). This survey indicated that recreational fishers harvested approximately 136 million aquatic animals in the survey year across Australia (Henry & Lyle 2003).

In the study area the popular recreational fish species are brown and rainbow trout in the upper reaches of the tributaries and Murray cod and golden perch in the lower reaches of tributaries, and the River Murray. The areas accessed for fishing have increased over the past few decades with newer, more reliable outboards (Figure 11.11). Use of 4WD vehicles for access is also becoming more common.

Figure 11.11 Fishing from a small boat on the River Murray near Barmah.

A Victorian fishing licence is required to fish in all Victorian waters while a NSW fishing licence is required to fish in the River Murray. In 2004-05, 245,230 recreational fishing licences (administered by the Department of Primary Industries) were purchased in Victoria, producing revenue of more than $4.5million. This was a $300,000 increase compared with the previous year. Revenue from the fishing licences in Victoria goes to the Recreational Fishing Grants program from which it is dispersed to projects designed to improve recreational fishing such as new fishing platforms, improved fish habitat and increased stocking. In 2004-05, over $759,000 was allocated to 35 such projects.

In addition to fishing licences, there are also closed seasons and size- and bag-limits for many species in an effort to maintain sustainable fish populations.

Table 11.2 Estimated annual harvest (rounded to the nearest thousand) for all of Victoria in 2000-01, including the River Murray for species found in the study area.

Recreational Fishing species	Estimated number	Estimated weight (kg)
Native species		
freshwater crayfish	1,887,000	75,000
golden perch	142,000	85,000
Murray cod	11,000	27,000
Introduced species		
redfin	949,000	237,000
trout/salmon including rainbow and brown trout	345,000	173,000
European carp	328,000	246,000

Source: Henry and Lyle (2003).

Table 11.3 The growth stage, species, number, location and cost of fish stocked (in the study area) through the Recreational Fishing Grants program.

Stage and species	Number	Location stocked	Cost ($)
Yearling brown trout	10,000	Lake Hume	10,780
Fingerling Murray cod Fingerling golden perch	5000 15,000	Goulburn River from Murchison to Mooroopna	6818
Yearling Murray cod Fingerling golden perch	3000 40,000	Kow Swamp, Reedy Lake, Lakes Charm, Kangaroo, & Boga	23,636
Fingerling golden perch	150,000	Lake Hume	27,273
Fingerling Murray cod Fingerling golden perch	10,000 50,000	Campaspe River & near Greens Lake	17,727

Source: DPI (2005)

For example, Murray cod have a minimum legal size of 50 cm, the bag limit is two (of which no more than one fish may be equal to or exceed 75 cm in length) and the season is closed from the beginning of September to the end of November to protect reproduction. In comparison, trout cod (which are very similar in appearance to Murray cod) are a fully protected species.

Fish stocking is carried out in many Victorian rivers, dams and lakes to address the conservation status of some species and to improve the recreational fishing opportunities of other species (Table 11.3). Fish stocking is coordinated by the Department of Primary Industries. Some of the funding for fish stocking comes from recreational fishing licence fees.

Bardi grubs are popular bait for fishing, especially as bait for Murray cod. Digging for grubs is not permitted in parks, the River Murray Reserve or public land water frontage reserves and only permitted in State Forest with a permit under the *Forests Act 1958*.

Four-Wheel Drives, Motor Bikes and Trail Bikes

Four-wheel driving is an activity that allows participants to access remote areas. Experienced drivers can safely gain access on slippery tracks without damage. Four wheel-driving is legitimate on formed tracks that are open to the passage of vehicles. Driving off formed vehicle tracks is illegal under the *Land Conservation (Vehicle Control) Act 1972.* Parks Victoria has established a Memorandum of Cooperation with Four Wheel Drive Victoria to work towards common goals for 4WD use in parks and reserves in Victoria (Parks Victoria & Four Wheel Drive Victoria 2004). The Department of Sustainability and Environment has published a 4WD Touring code that promotes safety and care of the environment. It advises that vehicles should only be driven on formed roads and vehicle tracks, and that driving off-track can cause erosion and damage vegetation. Participants should avoid using muddy tracks and remove fallen tree branches from the track rather than driving around them. Care should be taken in creek crossings to disturb the creeks as little as possible.

Unfortunately, some 4WD participants do not adhere to the code recommended above. This often results in roads and tracks being badly damaged with rutting, potholes and corrugations. As a consequence, large proportions of land managers' budgets are consumed with continually repairing damaged tracks. This is particularly the case in areas around Mildura, Gunbower Island and Yarrawonga. Road damage also leads to erosion, damage to vegetation and water pollution.

Rallying is conducted on formed mapped roads and is highly regulated. Rallying is conducted in close cooperation with forest managers from the Department of Sustainability and Environment with processes for scheduling events, financial provision for road damage to be compensated, insurance cover and community consultation.

Many people enjoy motor bike and trail bike riding as it gives them an exhilarating way to see rugged and beautiful country that many other people don't get to see. It also fits in well with other similar activities such as spending time in the outdoors and camping (Figure 11.12). Public land in state forest and national parks provides large tracts of land with well-formed tracks for trail riding. All bikes ridden on public land must be registered, the rider must be licensed and must wear the appropriate safety equipment as required by law. Additionally, bikes must stay on formed tracks, similar to 4WDs.

Some areas of State Forest have been temporarily or permanently closed to trail bikes due to environmental damage. In New South Wales, Benarca State Forest west of Moama and parts of Moira State Forest adjacent to Barmah Forest were closed to trail and motor bikes in 2004 (NSW Department of Primary Industries 2005b). Inappropriate use of bikes was degrading vegetation on sandhills and in the forest, and spreading weeds such as spiny burr grass. Bikes also often cause noise pollution and disturb wildlife. Some bike riders cause damage to Indigenous heritage areas as they use midden and burial sites as ramps from which to jump. Fencing is required at some sites to prevent this.

The Department of Sustainability and Environment has developed guidelines for trail bike riders to limit environmental damage. The Australian Motorcycle Trail Riders Association (AMTRA) advises riders to follow the Tread Lightly principles and aim for minimal impact.

Figure 11.12 Trail bikes at a campsite along the River Murray.

Hunting

Hunting is a permitted recreational activity during the prescribed season on both public and private land within the study area. The land categories that permit and do not permit hunting game and feral animals on public land are shown in Table 11.4. This section provides brief information about hunting in the study area. Recreational hunters should consult the *Victorian Hunting Guide* for further information.

Duck hunting is a popular recreational activity in Victoria with over 22,000 hunters licensed to hunt ducks in 2006 (DSE 2006j). The wetlands in northwest Victoria are an important area for recreational hunters as this area provides suitable wetland habitat. The most visited wetlands tend to change between years as the water levels change and the ducks move from area to area. In 2006, duck hunting was permitted on a number of Goulburn–Murray Water storages in the study area including Greens Lake (near Corop), Lake Boga, Lake Charm, Little Lake Charm, Racecourse Lake, Yarrawonga Weir (Victorian waters), Lake Tutchewop and Kangaroo Lake. Duck hunting is not permitted on Goulburn–Murray Water irrigation channels.

The *Wildlife Act 1975* provides for the hunting of eight species of native duck that have been declared "game". The prescribed open season starts on the third Saturday in March and finishes at sunset on the second Monday in June each year. This is reviewed annually. In addition to the restricted seasons, bag limits are also imposed to assist in sustaining duck populations. The regulations specify a notional bag limit of 10 birds per day but drought and declining habitat mean that the bag limits have been reduced in recent years. The aerial survey of wetland area index and wetland bird counts help to set the bag limits each year (Kingsford et al. 2005).

The number of ducks counted in the Summer Waterfowl Count was high in 2004 because populations from interstate were concentrated on Victorian waters. Numbers reduced close to the long-term average in 2005 but the wetland area index (conducted across eastern Australia and incorporating 1500 wetlands) for the 2006 duck hunting season was the second lowest in 23 years (DSE 2006a).

In 2006, the bag limit was imposed at seven ducks per day including a maximum of one Blue-winged Shoveler. Eight species of native duck were permitted to be hunted: Pacific Black Duck, Chestnut Teal, Hardyhead (White-eyed duck), Australian Shelduck (Mountain duck), Pink-eared duck, Maned Duck (Wood duck) and Blue-winged Shoveler.

Hunters require a Firearms Licence as well as a Game Licence. To hunt ducks they must also pass a Waterfowl Identification Test that requires them to successfully identify bird species, and hunters are required to follow the ethical guidelines set out by the Department of Sustainability and Environment. Firearms are prohibited in Murray River parks and reserves (Parks Victoria 2004a).

In February 2004, there were in excess of 11,100 licensed deer hunters in Victoria, an increase of 60 percent over the last eight years. In 2005 the number had risen to approximately 14,600. Deer species legally hunted in Victoria include sambar deer, hog deer, red deer and fallow deer. Only sambar may be hunted with gundogs and scent-trailing hounds (in restricted areas). Scent-trailing hounds can only be pure beagles or pure bloodhounds as both of these breeds are slower than other dog breeds, putting less pressure on deer being trailed. Hunting of Sambar in the study area does not seem to be as popular as in other areas of Victoria due to smaller areas and limited populations.

Fallow deer have been found in Barmah Forest but hunting of this species is only permitted on private land. Red deer and hog deer are probably not found within the study area. Other game species hunted in Victoria include stubble quail, and introduced game birds such as pheasants and partridges. While stubble quail is a popular game species, with about 8000 active shooters, they are mostly hunted on private property.

Hunting of feral species is also undertaken within the study area. A Firearms, but not a Game Licence, is required. Species hunted include pigs, foxes, hares, rabbits, wild dogs and goats. Instead of setting out to hunt a particular species as in duck or deer hunting, people hunting feral animals will generally shoot opportunistically at whichever feral species is found. People generally hunt feral animals to be in the outdoors, to socialise, to help reduce feral animal populations and, for some species, for food. Hunters also participate for trophies including horns, tusks, skins for tanning and heads to mount. Increasingly, hunters film the hunt and associated activities, with the films forming a type of trophy.

Pigs are generally hunted by walking through the bush with a rifle or spotlighting at night. Dogs can be used to track pigs but must not be used to hold the pigs. Foxes and rabbits are generally spot-lit at night although hunters are more likely to shoot rabbits during the day if the rabbits are for food.

Table 11.4 Public land use categories in the study area where hunting is generally permitted or not permitted (specific details should be obtained from a DSE office).

Land Category	Game species	Pest species
National parks and state parks	✗ (with some exceptions)	✗ (with some exceptions)
Nature Conservation Reserves and Flora and Fauna Reserves	✗	✗
Natural Features Reserve-wildlife areas, classed under the *Wildlife Act 1975* as:		
• Sanctuaries	✗	✓ at any time.
• State Game Reserves	✓ during open seasons only. authorised by DSE).	✓ at any time (unless specifically
State forest	✓ during open seasons only.	✓ at any time.
Licensed Crown land (including licensed water frontages and unused roads)	✓ during open seasons only unless licensed under the *Land Act 1958*.	✓ at any time unless licensed under the *Land Act 1958*.
Private land	✓ during open seasons only & with permission of land owner/manager.	✓ only with permission of land owner/manager.

Source: Table modified from DSE(2006j).

Horse-riding

Numerous horse-riding clubs are located in the study area. These include the Cohuna Trail Riding Club, the Murrabit Riding Club, the Murray Darling Trail Horse Riders Club and the Shepparton Adult Riding Club. Such clubs provide the opportunity for beginner riders (both children and adults) to gain experience and see more country. Most clubs organise rides on public as well as private land. The Australian Trail Horse Riders Association, ATHRA, also holds rides in the study area.

Trail riding businesses conducting trail rides in the study area include the River Murray Horse Trails at Strathmerton, Billabong Horse Trail Rides at Echuca, Riverland Trail Rides at Wodonga, Cohuna Trail Riding club and Murray–Darling Trail Horse Riders Club in Mildura.

The major annual horse-riding event in the study area is the Barmah Muster, held over a week in April (Figure 11.13). The Muster culminates when as many as 150 riders assemble and bring the cattle into the muster yards. Several other events are held in association with the Muster including a dance and trail ride that attract up to 2000 visitors from across Victoria and interstate. The Barmah Cattleman's Association estimates the event has a turnover of approximately $50,000 and contributes to the local economy.

Horse-riding is permitted in State forests in the study area but permits are required for some activities. Impacts on the environment from horse-riding including soil compaction and erosion, making new tracks and weed introduction are generally highest in areas without tracks or where tracks are wet, boggy or steep.

Figure 11.13 Horse-riders checking the cattle in the muster yards during the Barmah Muster.

Thus, riders are required to stay on track, avoid easily damaged areas and use buckets to carry water from streams to horses (Cook 2003).

Bushwalking

Bushwalking, both overnight hiking and day walks, are popular activities in Victoria. There are many clubs where novice bushwalkers can join more experienced people. Formed, walker-only tracks are not as numerous in the study area as in other areas of Victoria (e.g. the Great South West Walk) and bushwalkers generally use vehicle tracks and camp at sites that are also accessible by car. Presence of public land with frontage along most of the rivers and streams in the study area means that walkers have access to long stretches of river. This contrasts with New South Wales where the river frontage is private in many areas.

Enjoyable bushwalking is diminished by lack of practical access and degraded areas which have lost some of their natural beauty. The latter may be caused by development on adjoining private land, resource extraction and degradation of the natural environment, for example spread of weeds or a high density of cow pats.

Dog walking

Many pet owners consider their dog as 'part of the family' and make decisions about where to go on holiday based on whether they can take their dogs. Also, many people living in the study area enjoy walking their dogs in areas of high scenic value. While dogs off the leash are known to chase wildlife and disrupt breeding birds, dogs on leads can also cause lesser impact simply by leaving the scent of a predator in the area. To minimise the disruption to breeding birds, dogs are better kept on the leash (Burger et al. 2004) and should not be permitted in key areas for native species.

Other Recreational Pursuits

The study area is used for a number of other passive recreational activities including sightseeing, car and bicycle touring, picnicking, birdwatching, wildflower study (e.g. orchids) and photography (Figure 11.14). Birdwatching is particularly popular at Hattah–Kulkyne National Park where a number of different habitat types intersect allowing the possibility of observing many different bird species. The ibis rookery at Reedy Lake near Kerang also attracts many bird watchers. The northern plains grasslands are of special interest to wildflower specialists as a number of species grow there and are very difficult to find elsewhere in Victoria. These activities do not require many facilities and bring tourists dollars to the local economy.

Sightseeing is an activity enjoyed by many in the study area. Visitors can see many natural attractions, Aboriginal historic sites including middens and canoe trees and European historical attractions such as the port precinct at Echuca, homesteads such as Tyntynder and Byramine, and the Swan Hill Pioneer Settlement (see chapter 7).

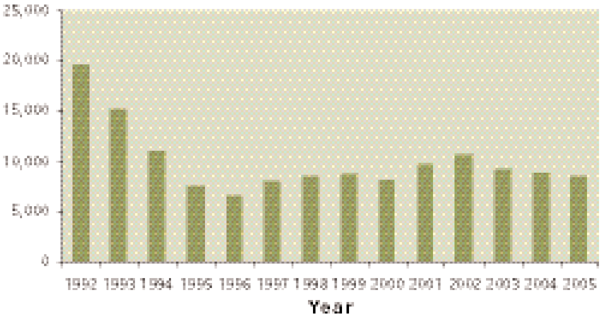
The Dharnya Centre is an information and education resource located on Sand Ridge Track in the Barmah forest. It was established in the 1980s to enable groups and individuals to learn about the heritage and ecology of the forest and originally offered accommodation. Aboriginal Cultural Officers are on hand to help visitors gain an appreciation of the culture and history of Aboriginal people such as the Yorta Yorta. The number of visitors to the Centre (Figure 11.15) demonstrates its importance as a tourist attraction in the area. The second figure demonstrates that the greatest number of visitors come to the Centre in April although the number per month is highly variable between years.

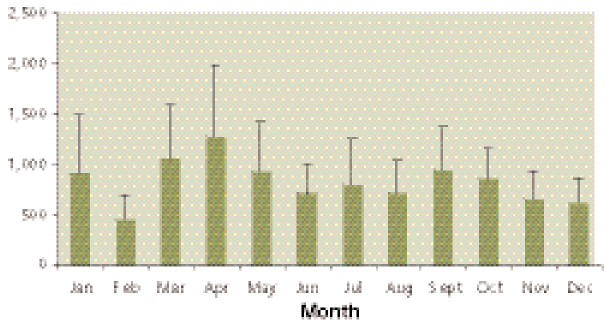
Figure 11.14 Picnic tables and BBQ facilities at near Howlong.

Figure 11.15 demonstrates the high degree of seasonality found in recreation and tourism along the River Murray generally. The peak in March and April is due to the relatively warm (but not too hot) daily temperatures and the Easter holiday. The peak in visitors to the Dharnya Centre in April may also be due to the Barmah Muster attracting people to the region at that time. The lower numbers in November and December probably reflect the decline in numbers of people camping in the Barmah forest while it is flooded in spring.

Rail trails provide pleasant and often scenic ways of exploring the landscape for walkers and bike riders. Horses can also use some sections of these trails. There are three Rail Trails established (or in development) in or close to the study area. The Murray to the Mountains Rail Trail follows the edge of the study area along the Ovens River from Bright to Wangaratta. This trail has the gentle gradient common to most rail trails and provides great views of the Alpine Country. The High Country Rail Trail begins near Bonegilla and heads east along the shores of Lake Hume (just to the east of the study area). Like many rail easements in Victoria, this rail trail has significant remnant vegetation as historically it was not grazed heavily or cropped but was burnt frequently (see also chapter 9 and 17). The Bonegilla Station Bushland Reserve and School Bushland Reserve have remnant populations of the threatened orchid Wedge Diuris and Western Golden Wattle and also representation of White-Box Grassy Woodland community. There are plans to develop a third rail trail from Whitfield to Wangaratta along the King Valley.

Figure 11.15 The total number of visitors to the Dharnya Centre in Barmah forest from 1992 to 2005, and the average (mean and one standard deviation) number of visitors per month.





Source: Parks Victoria, unpublished data

Economic Values associated with Recreation

A study was conducted in 2004 that looked at the value of a range of recreational activities in the River Murray, the Lower Darling and the Goulburn Broken systems (Hassall & Associates & Gillespie Economics 2004). They aimed to quantify in dollar terms the total economic value of river dependent industries in these areas. They estimated the total economic value of 'non-consumptive' industries (i.e. those other than irrigated agriculture and urban water) that are dependent, or partially dependent, on healthy rivers in the Southern Murray-Darling Basin around $1,620 million.

TOURISM

Tourism is an extremely important part of the economy. Tourism Victoria estimates that in 2003–2004, tourism contributed $10.9 billion to Victoria's economy (5.3 percent of GDP). This is an almost 50 percent increase from six years previously. Approximately half (46 percent) of this reflects Victorians travelling within Victoria, about one quarter is interstate visitation (25 percent) and the other quarter is international visitation (29 percent, equating to $3,108 million) (Tourism Victoria 2005a).

Tourism expenditure in the Murray Tourism region in 2004 was estimated at $696 million from domestic overnight visitors, $229 from domestic day trip visitors and $51 million from international visitors. This equates to an average of $273, $89 and $848 per person per visit, respectively (Tourism Victoria 2006).

The Murray Tourism region received a 19 percent market share of all domestic visitors to regional Victoria for the year ending June 2005. The region also had over 2.5 millions domestic day trip visitors (12 percent market share) (Tourism Victoria 2006). There were 5.7 million visitor nights (number of visitors multiplied by the length of stay) making the region the second highest for visitor nights in Victoria (Tourism Victoria 2005b). Table 11.5 shows the number of overnight visitors to the Murray Tourism Region from within Victoria, interstate and overseas. 54 percent of interstate visitors to the region in 2005 were from New South Wales.

The River Red Gum Forest study area overlaps in areas with the Murray Tourism region, which covers the local government areas of Towong, Wodonga, Indigo, Moira, Shepparton, Strathbogie, Mitchell, Campaspe, Gannawarra, Swan Hill and Mildura. Approximately 7000 people were employed directly in the tourism industry in the Murray region in 2003–2004 (DITR 2005). This was a 4.3 percent increase from 1997–1998. This increase is relatively small compared with some areas. For instance, the areas with the largest increases in tourism employment were the Mornington Peninsula (24.1 percent) and Great Ocean Road (21.5 percent). For further information on the economics and employment associated with tourism, see chapter 8.

The Legends, Wine and High Country area (Figure 11.16), which also takes in a small part of the study area, received 1.1 million domestic overnight visitors for the year ending June 2005 (9 percent market share). The regional also had over 828,000 domestic day trip visitors (4 percent market share). The Legends, Wine and High Country region received 17,000 international overnight visitors (5 percent market share).

Table 11.5. The number of overnight visitors (000s) to the Murray Tourism Region.

	1999	2000	2001	2002	2003	2004	2005
Victorian	1 605	1 576	1 860	1 615	1 739	1 773	1 656
Interstate	577	517	526	596	665	687	442
International	44	49	36	46	50	60	39

Source: Tourism Victoria (2005b; 2005c).

Figure 11.16 A vineyard in the Rutherglen area.

Over 80 festivals and events bring large numbers of tourists to the study area and adjacent areas. A sample of these includes:

- The Peaches and Cream Festival in Cobram/Barooga in January;
- Riverboats Jazz Food and Wine Festival held in Echuca/Moama in February;
- The Music on the Murray event in Swan Hill in March;
- The Barmah Muster in Barmah Forest in April (Figure 11.17); and
- The Golden Rivers Red Gum Forests to Furniture Showcase (Figure 11.18) in Koondrook in November.

Figure 11.17 Preparing for the Barmah Muster.

Figure 11.18 Wood-chopping competition during the Golden Rivers Red Gum Forests to Furniture Showcase in Koondrook.

Visitation to Victorian parks and reserves has increased slowly since 2001–2002. Parks Victoria surveyed Victorians and people from interstate and overseas to determine what types of parks they visited (Table 11.6). The total number of people visiting non-metropolitan parks in 2004/2005 was 28.6 million (www.parkweb.vic.gov.au—Visitation Statistics).

Table 11.6 The estimated number of people visiting areas within the Parks Victoria estate (derived from a phone survey of 12,000 people).

Type	2001/02	2002/03	2004/05
National Parks	26.8 m	24.9 m	28.6 m
Metropolitan Parks	13.5 m	11.6 m	14.1 m
Piers	29.9 m	29.9 m	30.8 m
Total	**70.2 m**	**66.4 m**	**73.5 m**

Source: www.parkweb.vic.gov.au —Visitation Statistics.

Approximately 0.65 million people visited parks and reserves along the River Murray in 2004/05 (Newspoll 2005). Forty-two percent of these visitors went to national or state parks whereas 58 percent went to Murray River reserves (Figure 11.19). It is estimated that 32 percent of visitors were from Melbourne, 58 percent were from regional Victoria and the remaining visitors were mostly from New South Wales. The average number of nights stayed was two; with approximately 1.3 million total overnight stays. Parks Victoria estimates that the largest numbers visit River Murray Reserves (Central), Yarrawonga Regional Park, Barmah State Park, River Murray Reserves (West), Hattah–Kulkyne National Park and Murray Kulkyne Park.

Figure 11.19 Campers enjoying beach activities at Easter on Ulupna Island in Barmah State Park.

Eco-tourism is a fast-growing industry that is focused on natural environments. However, due to its fast growth, it can lack strategic planning and this may lead to the degradation of the environmental resources that were attracting the tourists initially. This has been demonstrated in several studies examining disturbance of wildlife by tourism, resulting in reduced breeding and feeding capacity (Burger et al. 2004; McClung et al. 2004). In other areas both eco-tourists and general visitors/campers place stress on natural resources. Eco-tourism may alternatively lead local tourist operators to place a higher value on the natural resources and thus may encourage sustainable use and protection.

Australia has signed the Convention on Biological Diversity, which has produced international guidelines for eco-tourism, specifically activities related to sustainable tourism development in vulnerable habitats of major importance for biological diversity and protected areas. The guidelines state that any tourism development requires policy-making, development planning and management. These comprise the following steps: baseline information and review, vision and goals, objectives, review of legislation and control measures, impact assessment, impact management and mitigation, decision-making, implementation, monitoring and reporting, and adaptive management. These guidelines have implications for the planning and management of tourism in Victoria.

Community and Tourism Values of the River Murray Region.

Parks Victoria, Monash University, Tourism Victoria and the Department of Sustainability and Environment have commissioned a study into the community and tourism values of the River Murray region. This study commenced in March 2006 and will conclude in December 2006.

The project will evaluate community and tourism values assigned to specific conservation or camping sites along the River Murray. The aim of the project is to provide Parks Victoria, Tourism Victoria and the Department with key insights into community values regarding River Murray sites, for the specific purpose of allowing appropriate prioritisation and development that is consistent with community values. Specifically the project will provide:

- A set of survey instruments that provide community valuations for sites within an area.
- Information on the main locations and tourism attractions along the River Murray mapped from different community valuation perspectives.
- The community perspective on the importance of specific sites along the River Murray.
- The community's assessment of values in the area.
- GIS spatial analysis of this information.

An important potential use of this information is to strategically benchmark and prioritise a specific group of sites for service provision and development consistent with the community's values. Similar work has previously been undertaken by Greg Brown (University of South Australia) in the Otway Region.

Strategic Directions and Plans for Tourism

Many nodes within the study area are major tourism destinations. These include Albury/Wodonga; Yarrawonga; Cobram; Echuca; Barmah; Swan Hill and Mildura.

Tourism Victoria has developed Regional Tourism Development Plans 2004–2007 (RTDPs) for both North East Victoria and The Murray regions. These plans outline the types of tourism activities identified as "product strengths" for both regions. These include the primary segments: food and wine (Figure 11.20); nature and water-based tourism; adventure tourism; and golf. Secondary segments include Aboriginal tourism, touring, arts and cultural heritage. The Regional Tourism Development Plans also identify infrastructure requirements for both regions. For example, the plan for North East Victoria 2004–2007 has a key strategy of "upgrading visitor service facilities and interpretation of key natural attractions". The accompanying action is to "work with Parks Victoria to improve visitor service facilities and interpretation in the North East Victoria region, as well as conducting an audit of facilities and interpretation in the region". For specific detail on these proposed projects and a copy of the Regional Tourism Development Plans, refer to: www.tourismvictoria.com.au

The tourism industry is increasingly focused on enhancing the value of tourism by increasing the length of stay, spreading seasonal visitation patterns, improving

Figure 11.20 Events in neighbouring regions, such as a wine and food event on Pfeiffer's Bridge over Sunday Creek, bring visitors to the River Murray.

visitor dispersal and avoiding duplication of experience across sites. The economic result of this is described as visitor yield. Increasing visitor yield is favoured as an alternative to building capacity for more short stay visits that often provide increased demand on resources but little economic return for input.

The Shire of Campaspe and Murray Shire Council (NSW) recently released a tourism development plan that aims to increase visitor expenditure and increase visitor dispersal both geographically and seasonally (Tourism Destination Plan Steering Committee 2006). A positive aspect of this plan is that it integrates tourism planning in Victoria and New South Wales. However, it does not integrate planning with other shires along the River Murray. Instead it perceives other regions as competition. An integrated tourism development plan is desirable for the length of the River Murray. Such a plan, similar to the Victorian Coastal Strategy, would have a different focus from the plans described above and set directions for priority geographic locations for growth and development given increasing popularity and resulting pressures.

Recently, Tourism Victoria released Victoria's Aboriginal Tourism Development Plan 2006–2009. Tourism data indicates that international visitors have a high interest in experiencing distinctly Australian culture, including our Indigenous culture. Aboriginal tourism visitors represent 18 percent of all international visitors to the state. The Plan identifies key issues and objectives to promote the expansion and success of Indigenous cultural tourism businesses (Tourism Victoria & Victoria's Aboriginal Tourism Industry 2006).

Tour Operators Licences

Much tourism and recreation is dependent on access to public land. Public land is regularly used for non-commercial recreation and tourism purposes, either in a formal organised sense (e.g. community or sporting events), or an informal sense (e.g. family outings). There is a growing market for Indigenous heritage tourism.

All commercial recreation and tourism businesses operating on land managed by DSE directly or by Parks Victoria require a permit/licence. Licensees are given legal access to run a trade or business, subject to conditions. Conditions may relate to the activity, location or more general matters. Operators who breach their licence conditions can have their licence suspended or revoked.

Different activities require different settings, hence certain tourism and recreation activities may be more prevalent in one area (or category of public land) than another. Conditions are applied to licensed tourism and recreation activities to reduce environmental impacts. Local land managers help to determine these conditions.

Parks Victoria (PV) is responsible for managing the Tour Operator Management System, governing all commercial recreation and tourism businesses operating on land managed by DSE or PV. The costs of the licences do not allow full cost recovery of the Tour Operator Management System but operates at about 25 percent cost recovery.

Licence reform

Currently, DSE has released a directions paper aimed at reforming current licensing systems for tour operators and activity providers on public land (DSE 2005c). This is in order to encourage a viable, growing nature-based industry on public land, and ensure safe and sustainable use of that land. DSE sought public consultation on the document (March 2006), which will assist in finalising the policy on the tour operator licensing system. It is expected that this will be available before VEAC completes its Final Report for the River Red Gum Forests Investigation.

The Economics of Tourism

Tourism Victoria commissioned Access Economics to undertake a study into the value of tourism in 2003/04 (Tourism Victoria 2005a). It addresses tourism expenditure, employment in the tourism industry, tourism in regional Victoria, "export" income and tourism's contribution to gross state product. Detailed information in relation to this study can be found on Tourism Victoria's web-site. Further information on the economics of tourism is located in chapter 8.

12 Cultural Heritage

Cultural heritage places and objects are a tangible link to the past. They illustrate Victoria's written and verbal history. These irreplaceable resources evoke a strong spiritual connection to the past for many people. The landscape itself forms a spiritual and cultural heritage place for many Indigenous peoples and reflects deep spiritual connections to traditional lands or country.

This chapter focuses on the management and protection of both Indigenous and non-Indigenous cultural heritage on public land within the River Red Gum Forests study area.

Aboriginal cultural heritage places and sites exist throughout the landscape of Victoria and are often only identified or clarified after disturbance such as infrastructure works. As such, many sites have been lost and the landscape has changed significantly since the arrival of Europeans. The connection and relationship that many Indigenous people have to traditional lands is profound and deeply spiritual after 50,000 years of occupation (see chapter 6).

During the 200 years of European settlement, major changes in technology and patterns of land use have occurred. Initially people were attracted by the promise of vast grazing lands, while other waves of settlement were associated with the discovery of gold and exploitation of natural resources, which underpinned the economy of the state. Over time, many people have grown to appreciate the land and feel a strong connection to many places, particularly along the River Murray, despite or perhaps because of the often harsh and variable environment. Visiting cultural heritage places or objects provides an opportunity for visitors and residents alike to connect to the past. A thematic non-Indigenous history of the River Red Gum Forests study area is presented in chapter 7.

INDIGENOUS CULTURAL HERITAGE

Pre-European Contact

Aboriginal people have occupied the Australian continent for many thousands of years, and there is ample physical and oral evidence that the areas within the Murray Valley supported a rich culture for much of the last 50,000 years.

Archaeological sites from the Willandra Lakes (Lake Mungo)—about 100 km to the north of the River Murray—have yielded remains of some 135 individuals and provide evidence of Australia's oldest human remains dated at between 45-50,000 years before present (BP) utilising new techniques that reach beyond the reliable range of radiocarbon dating (Bowler et al. 2003).

The Murray Valley region contains numerous burial sites, including the unique occurrence of extensive cemeteries. Human remains in the area have been found to date to the late Pleistocene-early Holocene times. More recently, Indigenous groups have reburied ancestral remains within the study area. Sites such as Kow Swamp (Thorne & Macumber 1972; Stone & Cupper 2003) and near Robinvale (Bowdler 1983) show evidence of occupation continuing intermittently through to recent times, and an apparent continuity in cultural practices including complex burial rituals and rights. The Kow Swamp site in particular is one of the largest collections of late Pleistocene human burials at one site. Dating of the site has yielded ages in the range 13,000 to 9500 years before present (BP). Of particular importance is the complex range of human physical characteristics observed across approximately 40 individuals. The site includes men, women, juveniles and infants with some individuals being anatomically quite distinct from both other ancient people—such as those at Lake Mungo—and modern humans, leading to theories regarding multiple waves of occupation of the Australian continent over time by discrete populations (see Flood 2004). Much debate has continued over the description of the rugged or robust characteristics of some Kow Swamp skeletal remains. A similar robust individual from about 6500 years ago recovered from northwestern WA indicates that this physique was not specific to a single population located on the east coast of Australia (Freedman & Lofgren 1979). The Kow Swamp remains were re-buried several years ago at the request of Aboriginal communities in northern Victoria and the full description of the materials has not been published, although documentation and casts exist within museum and research collections (see Flood 2004).

Freshwater shell middens also attest to early and extended Aboriginal use of food resources along the River Murray and its tributaries (see Box 12.1; Figure 12.1). Aboriginal mounds, some of which also contain human remains, are common. Likewise, Aboriginal scarred trees are common, including the largest Victorian concentration of these trees on Bumbang Island near Robinvale. Other types of Aboriginal sites in the study area include hearths, kitchen mounds and artefact scatters. Aboriginal cultural heritage places are often located close to resources required for their way of life. This is of particular interest in the study area given the generally poor preservation of remnant landscapes, such as prior and ancestral streams (see chapter 2 and 3), which may have contained cultural heritage sites. Much of the landscape of the Murray valley has been substantially modified by water management and agricultural practices, particularly on freehold land.

Written descriptions of Indigenous culture, economy and society are generally restricted to those of early European explorers (e.g. Sturt, Mitchell), settlers (e.g. Curr, Krefft, Beveridge) and government-appointed officials such as G.A. Robinson, Aboriginal Chief Protector. These descriptions come from a specifically European perspective which is unlikely to reflect how Indigenous communities might describe themselves. The intimate relationship that Indigenous people had, and in many cases still have, with the landscape is only now becoming apparent to the wider community.

Aboriginal associations with the study area also include broader spiritual values and Aboriginal cultural heritage places associated with the post-contact period. The latter include campsites, meeting places, historic reserves, massacre sites and stations.

European Impact on Indigenous Communities

Recognition of the history of cultural contact, conflict or resistance, adaptation, adjustment, and an awareness of places reflecting that history, are important for understanding our shared, and at times, poorly documented or acknowledged past. These places also provide a historical reference to explore the changing and evolving culture and values of both Indigenous and non-Indigenous societies within Australia.

European settlement significantly disrupted the lives of Indigenous people in the River Red Gum Forests study area. Even before widespread European settlement, a wave of introduced diseases, perhaps from earlier explorers in other parts of the country, had already spread with devastating effects. Smallpox and influenza epidemics in particular are believed to have significantly reduced the Indigenous population prior to the first pastoral settlers reaching the Murray valley area in the 1830s and 1840s (Atkinson & Berryman 1983).

In 1838 Sturt commented that although the Indigenous people he saw at the junction of the Goulburn and Murray Rivers were good-looking, strong and active, "disease had been busy with them" and there were many burials in the sandhills, which appeared "to have been recently tenanted" (Sturt in Hibbins 1978). Curr (1883) commented that both the state of disuse and the number of cooking ovens indicated that the population of Indigenous people in the Barmah region was much greater prior to the arrival of white settlers.

The wave of European settlers that followed the early explorers saw a clash of cultures with very different technologies, attitudes to the land and concepts of ownership, social values and spiritualities. Dispossessed and forcibly removed, Aboriginal people were in many cases relocated to missions and reserves outside their traditional lands. Many deaths occurred, particularly when Indigenous people resisted the occupation or invasion of their country (Clark 1996).

Today, the places of these interactions between explorers, settlers, including massacre sites, mission stations and reserves are often especially significant to Indigenous people as they form part of their cultural heritage. At a more individual level, many people lost their families and ancestors at these places. The protection of these locations is therefore vitally important to some Aboriginal communities, even if there is no remaining physical evidence of such events.

Protection and Management of Indigenous Cultural Heritage

Identification and documentation of Aboriginal cultural heritage places, sites and objects are important for future management and protection. Aboriginal Affairs Victoria or AAV (Department of Victorian Communities) has prepared information sheets to help identify physical cultural heritage such as middens, scarred trees, grinding stones, artefact scatter sites, stone tools and burials. A description of freshwater middens is provided in Box 12.1. AAV also funds regional Aboriginal heritage officers throughout the state to work in partnership with land management agencies, investigate reports of potential sites, carry out community programs and provide advice to the public, developers, or other government agencies about Aboriginal cultural heritage.

Aboriginal cultural heritage places, sites and objects are protected through cultural heritage legislation (described below). Traditional owners and other relevant Aboriginal groups have an interest in the long term survival of their cultural inheritance and are actively involved in ongoing protection and management of these places, sites and objects.

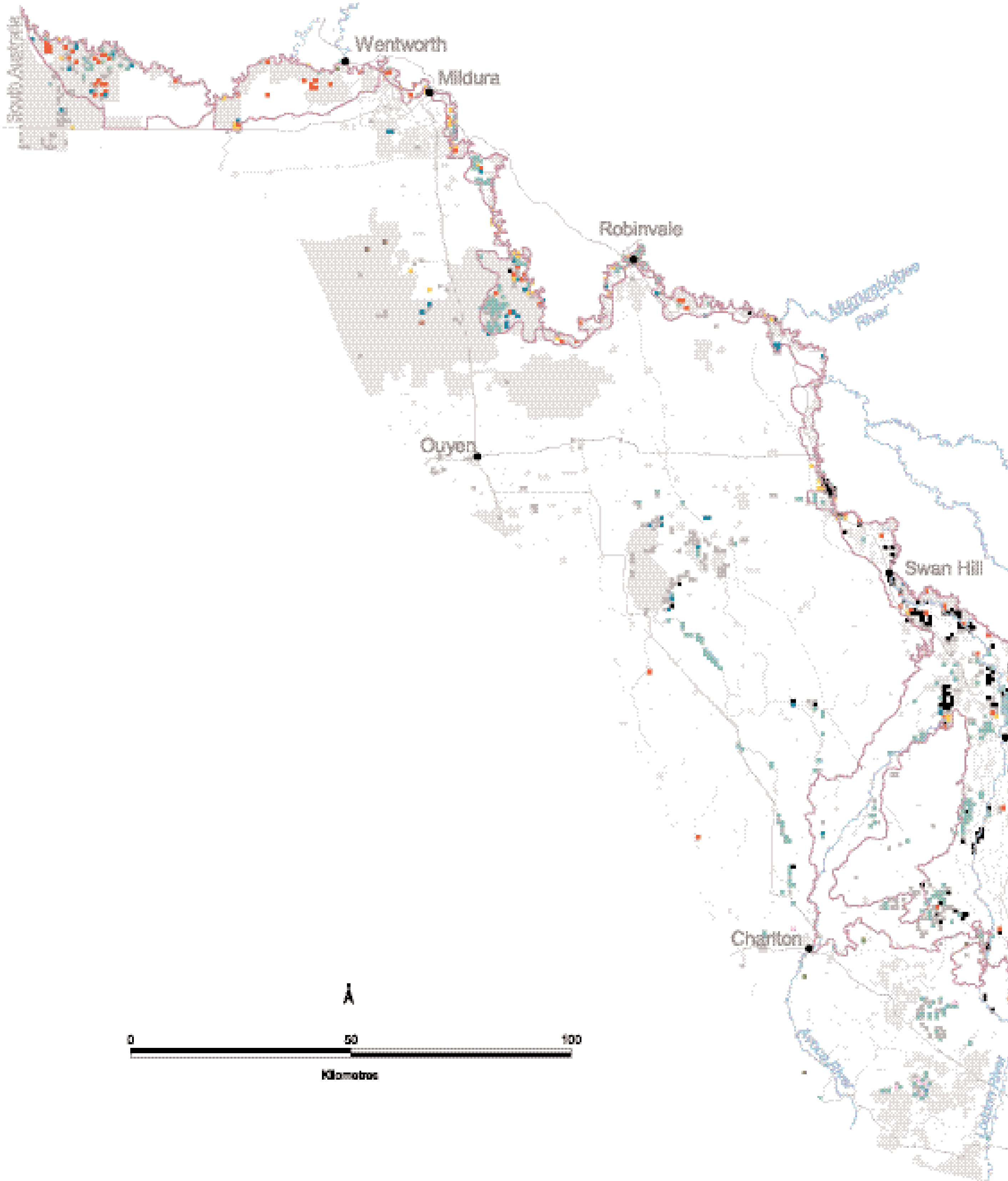
Identification of Sites and Survey Coverage

As described above, sites of Indigenous cultural heritage may have a material or physical nature (such as burials, middens, scarred trees, missions) or may be related to events or spirituality and have no tangible on-ground presence (meeting places, massacre sites, mythology). The documentation, identification, protection and management of Aboriginal cultural heritage places are the responsibilities of all land managers and land owners in Victoria. Aboriginal Affairs Victoria (AAV) and other state government authorities work in partnership with traditional owners and other relevant groups in all Aboriginal cultural heritage investigations and assessments. This includes surveys to locate and record Aboriginal sites and places as well as assessments of the potential impact of proposed works on heritage values.

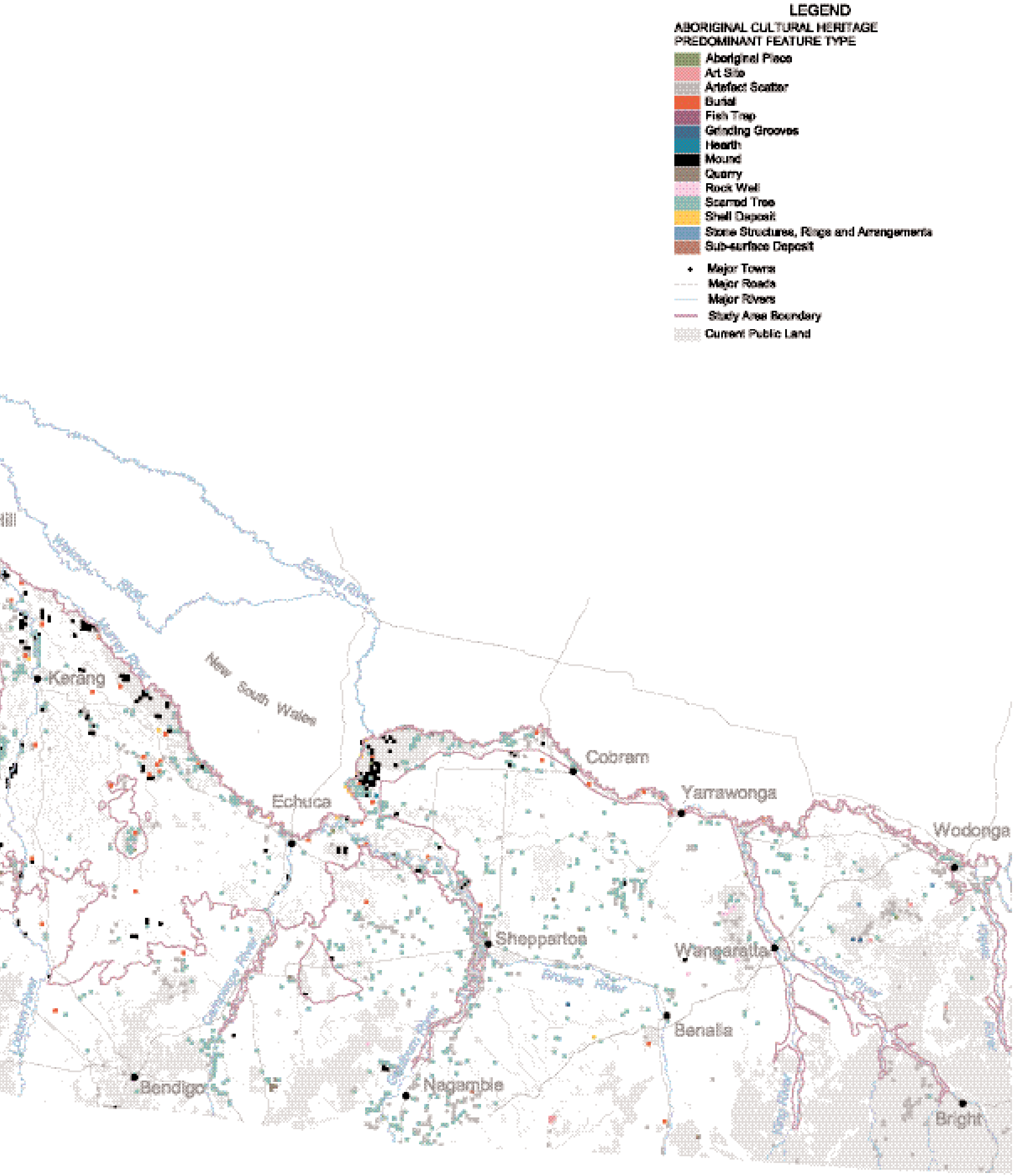
Only some sections of the study area have been systematically surveyed for Aboriginal cultural heritage places. Although the coverage is not comprehensive, a number of notable and important archaeological and cultural heritage sites are known, such as the unique cultural landscapes associated with the Murray Valley including the mound and cemetery complexes, evidence of old shell middens, Kow Swamp and the Robinvale burials, and Bumbang Island sites (Figures 12.1 and 12.2). Many systematic surveys have been associated with the planning and development of specific infrastructure works, such as the construction of roads and forestry activities (e.g. Presland 1981; TerraCulture 2005) while others have been more regional in approach (Bonhomme 1990; Craib 1992; Greenwood 2003; Johnston & Webber 2004).

AAV maintains a Heritage Register of all known

Map 12.1 Distribution of known Aboriginal cultural heritage places for the study area.



Source: AAV, data last updated, 30 June 2006.


LEGEND
ABORIGINAL CULTURAL HERITAGE
PREDOMINANT FEATURE TYPE
Aboriginal Place
Art Site
Artefact Scatter
Burial
Fish Trap
Grinding Grooves
Hearth
Mound
Quarry
Rock Well
Scarred Tree
Shell Deposit
Stone Structures, Rings and Arrangements
Sub-surface Deposit
Major Towns
Major Roads
Major Rivers
Study Area Boundary
Current Public Land
Edward River
New South Wales
Kerang
Echuca
Cobram
Yarrawonga
Wodonga
Shepparton
Wangaratta
Benalla
Bendigo
Nagambie
Bright
Broken River
Ovens River

Box 12.1 Aboriginal Shell Middens.

Many freshwater shell midden sites occur along the major waterways and wetlands within the study area, including both relatively recent ones and those created many thousands of years ago when the climate was much wetter. The middens are accumulations of materials from cooking and eating freshwater mussels. Often middens contain charcoal, ash, fire-stones, burnt earth or clay, and animal bones or shells. Some contain stone tools or, occasionally, burials.

The shells may form a discrete layer or an extensive area associated with a range of activities and the remains of meals eaten over thousands of years at a popular campsite (Bonhomme 1990). The shells are typically the freshwater mussel (*Velesunio ambiguus*) and river mussel (*Alathyria jacksoni*).

Some particularly good examples of middens occur along major waterways throughout the study area. As a consequence of this location, the meandering of rivers and erosion of river banks over time is a threat to some middens. Active conservation may be required to preserve the sites for future generations.

Freshwater shell middens provide valuable information about the past including Aboriginal economy and land-use, the local climate, as well as providing a record of events such as floods and droughts. The shells in middens provide information about the environment, and whether the shells were collected at the same time or at a number of different times. Dating techniques ascertain the time when Indigenous people occupied an area. Middens provide an important link to the past, and those that contain burials are particularly significant to Indigenous people (AAV 2003).

Figure 12.1 A stairway cut into a midden along the banks of the Murray River, Echuca Regional Park. It is against the law to disturb or destroy an Aboriginal cultural heritage site or object without written consent from the relevant local Aboriginal community.

Aboriginal sites and places in Victoria, in accordance with cultural heritage legislation. This includes detailed site information and historical information for some post-contact places. In addition, AAV holds copies of all reports relating to previous Aboriginal cultural heritage investigations throughout Victoria. Records for individual sites are generally subject to access restrictions. However maps of sites portrayed on a 1x1 km grid cell are available as an indicative tool to establish if sites have been registered and what general type of site is present. The distribution of these sites within the River Red Gum Forests study area is shown in Map 12.1. More than one site or cultural heritage type may occur within a grid cell. The absence of grid cells in many areas does not mean that there are no Indigenous cultural heritage sites, but that the area may not have been surveyed or sites documented.

The Aboriginal Community Heritage Investigations Program in 2001-2002 provided opportunities for Aboriginal communities to increase their capacity and participation in cultural heritage management. The program involved a series of training and fieldwork activities and included an oral history component—recording the stories and memories of community elders—extensive field surveys, archaeological excavations, training in cultural heritage management and administration procedures and site protection programs.

Some of the results have been the recording of over 400 new Aboriginal cultural heritage sites; participation of over 170 Aboriginal community members in the program from a diversity of backgrounds and the employment of seven program participants in cultural heritage management positions in various Victorian organisations. The success of this program has demonstrated an ongoing need for Indigenous communities to undertake cultural heritage field surveys and training exercises in partnership with land management agencies.

Another recent survey of Indigenous cultural heritage of the alpine area of Victoria following the 2002-03 alpine fires, has demonstrated extensive and widespread evidence of past Aboriginal occupation (DSE & Parks Victoria 2005). As a result of the fires, good ground surface visibility was provided through removal of dense vegetation, allowing many artefacts including flaked stone scatters, stone axes and rock shelters to be found. This survey revealed that identified individual sites are only point locations within a broader cultural landscape that contains not only artefacts but also places and associations of spiritual significance for Aboriginal people.

Additional surveys are likely to improve the existing level of knowledge and identification of cultural sites and places within the study area. Aboriginal people report that new sites are found regularly in the study area and there are likely to be many sites and places known to traditional owner groups that are not recorded on government registers. As part of the assessment of public land values throughout the study area, VEAC will commission a desktop study of available cultural heritage information, and where necessary, fill any data gaps revealed.

Legislation

Victorian and Australian legislation recognises the importance and value of identifying and protecting cultural heritage such as sacred sites, burial sites, places of significance and other important sites where there is evidence of Aboriginal occupation of country. Indigenous cultural heritage is protected specifically under two acts administered by AAV: the Victorian *Archaeological and Aboriginal Relics Preservation Act 1972* and the Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* Part II A. Under these acts it is an offence to wilfully deface, damage or otherwise interfere with an Aboriginal object or place without prior written consent from the relevant local Aboriginal community as listed in a schedule to the Commonwealth Act.

The Victorian Act protects sites and materials relating to Indigenous cultural heritage, with the exception of human remains interred after 1834. This includes artefacts, stone tools, rock art sites, ancient campsites, middens, burial sites, scar trees and ruins associated with Aboriginal missions or reserves. The Commonwealth Act provides additional protection for cultural property in a broader sense including places, objects and mythology from pre-historical through to contemporary sites. The Commonwealth Act takes precedence over matters where there is conflict with the state legislation.

The Victorian government is in the process of updating Aboriginal cultural heritage legislation. The new *Aboriginal Heritage Act 2006* will come into effect fully in late 2006 or early 2007 and will replace both the State and Commonwealth Aboriginal heritage legislation and provide for more effective protection and broader involvement of Indigenous people in cultural heritage decision making processes. It is anticipated that the new legislation will result in a more integrated and streamlined process for dealing with cultural heritage management issues between land owners, developers, local governments and Indigenous traditional owner groups.

Significant changes under the new Act include clarity for protection of Indigenous heritage in planning and land developments, including developments that require Heritage Management Plans, cultural heritage audit and stop orders, and dispute resolution mechanisms through the Victorian Civil and Administrative Tribunal (VCAT). Additionally, a Victorian Aboriginal Heritage Council will be established to consider applications and register Aboriginal organisations as cultural heritage decision-making bodies for specific areas. The composition of this Council will be broader than the existing cultural heritage 'communities' described under the schedule to Part II A of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* to include traditional owner groups. This Council will also provide advice relating to the protection of Aboriginal heritage to the Minister for Aboriginal Affairs (Victoria).

Registered Aboriginal parties will advise on the cultural significance of heritage places/objects, participate in heritage investigations and assessment processes, evaluate and endorse Aboriginal Cultural Heritage Management Plans and permits, and negotiate any Cultural Heritage Agreements. Under the *Aboriginal Heritage Act 2006*, a range of measures will be introduced to improve compliance and enforcement or penalties will be increased.

The Act builds upon the Regional Cultural Heritage Program established by AAV as a resource agency to advise on a range of planning, development and cultural heritage management. This program was staffed by Indigenous people with expertise in cultural heritage matters. Existing arrangements for the Regional Cultural Heritage Program will be wound up when the *Aboriginal Heritage Act 2006* is fully enacted. Inspectors will be employed under Part 3 of the *Public Administration Act 2004* and appointed by the Victorian Aboriginal Heritage Council.

The *Planning and Environment Act 1987* also applies to Aboriginal cultural heritage values including Planning scheme overlays (e.g. Kow Swamp is protected by a heritage overlay under the Campaspe Planning scheme). The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* also applies to Indigenous cultural heritage.

Management of Indigenous Cultural Heritage Sites

Aboriginal cultural heritage places are frequently fragile and may be disturbed or destroyed as a result of numerous activities and natural processes, including timber harvesting, controlled burns and bushfires, grazing, road building, sand extraction, channel construction, bardy grub collection, trail-bike riding, camping, pest management, water and wind erosion. The survival of living sites, such as scarred trees, has been affected by fires, land clearing and timber harvesting over the last 150 years. In places where timber harvesting and land clearing have been minimal, a substantial number of scarred trees remain.

Public Land

Within the study area, reservation of public land has been undertaken in order to specifically or exclusively protect Indigenous cultural heritage at Bumbang Island Historic Area (LCC 1989a) and in 2005 the Wallpolla Island Archaeological and Natural Interest Reserve was declared under the *Forests Act 1958*. A committee of management has been formed to manage the latter forest reserve located in the western area of the existing Wallpolla Island State Forest. The committee consists of a partnership between Government agencies and Indigenous communities. Bucks Sandhill in Barmah forest is currently covered by a Declaration of Preservation enacted under provisions of Part II A of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (declared in 2001).

The Yorta Yorta Co-operative Management Agreement between the Yorta Yorta Nation Aboriginal Corporation and the State of Victoria, provides for traditional owners to have a voice in natural and cultural resource management within the public land of Barmah Forest, Kow Swamp water supply reserve, lower Goulburn State Forest and other designated areas. This management arrangement is discussed in greater detail in chapter 6.

In other places throughout Victoria and the River Red Gum Forests study area, specific Indigenous management bodies have acquired land—through various arrangements—to serve specific community needs such as housing and welfare (e.g. Mungabareena Aboriginal Corporation centre, Wodonga; Rumbalara Aboriginal Co-operative, Mooroopna). The land tenure and management arrangements in both Victoria and other states are described in chapter 6.

NON-INDIGENOUS CULTURAL HERITAGE

Sites of European historic significance are located throughout the study area and largely relate to the major historic themes identified in chapter 7 such as exploration and settlement, transport, water supply, and industries such as timber harvesting and agricultural development.

Significant periods of change—such as closer settlement

Figure 12.2 Aboriginal mound fenced and sign-posted at Nyah State Forest.

Figure 12.3 Big Lizzie, on display at Barclay Square, Red Cliffs.

and agricultural development—are closely linked to the establishment of transport and water irrigation infrastructure throughout the study area. Early European settlement is often described in waves associated with pastoralism, gold mining, selection and agricultural developments in closer settlements with intensive farming linked to Government funded irrigation schemes.

Timber harvesting has a history within the study area. Paddle-steamers, plying the rivers, used large quantities of wood in their boilers and stacks of wood were maintained for use on the banks. Logging of the red gum forests began in earnest in the 1860s and by 1877 all suitable timber in Barmah Forest and along the Murray bank was cut back for an average of 2 miles (3.2 km) and partly or entirely worked, sometimes for a second time (Fahey 1987). Forestry records indicate that areas were cut depending on size and age of the stand and, in some areas regeneration events were noted (King 1963). The timber was exported to England for building wharf piles and much of the timber from near Mathoura and Deniliquin in New South Wales was exported to India, for railway construction (Mulham 1994). It was also used extensively in Victoria for railway sleepers, mine supports, bridge culverts, for wharf and jetty construction and most of Melbourne's streets were paved with red gum bricks until the 1960s (Lawrence et al. 1979).

Some cultural heritage objects or artefacts can be relocated without compromising cultural heritage values. For example, Big Lizzie constructed in 1917, is on display at Barclay Square, Red Cliffs as a monument to technology and design development. Its dreadnought wheel was designed to overcome the difficulties experienced with clearing sandy soils and outback conditions (Figure 12.3).

Protection and Management of European Cultural Heritage

Heritage Site Documentation and Lists

Sites and places of cultural heritage are recorded on many lists and registers, although none of these are comprehensive. At the same time, many lists and registers overlap but generally have a confined scope such as sites of national or state significance, or those of natural or historic values. Such registers include the following:

- Register of the National Estate, now maintained by the Australian Heritage Council, is a record of more than 13,000 places of natural, Indigenous and historic places throughout Australia.
- Sites of outstanding national heritage value listed on the National Heritage List are protected under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. These places are selected by the federal Minister for Environment and Heritage, protected by Australian laws and managed under special agreements with state or territory governments and with private land owners. Examples of such places are the Sydney Opera House, Budj Bim National Heritage Landscape (Tyrendarra, Mt Eccles-Lake Condah areas) and the Royal Exhibition Building (Melbourne).
- Places of state significance are listed in the Victorian Heritage Register which is maintained by the Victorian Heritage Council. This register is available to the public and may be searched on the internet. The register includes a range of significant places and objects including extensive land areas, gardens and trees, and archaeological sites.
- Historic archaeological sites and relics are documented on the Heritage Inventory maintained by Heritage Victoria (DSE). Sites listed are protected under the provisions of the *Heritage Act 1995*.
- Historic places on public land are listed in the Historic Places database (DSE).
- Sites of local or regional significance may be listed in a local municipal planning scheme and protected under provisions of the *Planning and Environment Act 1987*.

Sites older than 50 years may be recorded on the Heritage Inventory and those of state significance are recorded and assessed in greater detail for inclusion on the Victorian Heritage Register. This includes both those sites that have been included on a register of cultural heritage places, relics and objects, and those previously unknown sites uncovered during excavations or works.

Sites are identified and then listed on the Heritage Inventory or Victorian Heritage Register. Those sites identified on the Victorian Heritage Register within the River Red Gum Forests study area are listed in Table 12.1. Management of cultural heritage sites is undertaken in a manner consistent with the Victorian Heritage Strategy 2000–2005 (Heritage Victoria 2000).

Identification of Sites and Survey Coverage

In addition to the resources described above for highly significant sites, many local municipal councils have conducted cultural heritage investigations, largely focussed on specific sites, townships and historic buildings or local or regional significance. Examples include Greater Shepparton Heritage study (Allom Lovell & Associates 2003), Indigo Shire Heritage study (Peter Freeman and Associates 2005), and the Mallee Area Review—Study of Historic Sites (Andrew C. Ward and Associates 1986). These studies typically identify historic places and recommend conservation actions to land managers. This information supports decisions made in regard to municipal planning schemes and overlays.

Historic Places section (DSE) has surveyed extant historic gold mining sites on public land across Victoria. Such sites vary in terms of the nature of materials and state of preservation and include mine workings, industrial machinery such as batteries, and habitation sites. However there are some major cultural themes that lack representation on the lists and registers and have not been systematically surveyed within the study area (i.e. forestry, and water management). As part of the assessment of public land values throughout the study area, VEAC will review available cultural heritage information, and where necessary, fieldwork and survey will be undertaken to fill any data gaps revealed.

The National Trust of Australia (Victoria) is a not-for-profit community organisation that owns and operates several historic buildings and museums throughout Victoria and maintains a register of sites. Sites listed on the National Trust Register provide an indication that the community values the attributes present, but does not afford any legal protection. The Trust has compiled a vast body of information since it was established in 1956, and is a strong advocate for nominating and protecting historic places on government registers.

Legislation

In Victoria, the *Victorian Heritage Act 1995* protects all non-Aboriginal archaeological sites older than 50 years. Anyone who damages or excavates an archaeological site without obtaining the appropriate permission, faces a penalty under the Act. Legal recognition and protection under this Act encompasses a range of places, objects, precincts or landscapes, gardens and trees, and archaeological sites. Specific protection measures apply to places listed on the Victorian Heritage Register.

The *Planning and Environment Act 1987* contains provisions for local municipalities to govern cultural heritage values through provisions of planning schemes and overlays. An example is a heritage overlay, or design and development overlay that informs decision making by local councils in response to planning applications and permits.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* is administered by the federal Department of Environment and Heritage which implements programs and legislation to protect and conserve Australia's cultural and natural heritage.

Historic places on reserved Crown land are also recognised under the land management objectives and provisions of relevant acts. A number of historic sites and places are currently within parks and reserves and state forest throughout the study area and are protected under the provisions of each relevant act (see section below).

The Burra Charter

Both Indigenous and non-Indigenous historic and cultural heritage places on public land are managed in accordance with principles of the Burra Charter of Australia ICOMOS (International Council on Monuments and Sites) 1999 which provides principles for the protection and conservation of cultural heritage places and sets a national standard for best practice adopted by many heritage organisations. The Charter can be applied to all types of places of cultural significance including natural, Indigenous and historic places with cultural values. The Charter embodies seven basic tenets:

- Recognise that the place is important
- Understand the significance of the place
- Understand the fabric
- Let significance guide decisions
- Do as much as possible and as little as necessary
- Keep records
- Do everything in a logical order.

In general the principles embodied by the Charter are to manage and conserve sites of cultural significance *in situ* where possible with minimal intervention, alteration or disturbance. The degree to which this can be achieved, and to which management and conservation activities impact with cultural heritage values, is largely dependent upon the type of values present, such as rarity, age, condition, integrity, significance, and aesthetic values. In this context, conservation means that the values or meaning of a site are retained.

Public Land

Many historic places or sites of cultural heritage significance are located on public land and typically those with the most outstanding values are within Crown land reserves. Some sites such as historic buildings may remain as functional institutions and entertain current community use. A number of land status and zoning mechanisms are applied to sites associated with European cultural heritage as described below.

Previous studies of public land in the study area have identified a number of historic places. The Land Conservation Council's 1997 special investigation into historic places across south-western Victoria overlaps slightly with the current River Red Gum Forests study area. In that study eleven historic sites of state significance were identified, as well as a range of other significant and notable historic places on public land. Other LCC studies undertaken as part of the North Central Investigation (LCC 1981a) and Mallee Review (LCC 1989a) identified a number of historic sites (Jacobs Lewis Vines & Architects and Conservation Planners 1979; Andrew C. Ward and Associates 1986). As a consequence, reserves were established to protect places with highly significant historical values that were not within other permanent reserves or parks.

National Parks

National Heritage Park is a relatively new public land category recommended by the ECC in the 2001 Box Ironbark Forests and Woodlands Investigation Final Report. The category was developed to recognise the outstanding and largely intact cultural heritage values present in the Castlemaine area from the gold mining era, whilst recognising that the natural values present did not warrant national park status. The Castlemaine Diggings National Heritage Park is reserved under the *Crown Land (Reserves) Act 1978* and listed under schedule 4 of the *National Parks Act* 1975. This park is the largest protected non-Indigenous cultural landscape in Australia and is registered on both the Victorian

Heritage Register and the National Heritage List. Places on the list are protected under the provisions of the EPBC Act 1999.

Historic and Cultural Features Reserves

As described in chapter 9 Public Land Use Categories and Management, areas of historic significance within the study area have been reserved and protected using existing legislation. These historic sites are reserved under the *Crown Land (Reserves) Act 1978* for protection of the identified historical values. Typically these reserves are small, often containing a single building or group of structures, or remains of structures (e.g. Murchison Waterworks Trust Historic Area, 1 ha). However, some reserves may be more extensive such as Kinipanial Creek Historic Area (61 ha) and Bumbang Island Historic Area (639 ha).

State Forest Historic Sites

In state forest, known historic places are listed in Department of Sustainability and Environment (DSE) forest management plans or regional inventories. In 2002 there were over 1400 historic places recorded in state forests throughout Victoria (DSE 2005h). Typically sites within state forests relate to resource use and include timber mills, railways, cattle muster yards, campsites and buildings. Statewide management procedures for Timber Harvesting Operations (DSE 2005h) apply management procedures for protection of historic heritage values. There are also requirements to protect historic places in the Code of Forest Practice and the Code of Practice for Fire Management. Forest management plans specify management actions designed to protect each site from potentially damaging processes. Significant sites are also protected through forest management prescriptions or heritage management plans. Prescriptions may include buffers, which exclude various activities within a specified area, and filter strips, in which machinery entry and felling of trees may be only be permitted in certain circumstances and under specified conditions.

Information on the location and significance of historic places is incorporated into annual forest management operational plans including the Wood Utilisation Plans, fuel-reduction burning plans and road management plans. Conservation management plans for historic places, or groups of places, may also be developed for the most significant or vulnerable sites. These plans document the cultural heritage significance of the place and make recommendations that will ensure the place is conserved to protect and enhance its identified values. An example of such a site is the Barmah muster yards located at Goose Neck, in Barmah State Forest, or Murray's timber mill in Echuca.

New sites discovered in the course of forest management activities or as the result of further research are documented and assessed by DSE.

Table 12.1 Historic places list of sites of state or regional significance for public land in the study area.

HP No	Site Name	Significance
2969	Condidorio's Bridge	State
119	Echuca Courthouse	State
1626	Lake Hattah Regulator	State
1671	No 1 Flying Boat Repair Depot	State
1552	Pumping Station	State
140	Rochester Shire Hall	State
1711	Yelta Railway Station	State
3592	Dockendorff and Heach's Boorhaman Sawmill	Regional
1705	Lock 9 Lockmasters Residence & Former Post Office	Regional
1574	Locomotive Depot	Regional
6509	Porepunkah Area	Regional
1672	Railway Storage Shed	Regional
1674	Tresco Main Pumping Station	Regional

Source: DSE July 2006.

13 Primary Production

Although primary production in the River Red Gum Forests study area is largely conducted on private land it exerts considerable influence on the economy, community and environment of the whole study area. This chapter therefore, provides an overview of primary production in the study area before focusing on grazing and beekeeping which are the predominant primary production uses on public land.

IRRIGATED AND DRYLAND AGRICULTURE

Both irrigated and dryland agriculture are major forms of primary production and are the dominant land uses in the study area region[1] and across much of the Murray-Darling Basin (MDB) as a whole. The Murray-Darling Basin accounts for one third by value of Australia's agricultural output, and the value of agricultural produce from the Murray-Darling Basin now exceeds $10 billion per year (MDBC 2002). As one of the most agriculturally intensive parts of the Murray-Darling Basin the area along the River Murray and its tributaries contributes substantially to this output.

Irrigated agriculture replaces or supplements rainfall with water from another source in order to produce crops and pastures. The water may be sourced from groundwater, irrigation systems and channels or recycled and re-used irrigation water and wastewater. The scale of irrigation production in the study area is largely due to the land development and settlement policies of Victorian governments over a century and a half. These policies resulted in closer land settlement patterns as well as the development of large-scale water supply infrastructure systems, as discussed in chapters 7 and 15. This use of water for irrigation purposes has major implications for environmental values across the study area, particularly on public land.

The total value of all primary production across the Mallee, Loddon, Goulburn and Ovens–Murray statistical local government areas is in the vicinity of $3.5 billion: approximately $1.3 billion for Mallee, $400 million for Loddon, $1.5 billion for Goulburn and $253 million for Ovens–Murray. Most of this revenue comes from irrigation-based production such as fresh and dried fruit, wine grapes, dairy products and fodder for stock. Map 13.1 shows the distribution of various types of irrigated and dryland agriculture around the study area. Output from irrigated agriculture in revenue and products are expected to increase in the future (GBCMA 2003), primarily due to improved irrigation efficiency and a shift of water resources from irrigated grazing to higher value activities such as horticulture. For example, in north central Victoria horticulture expanded on average 6.3 percent per annum between 1997 and 2001 (NCCMA 2003). Similar trends are evident in the Mildura and Shepparton irrigation regions of Victoria (GBCMA 2003, MCMA 2003a).

Dryland agriculture occurs where agricultural production is based solely on natural rainfall and the resulting soil moisture availability. This form of agriculture is more susceptible to climate variation. Dryland agriculture consists mainly of grain and oilseed cropping as well as livestock production—mostly sheep (for wool and meat) and beef cattle. Like irrigated agriculture, dryland agriculture is an important industry in the study area through its contribution to regional economies and the Victorian economy as a whole, with a total value of approximately $1.5 billion.

A key difference between irrigated and dryland agriculture is the much higher value of production per hectare of land used under irrigated agriculture. A brief description of irrigation and dryland agricultural industries follows.

Livestock Production

Northern Victoria is one of the three major livestock production areas in Victoria and beef-, sheep- and pig-meat production are all significant. Production is for both export and domestic markets. The major beef and sheep-meat producing areas are illustrated in Map 13.2. The value of these industries, including egg production and pig-meat production to the regional economy is $8.7 million per year.

Livestock production is conducted on both irrigated and dryland production systems. Dryland livestock production is more prominent in the north east part of the study area where rainfall is higher (DPI 2006b). In dryland areas sheep-meat production is often preferred over beef because sheep offer additional benefits of wool production and more effective grazing of cereal stubble. Sheep-meat production is therefore more prominent around the grain producing areas of north-western Victoria.

Other livestock activities situated close to the study area include poultry and goat meat production (DPI 2006b).

Dairying

The dairying industry is one of the major agricultural industries adjoining the study area, particularly in the irrigated areas around Kerang, Echuca and Shepparton (as shown in Map 13.3). Victoria dominates the Australian dairy industry producing approximately 6.4 billion litres of milk. The total value of dairying for the statistical local government areas linked to the study area is $5.38 million per year.

Cropping

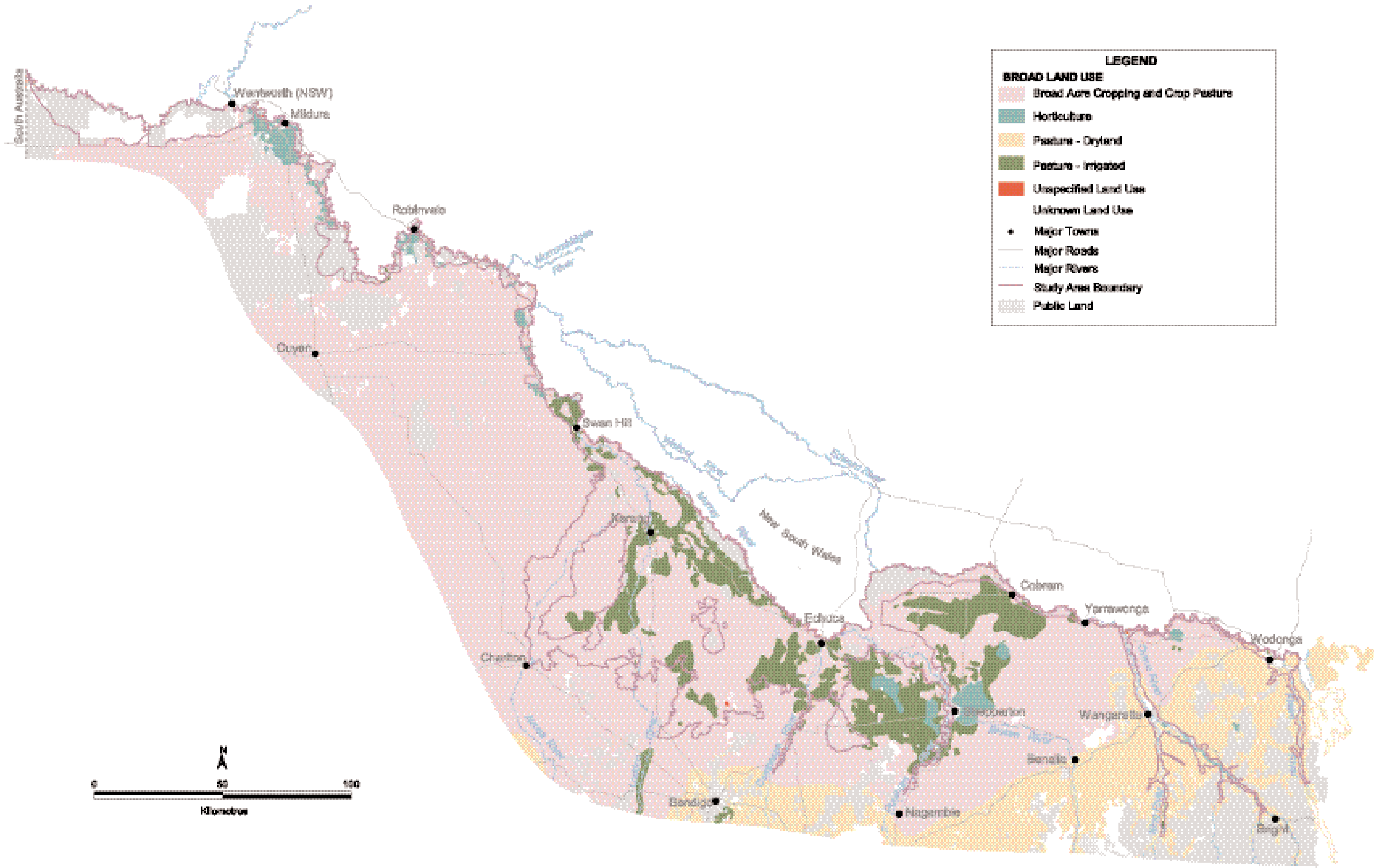
Cropping includes the production of hard grains (such as wheat, barley and oil seeds) and fodder but not horticulture. It may be based on irrigation or dryland production techniques.

Cereals

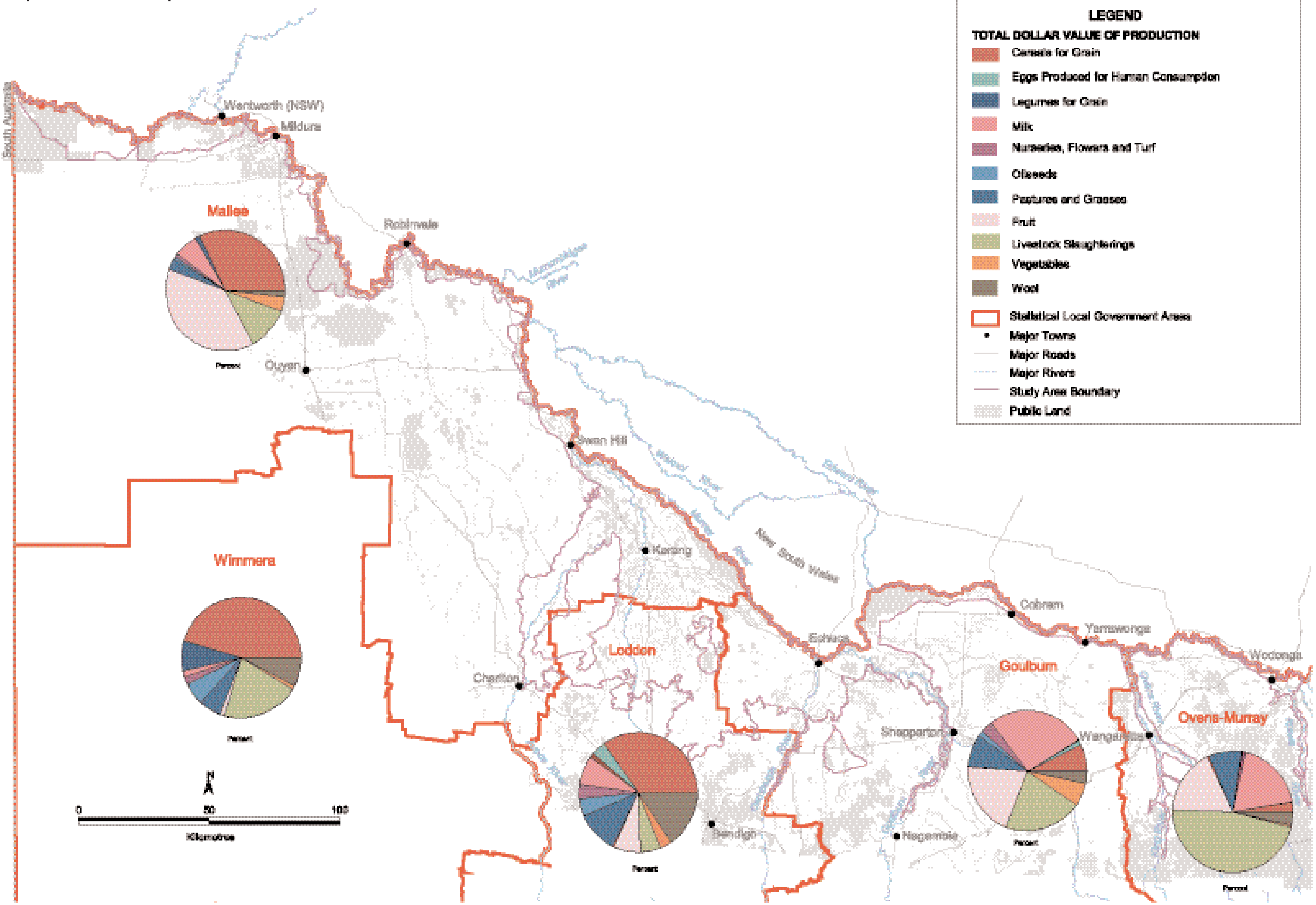
Cereal production, including all grains, legumes and oilseeds is a significant industry for Victoria. Cereal grains are predominantly found around the central and western part of the study area region as shown on Maps 13.1 and 13.2 above. For example, in the Mallee region

1 Note: Agricultural land-use is not a major activity on public land in the study area. However the information regarding agriculture on private land is important to provide some context for the Investigation. To provide some spatial context for the overview of agriculture the area under discussion will be referred to as "study area region".

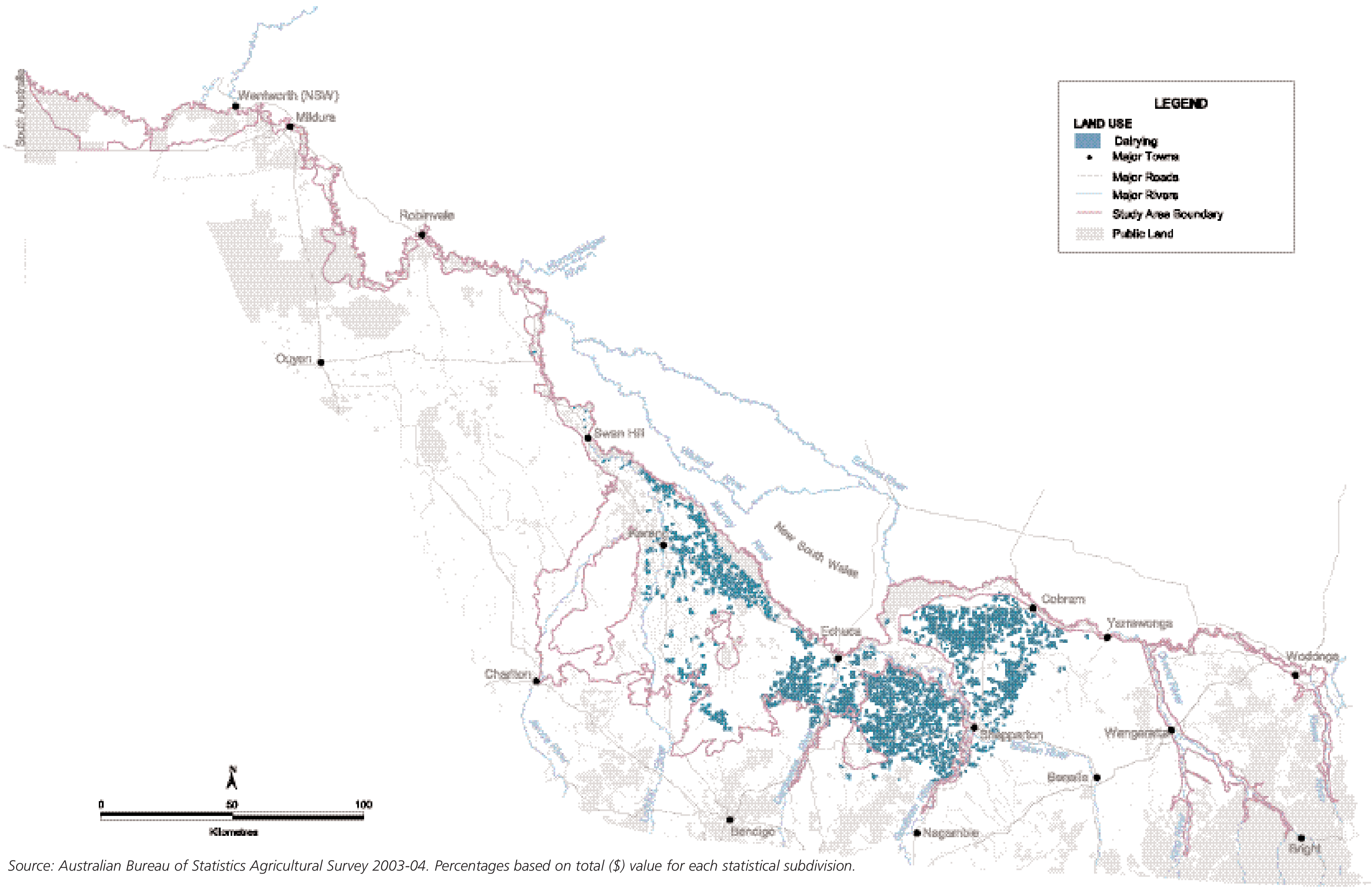
Map 13.1 Broad acre cropping and irrigation land uses.



Map 13.2 Total value production across commodities.



Map 13.3 Dairying areas in proximity to the study area.



Source: Australian Bureau of Statistics Agricultural Survey 2003-04. Percentages based on total ($) value for each statistical subdivision.

cereal production was worth more than $3.9 million in 2003–04.

Major grains produced in the vicinity of the study area are wheat, barley and oats. In most cases these grains are produced under dryland conditions and are therefore most vulnerable to climate variation such as drought and waterlogging. Other grains produced include nitrogen-fixing plants such as field peas, lentils, faba beans, chickpeas and lupins. Production of these grains is often dependent on irrigation.

Oilseeds such as canola and sunflowers are other important crops produced in the study area, albeit not as much as the cereal grains. Oilseeds may be produced through dryland or irrigation techniques and supply both the domestic and export markets.

Rice is also produced in the central part of the study area, abutting the large rice production area of the New South Wales Riverina. Rice growing is totally dependent on irrigation.

All cereals are produced for both the domestic and export markets and for both stockfeed and human consumption.

Hay

Hay production, particularly lucerne, clover and pea straw-based hay under irrigation, is an increasingly important industry for both the export and domestic markets (GBCMA 2003). Straw hay is also sourced through the harvesting of cereal crop stubble such as wheat, oats and barley. This hay is largely used on the domestic market, particularly in the horse industry. Pastures and grasses, including hay production had a value of $2.13 million across the four statistical local government areas in 2003–04.

Horticulture

Fruit

Fruit production is the largest horticultural industry in Victoria and, in 2002–03, had a market value of $966 million. Fruit in the study area is predominantly produced around the Goulburn Valley and near Swan Hill and Mildura, as illustrated in Map 13.1 and 13.2. Major fruits produced in the Goulburn Valley region are pears, apples and stone fruits such as peaches, nectarines, plums, cherries and apricots (GBCMA 2003). In 2002–03 stone fruit production from this area was worth $137 million. Because of the concentration of fruit producers in the Goulburn Valley, the region also supports Victoria's largest cannery.

Citrus production is another major fruit crop with production mainly concentrated around the Robinvale–Mildura and Cobram regions of Victoria. Production is for both the fresh fruit and juice markets and for domestic and export markets.

Grape production is also a major fruit crop industry. Grapes are sold fresh (table grapes) or used to produce wine (see below) or dried fruit as shown in Table 13.1. Table grapes make up 43 percent of all Victoria's fresh fruit exports at a value of $65 million per year (DPI 2006a). Most of these grapes are sourced from the Mildura region, as are dried fruits such as raisins and sultanas.

All fruit production is dependent on irrigation for its production and is for either the domestic food processing industry or for the domestic and export fresh fruit markets.

Vegetables

Vegetable production is second to fruit production as a major horticultural industry and its relative value across the four statistical local government areas is shown in Map 13.2. This map also illustrates the concentrations of horticulture around Shepparton, Swan Hill and Mildura regions. The major products by volume include tomatoes and asparagus (GBCMA 2003; DPI 2006b).

Other Horticulture

Several other horticultural crops are produced in the study area. Some, including olives, strawberries, kiwi fruit, avocadoes, mushrooms, potatoes and nuts such as almonds and walnuts, have the potential to expand in terms of production area and income dollars (GBCMA 2003; DPI 2006b). These crops are also dependent on irrigation and are produced for both the export and domestic markets, including the Victorian food processing market (GBCMA 2003).

Finally, cut flowers such as proteas have recently been grown commercially in some parts of the study area. These are for both domestic and export sales. When vegetables and other horticulture such as nurseries, flowers and turf are included horticulture across the area has a value of approximately $220 million per year.

Table 13.1 Yields and value of grape production around Victoria.

DPI agricultural production zone	Total area in grape production (ha)	Wine grape production (t)	Dried and table grape production (t)	Total grape production (t)	Estimated value of wine grapes
North-west	25,098	224,322	122,221	346,543	$132.0 m
North-east	3514	22,430	172	22,601	$23.3 m
Central	3,798	15,072	345	15,418	$19.2 m
Other	5874	20,615	231	20,856	$36.0 m
Total	**38,284**	**282,439**	**122,970**	**405,409**	**$208.5 m**

Source: DPI (2006b).

Wine

Several of Victoria's major wine producing areas are located in proximity to the study area, including areas in central and north-eastern Victoria and the Sunraysia in the northwest. Due to the diversity of conditions such as soil types, rainfall, sunlight hours, aspect and frost frequency across these regions different wines are produced using different production techniques. For example, some wineries concentrate on small-scale, labour-intensive, low-volume, high-quality products to service the boutique wine outlets. Other wine-making techniques are highly capital intensive and concentrate on high volumes for the supermarket-type wine market. Often this form of production involves sourcing grapes through annual contract arrangements with growers rather than through grapes being produced on-site by the wine producers themselves. In 2003, the northwest region of Victoria produced 66 percent of all wine grapes in Victoria (Table 13.1). The wine industry services both the export and domestic markets.

PUBLIC LAND STOCK GRAZING

The history of public land grazing within the study area is closely aligned with the development and expansion of European settlement across Victoria. Initially, the region was occupied by squatters grazing sheep and cattle on their runs, followed by consolidation into pre-emptive rights (for the squatters) and large selections. From the 1840s, at least one squatter regularly drove sheep from southern Victoria to the Moira grass plains of Barmah forest for the summer months (Curr 1883). Gradually grazing was brought under government control and licences or land holdings were issued (see chapter 7).

Over time a preference for cattle grazing became established on much of the river red gum forest and floodplain areas, although downstream of about Swan Hill sheep grazing is more common. Most cattle on public land are beef cattle but the widespread establishment of irrigated dairy farms in many areas—mostly between about 1920 and 1970—has lead to some public land grazing by dairy cattle, particularly along water frontages in the irrigation districts.

Grazing on floodplain river red gum public land has been an additional or alternative source of forage for livestock, provides access to water and management flexibility on private holdings, and reduces the need for fencing. However, with changes in emphasis and improvements in land management over time, the overall economic importance of stock grazing on public land has declined and few graziers depend substantially on public land.

Despite its declining economic importance, public land grazing remains an important cultural tradition for many people, with a history of some 150 years. This tradition is epitomised at the Barmah Muster. Each autumn cattle agisted in Barmah forest over the preceding year are mustered. Since the 1950s the Muster weekend has become a festival and celebration of cattlemen which attracts many visitors, particularly for the associated social activities that include a bush dance and story telling (yarn spinning) competition.

In the decades after the arrival of European stock, grazing probably occurred on nearly all public land in the study area, amounting to several hundred thousand hectares at that time. Currently, the area of public land in the study area authorised for grazing by domestic stock is around 117,000 ha (see Map C) although there is a number of qualifications to this figure (see below). The vast majority of grazing occurs on state forest, the River Murray Reserve and public land water frontages. Other areas grazed include some streamside and other natural features reserves, unused government roads, unreserved Crown land, Barmah State Park, and some land held by public authorities, such as Goulburn Murray Water. National parks, state parks, nature conservation reserves and reference areas are the only public land categories for which stock grazing is specifically excluded as a general rule.

Grazing of domestic stock on public land was addressed in detail in two major LCC investigations that overlap with the River Red Gum Forests study area: the Murray Valley Area (LCC 1985) and the Mallee Area Review (LCC 1989a). The LCC (1985) stated that where public land is managed for the maintenance and enhancement of ecosystems, domestic stock grazing is inappropriate and the land manager should take all steps practicable to exclude it. Recommendations described some areas with high natural values where grazing should be excluded, while the administration and conditions for continuation of grazing in Barmah State Forest and Gunbower State Forest were also outlined. The Murray Valley Final Recommendations (1985) also recommended that domestic stock grazing be phased out of Barmah State Park no later than three years after acceptance of the recommendations because of its incompatibility with the objectives of a state park. This recommendation was accepted by government but following Parliamentary debate on the *National Parks (Amendment) Bill 1987*, specific provision was made for grazing in Barmah State Park. Grazing in Barmah State Park is discussed in greater detail in Box 13.1 below.

Following the Mallee Review Final Recommendations (LCC 1989a), stock grazing was removed from parks and many reserves in the Mallee study area, but permitted to continue on other public land (including the floodplain forests) at the discretion of the land manager and subject to a management plan. However, the LCC (1989a) also recommended that no areas of state forest beyond those licensed at that time should be used for domestic stock grazing. The government accepted these recommendations.

A key step in the implementation of these recommendations has been the preparation of Forest Management Area (FMA) plans. Under the Mid-Murray FMA Plan (DNRE 2002a), grazing management strategies were to be developed by May 2003 for sites with high conservation values and priority areas such as those along parts of the Goulburn and Ovens Rivers which are Victorian Heritage Rivers (LCC 1991). These strategies are still being developed, although details of conditions and principles established by the Department of Sustainability and Environment (DSE) for grazing management are described in more detail below.

The Mildura FMA plan (DSE 2004f) has general management guidelines for grazing activities which emphasise the maintenance or enhancement of natural ecosystems. The plan allows grazing land management plans to be prepared in consultation with the licence holder for each licensed area on the floodplain. Initially, priority was given to areas over 1000 ha with plans to be developed by August 2005. A review of grazing within special protection zones, ephemeral wetlands and carpet python special management zone are also described in the plan. The Mildura FMA plan also recognises the need for research into tactical grazing on floodplain state forests for management purposes (such as through limited agistment permits) and annual vegetation monitoring using photo points to monitor grazing pressure.

The LCC Rivers & Streams Special Investigation Final Recommendations (LCC 1991) for public land water frontages replaced all equivalent earlier LCC recommendations, envisaging an integrated system of habitat networks along water frontages. Grazing under licence by adjoining landholders was to be allowed only where it did not conflict with: conserving native flora and fauna, maintaining and restoring indigenous vegetation, protecting adjoining land from erosion and providing for flood passage, protecting scenic quality of the landscape, protecting cultural heritage features, and providing access for recreation.

Administrative Arrangements

Domestic stock grazing on public land is authorised and managed under (1) Crown land licences (most areas), (2) agistment permits (Barmah forest and, until recently, parts of Gunbower forest), and (3) commercial arrangements set up by public authorities over land for which they hold title. Terms such as 'licensed grazing' or 'grazing licences' are commonly used—including throughout this Discussion Paper—to encompass all three of these arrangements collectively. Note that there is no public land leased for grazing in the study area (and little elsewhere in Victoria for that matter). Leases are generally for longer terms and provide additional entitlements (often greater exclusivity of access for people as well as stock) than the arrangements for grazing that currently apply in the study area.

Crown land licences have three components: a schedule describing the licence area and details about the licensee; a map showing the extent of the licence area; and standard licence conditions including fees, duration (typically one year), maintenance, fire protection works and other requirements. Licences usually specify allowable stock numbers and requirements for control of stock and pest plants and animals. Crown land licences currently cover approximately 75,000 ha—with large licences over state forest and some regional parks (about 400 licences with an average size of approximately 140 ha), and small licences over public land water frontages (1200 licences, 10 ha average) and unused roads (30 licences, 3 ha average). Usually these licences do not overlap—that is, only one licensee's stock grazes in each licence area (however public access remains unaffected). Water frontage and unused road licences are nearly always held by adjoining land owners, who manage the grazing as part of their overall grazing operation. These areas are often used, for example, to hold temporarily or transfer stock, to provide water, or to maintain usage rights over the area. Many licence areas are not fenced, although in recent years some Catchment Management Authorities have overseen successful programs to fence many water frontages (see chapter 19). In circumstances like these a licensee may agree to implement conservation related-conditions (i.e. fencing and revegetation programs), and even convert to a non-productive licence under Section 138 of the Land Act 1958 at a significantly reduced fee (e.g. $1 per year) compared to the productive agricultural licence rate.

Grazing conducted under Crown land licence is charged according to the carrying capacity of the land, expressed as 'dry sheep equivalents' (see Glossary). This applies to public land water frontages, unused government roads and unreserved Crown land. Licences over unused roads for agricultural use are generally annual but can be issued for up to 99 years. They may be cancelled if conditions are not met or the road is required for traffic purposes.

Some licences over state forest and regional park share characteristics with Crown land licences but many are much more intermittent, with licensees changing and licences frequently lapsing and resuming. Recently some licences for state forest grazing have been reviewed and offered for a ten-year period in conjunction with a customised grazing management plan developed in partnership with the licensee. Under these agreements, grazing timing and intensity may be modified or excluded from specific areas to conserve or protect important environmental or cultural values.

Grazing under agistment permits occurs in Barmah forest and, until recently at least, in parts of Gunbower forest (and there are other areas where land managers have the discretion to issue agistment permits). Currently and historically, agistment permits generally apply to a specified time period and number of head of stock and cover relatively large areas of land, often with stock from more than one grazier. Specific details of current agistment permit grazing in Barmah Forest are provided in Box 13.1.

Control of pest plants and animals is the responsibility of the licensee on areas held under licence as described in the licence conditions. In state forests, this includes the prohibition of feeding out unless specifically approved by the DSE forest manager. Agistment permits do not require pest plant and animal control to be undertaken by the permit holder.

Legislation

State forest grazing is permitted under Section 52(1)(a) of the *Forests Act 1958* and management guidelines under forest management plans (DNRE 2001, 2002a; DSE 2004f). On public land water frontages, some regional parks, unreserved Crown land, unused Government roads, and some land reserved under the *Crown Land (Reserves) Act 1978*, grazing is conducted as an agricultural activity under Sections 130 and 133 of the *Land Act 1958* and is largely restricted to the owners or managers of adjoining private land. Section 32E of the *National Parks Act 1975* provides for grazing in Barmah State Park, although no relevant licences have been issued under that Act. The grazing that occurs there administered under the *Forests Act 1958* (see Box 13.1). At least partly because of the difficulty in maintaining fencing in the flood-prone public lands along the major rivers in the study area, it is not uncommon for grazing to be authorised under one Act to spread onto adjoining land where that authority does not permit grazing—most frequently along the numerous long boundaries between the River Murray Reserve and adjoining state forest. The River Murray Reserve (Natural Features Reserve) is managed by Parks Victoria to protect a range of natural and cultural values. Grazing is only permitted where it is compatible with such values. It is administered by the land managers in association with adjoining DSE public land: under the provisions of the *Land Act 1958* consistent with public water frontage licence arrangements in the Mildura FMA; and under the *Forests Act 1958* in the Mid-Murray FMA; and under both arrangements in the North East FMA.

Some areas of public water frontage and other public land abutting the Ovens and Goulburn Rivers, which are within a Victorian Heritage River overlay (LCC 1991) are held under grazing licences for both public land water frontages and state forest. Also, the Victorian portions of the Barmah–Millewa, Gunbower, Koondrook–Perricoota and Chowilla Floodplain (Lindsay–Wallpolla) Living Murray significant assets (see chapter 15) are also partially or wholly held under public land grazing tenures.

Controlled sheep grazing for ecological outcomes is utilised at Terrick Terrick National Park and other land containing northern plains grasslands purchased for nature conservation reserves on the Patho Plains area. Intermittent, adaptive and seasonal grazing at low stocking rates has maintained conservation and habitat values present prior to the acquisition of this land (Diez & Foreman 1996; Tscharke 2001). This grazing pattern largely reflects past grazing practices in these areas. Grazing is in accordance with guidelines that are reviewed every three years and subject to future research outcomes (Parks Victoria 2004b). A particular emphasis is on maintaining habitat structure for the plains-wanderer—a threatened bird species. Future research will inform and guide the use of grazing, ecological burning or other management tools to enhance the

Box 13.1 Barmah Forest Grazing

Cattle are grazed in Barmah forest except in reference areas (300 ha) —29,660 ha comprising Barmah State Forest (21,600 ha) and Barmah State Park (8360 ha) under agistment permits issued under the *Forests Act 1958*. Grazing within most of Barmah State Park may be licensed under Section 32E of the *National Parks Act 1975* with annual licences issued for terms commencing 1 May. However, even though grazing is allowed to occur in the park, because no licences have been issued for the park under the *National Parks Act 1975*, current grazing is technically unauthorised there.

Cattle agistment is restricted to members of either the Barmah Forest Cattlemen's Association (grazing the west end) or the Yielima Forest Grazier's Association (the Yielima or east end). Currently there are 31 and 7 owners respectively in each organisation.

A Barmah Forest Grazing Advisory Committee, which predated the park, currently comprises three representatives from DSE, one from Parks Victoria, and four representatives from the cattlemen's associations (three from Barmah and one from Yielima associations). Following inspection of the forest, the committee makes a recommendation to DSE North East Regional Director and Parks Victoria Central Regional Manager on stocking numbers for each of the summer (1 November to 30 April) and winter (1 May to 31 October) terms. Once the stock numbers are decided by both DSE and Parks Victoria, the Cattlemen's associations allocate quotas to individual members for each section of the forest.

In the past stock numbers have been varied according to seasonal conditions in the forest and the occurrence of 'rain-rejection' floods (see chapter 15 Water Resource Use and Environmental Flows) which, even in dry conditions, occur as a result of the need to transmit large volumes of water downstream at short notice. An average indication of stocking rates is about 2000 head of cattle in the summer term and about 800 head in the winter term, although there has been an overall reduction in number with the persistent dry conditions recent years.

The current fees (set by the Valuer General in 2003) for grazing under existing agistment arrangements in Barmah forest are $14.08 per steer for the summer term and $10.12 for the winter term (including GST). While this value may be less than that commercially charged elsewhere—depending upon seasonal conditions and location—there are significant costs in terms of time and logistics expended in association with agistment, especially transportation and mustering and maintaining facilities. Land managers also have significant grazing related management costs that typically exceed the revenue generated though agistment fees.

Note: *The National Parks Act 1975* specifies that grazing in Barmah State Park involve a Barmah Forest Grazing Advisory Committee appointed by the Minister for Environment, advising the Minister on various matters relating to grazing in the park. Under the Act, the committee has eight members of whom:

(a) One is appointed convenor;
(b) Three are nominated by the Barmah Forest Cattlemen's Association;
(c) One is nominated by the Yielima Forest Grazier's Association;
(d) Three are officers of the [former] Department of Natural Resources and Environment

Although it has not been formally appointed for the park, the existing Barmah Forest Grazing Advisory Committee operates in the spirit of Section 32 of the *National Parks Act 1975*.

grassland values on these sites. Unlike grazing on other public land, grazing in the Terrick Terrick National Park and Patho Plains nature conservation reserves is strictly for ecological purposes. It is administered through short-term contracts rather than under licence.

Overall Extent of Grazing

In total, there are some 1790 licences held by around 1425 licensees (many of whom hold more than one licence), and covering approximately 117,000 ha (see Map C), however this overall impression of public land grazing must be qualified by the following variables:

- Changes in stocking rates. While many licence details include a stocking rate, that does not mean that stock are maintained at that level at all times—indeed there will be times (in some cases more or less permanently) when there are no stock on all or part of many licence areas, even though the licences remain current. In addition, there are permanent 'exceptions' such as the two reference areas in Barmah forest which, although shown in Map C as not subject to grazing licences, are poorly fenced from the surrounding forest. Barmah Lake, by contrast, is shown in Map C as licensed for grazing but is only grazed on its margin because it is permanently inundated.
- Types of licences. DSE issues licences for many activities on public land other than grazing, and it is not always clear whether grazing is permitted or not—when the licence is for 'non-primary producers', for instance. VEAC has categorised these licences as accurately as possible in consultation with DSE.
- Turnover and intermission. While the majority of grazing licences have been continually renewed for long periods, occasionally licences are not renewed, are modified to exclude grazing (see below), or new licences are granted. More significantly, some licences are issued for relatively short periods and renewed or not at the discretion of land managers in response to seasonal conditions or for particular management purposes such as to reduce adverse impacts or pest plant control. The most notable example of intermittent grazing is Gunbower State Forest, much of which was grazed until about five years ago, when permits were not renewed—largely to reduce the impact of prolonged below-average rainfall and flooding. Grazing could, however, be reinstated in the future.

DSE Grazing Licence Review Program

DSE advises that a review of grazing practices and licences is currently being undertaken in some of the designated priority areas described in the Mid-Murray FMA Plan (DNRE 2002a), not including Barmah forest, triggered by applications for renewal or transfer of individual grazing licences. The review process is guided by a set of 'Ecological Grazing Principles'. The Principles are:

- That grazing management in the river red gum forest estate will be based on sound scientific data and rationale to optimise biodiversity benefits and environmental outcomes.
- To utilise grazing as an ecological management tool to achieve biodiversity benefits and to restrict adverse changes in the floodplain forest environment.
- The grazing of stock should assist in the consolidation and recruitment of native plant species by helping to maintain or shift the vegetation composition to the EVC benchmark.
- Grazing livestock selection should be based on the stock type that will facilitate the intended ecological outcomes.
- Stocking rate adjustments for grazing livestock need to be based on Ecosystem condition.
- Appropriately timed rest and graze periods can be used to protect and enhance ecological attributes.
- Vulnerable ecological and cultural attributes can be protected by the appropriate management or exclusion of grazing herbivores.
- Supplementary feeding and watering of stock has the potential to increase the risk of negative environmental outcomes.
- That all grazing herbivores impact on ecosystem condition regardless of whether they are introduced or native.
- Total grazing pressure can reduce or eliminate the seed store of shrub and understorey plant communities necessitating action to restore or rehabilitate these areas.

Exclusion of grazing through fencing has occurred in other non-priority areas reviewed during routine licence renewal or transfer. Stock grazing has been removed from three sites following a review utilising these principles and an ecologically-based grazing management regime has been trialled at a fourth site on the Lower Goulburn in consultation with the licensee.

Management of Grazing on Public Land

It is important to note that throughout much of the study area there is no physical barrier between public land of different tenure e.g. Barmah State Park and Barmah State Forest, other state forests and the River Murray Reserve. In many cases it is impractical and costly to fence on a floodplain, particularly given the length of the River Murray Reserve frontage. Frequent flooding and the associated large debris damage fences. Where fencing has been erected on floodplains, such as those fences within Barmah forest, maintenance costs are met by the land manager and not the licensee or agistor. However, unrestricted stock access to the water's edge has significant effects on water quality in particular (DNRE 2002h). Catchment Management Authorities and land managers are undertaking projects to revegetate and fence along stream frontages and install off-stream watering points for stock (DNRE 2002h; MCMA 2003b; NCCMA 2003; GBCMA 2004; NECMA 2004). The fenced areas provide limited or seasonal grazing along the river's edge in the riparian zone.

A major impediment to fencing riparian land is the additional cost of fencing and installing alternative stock watering points. Investigations undertaken by CMAs into catchment health and riparian grazing practices indicates that fenced stream frontages were in significantly better environmental health than those unfenced, reflecting a reduced level of grazing pressure and reduced rates of land and water degradation (e.g. Robinson & Mann 1998).

In addition, overseas studies have shown that cattle growth rates or weight gain was up to 20 percent greater for animals drinking from a piped water source compared to those allowed unrestricted access to a water hole or stream bed (Kondinin Group 1996; Water and Rivers Commission 2000; Landerfeld & Bettinger 2002). These results reflect the lower volume of water consumed by stock when it is polluted or muddied, which in turns relates to a reduced level of production. Initial fencing and stock water point installation costs are likely to be recovered through increased production, in addition to the ongoing environmental benefits and preservation of infrastructure damaged by stream bank erosion.

Unlike some other economic activities undertaken on public land (e.g. timber harvesting), the revenue generated from public land grazing is returned to the state through consolidated revenue.

Livestock grazing is sometimes promoted as a management tool with the ability to reduce the ground vegetation component of wildfire fine fuel and provide a measure of fire protection. Grazing has not been identified or used as a primary broad-scale fuel management tool under the Mildura or Bendigo fire protection plans but may be used as a short-term method for fuel reduction where the effect on conservation values is minimal (DCNR 1992; DSE 2003f). Additionally, because livestock have preferences for specific vegetation types including native grasses, relatively intense grazing would need to occur for this to be an effective fire control measure. Unpalatable species and woody material remain, both of which can contribute to the intensity of wildfires (DSE 2004f). Grazing intensities required to significantly reduce fuel would be likely to result in adverse biodiversity impacts.

Grazing may compromise natural values and can result in habitat loss or modification, introduction and spread of exotic plants and inhibition of native vegetation establishment and growth (particularly river red gums and other seedlings—see chapter 5). Damage to wetlands has also been demonstrated to affect habitat values for animals such as frogs and birds (Jansen & Healey 2003; Jansen & Robertson 2005). Livestock grazing may also adversely affect on flora, fauna, soil structure and water quality (Robertson & Rowling 2000; Spooner et al. 2002; Jansen & Healey 2003; Dorrough et al. 2004; Jansen & Robertson 2005). Grazing may reduce capacity for riparian zone vegetation to act as a nutrient 'filter' by compacting the soil, increasing erosion and sediment input into waterways. These effects are strongest where grazing is continuous (DSE 2004f). The study area as a whole is an environmentally sensitive location encompassing riparian zones, wetlands and floodplain forests. Most public land grazing in the study area is close to waterways and wetlands. These waterways play a vital role not only in biological systems but also in sustaining agriculture and potable water for rural communities.

Fencing (particularly on floodplains) presents logistical difficulties for land managers as does governance and administration, and the ability of land managers to control overgrazing, stocking rates and potential breaches of licence conditions, while maintaining public access. To date there has been little consistency in management of grazing on public land across Victoria, either administratively or environmentally. The diversity of grazing practices and ecological values across such a broad area has made consistency difficult. In many places Crown land, in particular water frontages and unused roads, has been used as part of the adjoining private enterprise with limited assessment of its impact on natural or ecological values.

A consistent approach to grazing across all public land would provide a clear framework for deciding where it is appropriate for grazing on public land, the economic value of grazing a public resource and equitable fee rates comparable across all available land use categories. These matters are discussed further in chapter 19.

APICULTURE

Apiculture based on the introduced European honeybee (*Apis mellifera*) dates from the early days of European settlement in Victoria. When flowering prolifically, the indigenous eucalypt species found in the River Red Gum Forests study area are keenly sought by beekeepers, and orchards and pastures on nearby private land also have a significant role in the apiculture industry (and vice versa). Flowering of river red gum and black box trees is largely dependent on suitable flooding so, although these species produce high quality honey, significant production is relatively sporadic. Yellow and grey box trees also produce premium honey, although they are not as abundant in the study area.

As well as honey, beekeepers sell pollen, beeswax and queen bees, and are paid by farmers to enhance pollination—and hence productivity—of some pastures and orchards, especially almonds. For both these purposes, beekeepers leave appropriate numbers of hives at locations on private land for bees to access orchards, pastures, or native forests (including those on adjacent public land), as well as on designated public land bee sites for bees to access native forests. There is evidence that bees forage as far as 20 km from their hives (Schwarz & Hurst 1997), although beekeepers report that most bees range no further than a kilometre or two. There are two types of public land bee sites:

- permanent sites, which are licensed for 12 months and have a radius of 1.6 km (i.e. there must be at least 3.2 km between adjacent permanent sites); and
- temporary sites, which are licensed for 6 months and have a radius of 0.8 km.

As part of the implementation of the ECC (2001) Box-Ironbark recommendations and in response to the expansion of the Murray Valley almond industry, an 'Apiculture on Public Land Liaison Group' has been established by DSE. This group provides a forum for representatives of the apiculture industry, DSE, Parks Victoria and DPI to discuss relevant issues and developments as they emerge.

Beekeeping is generally permitted in most public land categories. Reference areas and wilderness areas and zones are the only categories in which bee sites are not permitted at all, although they are also excluded from other public land within two kilometres of these areas.

There are currently six reference areas and no wilderness areas or zones in the River Red Gum Forests study area (Map A). Some people have suggested that—as a commercial venture based on an invasive species with potential to adversely affect natural values (see below)—beekeeping is not an appropriate activity to allow in national parks. In practice, there are very few Victorian national parks suitable for apiculture from which beekeeping is excluded. Map C shows that bee sites are widely distributed on public land in the study area. There are 237 public land bee sites in the River Red Gum Forests study area (Map C), constituting just over 10 percent of the total number of bee sites on public land in Victoria.

Beekeepers are highly mobile, often moving large numbers of hives considerable distances—including interstate—to capitalise on favourable flowering events and to avoid frosts. In addition to full-time commercial apiarists, there are many part-time and non-commercial beekeepers who are not accounted for in official statistics. Although they own relatively few hives per beekeeper, they account for a large number in total. As a result regional data on beekeeping must be interpreted with caution.

Apiculture is worth approximately $10 million per year to the Victorian economy (Centre for International Economics 2005). On the basis that 10 percent of Victorian public land sites are in the study area, it is estimated that apiculture in the study area is worth around $1 million. The ECC (2001) estimated that the 600 or so bee sites on Box-Ironbark public land generated 79 full-time equivalent jobs. The 237 River Red Gum Forests bee sites, then, would be expected to account for around 30 full-time equivalent jobs, although many of these would be based outside the study area.

Apart from seasonal vagaries, apiculture is a reasonably stable industry in Victoria—product demand remains high, and the distribution of bee sites in most favourable native forest areas is at or close to capacity. The expansion of some agricultural enterprises requiring pollination by bees—most notably almond orchards in northwest Victoria—has increased demand for this service. Another issue for apiarists is the relatively recent arrival in Australia of the South African small hive beetle (*Aethina tumida)* which can severely diminish production. The pest does poorly in drier areas and, to date at least, has occurred only occurred sporadically in northern Victoria peripheral to its main distribution in coastal areas to the northeast.

As its name suggests, the European honeybee is an exotic species in Australia. Of the hundreds of exotic species that have established feral populations around the world, very few have (when studied) been found to not have an impact on natural values. It would be surprising, then, if European honeybees did not have an impact on natural pollination systems in Australia. However, studies of the effects of honeybees on natural pollination systems have had difficulty obtaining unambiguous results, largely because of the technical difficulties in excluding or introducing honeybees in a way that does not disrupt other significant plant-pollinator interactions. Feral honeybees also occupy tree hollows, potentially to the detriment of some of the large number of hollow-dependent fauna for which river red gum forests are noted. While carefully managed hives may be unlikely to be a source of feral bees, this is less likely to be the case for hives managed by part-time or non-professional apiarists. The presence of managed hives also constrains options for feral bee control. Honeybees can also have localised impacts on recreational values. The potential impacts of honeybees on natural values are discussed in more detail in chapter 5.

14 State Forest Management and Wood Production

The river red gum forests have been a major source of durable timbers in southeastern Australia since the earliest days of European settlement. While production has decreased over time, Victorian public land forests remain a major source of timber. The extent and nature of the forests varies across the study area, as does their management and the level of information about them. This chapter reviews the history, management and sustainability of timber production from forests in the study area.

While most of the original ecosystems of the broad alluvial plains of northern Victoria have been cleared or extensively altered since European settlement, most of the original river red gum forests (principally Ecological Vegetation Classes (EVCs) such as Riverine Grassy Woodland, Riverine Sedgy Forest and Riverine Swamp Forest—see chapter 5) remain across the floodplains. Regularly flooded land was generally considered unsuitable for conventional agriculture. The Barmah–Millewa Forest, covering about 60,000 ha, comprises the most extensive and consolidated occurrence of river red gum forest in Australia. Gunbower Forest and the contiguous Perricoota and Koondrook Forests in New South Wales comprise the next largest. Further downstream, river red gum forests occupy regularly flooded bends in the River Murray or are restricted to narrow bands along the river itself. Along the lower reaches of the Murray in Victoria, river red gum occurs as a band of about one-tree depth above the regular water line of the river, with black box of similar depth above that and chenopod shrubland as the surrounding vegetation type (Figure 14.1).

Figure 14.1 The lower reaches of the River Murray in Victoria where the band of river red gums is about one-tree depth above the regular water line. Saltbush shrubland occurs in the foreground, black box in the middle-ground and river red gum on the near bank of the river.

The primary commercial use for these forests is timber production, the history, management and sustainability of which is explored in this chapter. River red gum is now the only species available for commercial harvesting from public land in the River Red Gum Forests study area.

RIVER RED GUM TIMBER CHARACTERISTICS AND HISTORY

River Red Gum Timber Characteristics and Productivity

The ecology of river red gums has been described in chapter 5. In relation to timber production, river red gums have a number of salient characteristics. Seasoned river red gum is relatively hard (9.7 kN on the Janka test) and moderately dense (900 kg/m^3). River red gum has been structurally graded to F22-F27 indicating its high structural capacity (Australian Hardwood Network 2006). The wood is highly durable (Durability Class 2), particularly in the ground. It is resistant to white ants and borers and, when mature, fairly resistant to ship-worm (Ewart 1925; Forest Commission of Victoria 1928) however the sapwood is vulnerable to lyctid borers.

The interlocking grain and hardness of river red gum can make it difficult to cut and dress. Warping can occur during drying due to the timbers' moderate to high shrinkage rate (approximately 4 percent radially and 8.9 percent tangentially). Drying and seasoning of the timber is therefore a slow process and weighting the stacks may be necessary to prevent warping. River red gum has a low strength rating with an unseasoned strength rating of S5 and a seasoned rating of SD5 and a medium to light toughness rating (Australian Hardwood Network 2006).

River red gum has many uses including farm fences, posts and poles and for heavy construction (such as railway sleepers, beams, bridges, stumps, frames, sills, panels, flooring and lining). It is also used for particle board, plywood and veneer as well as firewood. Increasingly river red gums' rich vibrant colour and decorative grain when polished is appreciated for furniture and fine woodwork (Figure 14.2).

Figure 14.2 River red gum boardroom table in a furniture showroom.

River red gums can be tall (over 50 m), straight-boled trees when growing in relatively dense stands, but tend to branch with short bole lengths in open stands. Strong competition for soil moisture causes larger trees to develop a large 'zone of influence' within which they exclude smaller trees (Figure 14.3). Although seedlings do grow in the zone of influence, they are fewer in number and are less vigorous the closer they are to the mature tree. Such zones of influence seem to be larger on woodland and low quality forest sites than in higher quality forest sites. Larger trees with healthy vigorous crowns are the most competitive on any given site (Opie 1969; Florence 1996). This influence zone extends between 1.7 and 3 times the radius of the tree's crown, depending on the vigour of the tree and the availability of site resources (Bassett & White 2001).

Figure 14.3 Zone of influence where a larger tree reduces the number and vigour of smaller trees near it.

The quality of a river red gum forest for timber production depends on the frequency and timing of flooding. Although some stands may be accessing groundwater, the most productive stands are usually associated with floodways and depressions that are regularly flooded and reliably drained. Before river regulation, some 75 percent of the more productive areas received regular flooding for a few months in 7–8 years in 10 (MDBC 1992). River red gum regeneration on the floodplains of the study area is largely determined by flooding regimes. Recent low-level floods in some low-lying areas of Barmah Forest have fostered the survival of river red gum seedlings that normally would have suffered drought stress.

The productivity of river red gum forests has declined substantially, due partly to fewer and shorter winter–spring floods. This reduction results from the construction of the Hume Weir in the mid-1930s, the subsequent Eildon Weir across the Goulburn River and the Dartmouth Dam on the upper River Murray, as well as associated diversions for irrigation purposes (see chapter 15). These events may have increased the interval between successful forest regeneration events and reduced the growth rates of trees. Jacob (1955) noted that the average diameter increment of the better class trees prior to river regulation was said to be 0.76 cm per annum but, by 1983, growth rates of 0.25 cm per annum were recorded across a wide range of tree diameters (DNRE 2002a; Dexter & Poynter 2005).

Changed flood regimes may also be responsible for mortality in mature river red gums. Many floodplain forests, particularly downstream of Cohuna, are showing symptoms of stress, probably because of altered water regimes (see chapter 5). Pale-fruit ballart, a native root parasite, contributes to red gum deaths in stressed trees in the Gunbower and Nyah State Forests, where it may contribute to tree mortality (MDBC 2003). Water trapped behind weirs for irrigation and navigation and the low-level summer floods in the Barmah forest, have extended some swamplands and killed thousands of trees. Saline drainage water from farmland may also stress trees. Along the lower reaches of the River Murray, particularly downstream of Hattah–Kulkyne National Park but also as far upstream as Gunbower forest, several areas are exhibiting signs of stress that may be associated with salination.

A study into the causes and effects of the dieback of river red gums in northern Victoria and South Australia, under the auspices of the Murray-Darling Basin Commission in 2003, made the following statements on the causes of the observed health decline in river red gums:

- The observed symptoms are consistent with varying degrees of prolonged water stress, indicating a tree response to the significant change in flooding regime (i.e. flood frequency, duration and magnitude);
- Flooding has been insufficient to provide the additional water supply that is necessary for survival. Medium-sized flows in the lower River Murray have been reduced from an average frequency of once every three years, to an average frequency of once every eight years;
- The flooding regime was not sufficient to provide the leaching of salt from floodplain soils that counteracts the salt accumulation that occurs in the period between floods.

As well as reduced growth of river red gums, the effects of altered water regimes include changes to the understorey, replacing river red gum with box species at the margins, promoting crown die-back, limited regeneration and increased insect damage (Di Stefano 2002). Non-flooded areas are more susceptible to damage by the larvae of gum leaf skeletoniser moths because flooding and consequent high humidity facilitates the spread of an entomogenous fungus which, in turn, reduces predatory insects that would otherwise keep populations of gum leaf skeletoniser moths in check (see chapter 5).

River red gum is not particularly fire resistant. Although not killed by light fire, severe fire can kill pile-sized trees and cause dry sides on larger ones. Light fires mark trees, reducing the quality of the timber for saw milling.

When cut off at the base, river red gum trees coppice from the stump (Figure 14.4). Jacobs (1955) observed occasional river red gum trees of mill log size that he presumed were coppice shoots from the stumps of trees cut in the early days of the river trade. Coppice regrowth appears to be more prevalent within higher elevation stands where flooding is uncommon.

Figure 14.4 River red gum coppice.

History of Timber Production from the Study Area

Aboriginal people used the forests and woodlands of the region for shelter, implements and food, while early European settlers sought local building materials and fuelwood. As the intensity of settlement and the development of infrastructure increased, so too did demand for timber. Wood production and forestry has been a key industry in the history of river red gum forests (see chapter 7).

In the late 1800s and early 1900s, large quantities of round river red gum piles were used to underpin road and rail bridges around the state and the harbour wharves and piers of Melbourne and Geelong. River red gum was used for house stumps, road paving blocks, mining and fencing timbers and culverts, and to build the river steamers and barges that plied the River Murray. River red gum poles carried telegraph lines from the early 1900s and power transmission lines from about 1920. While used mostly for southeastern Australia's burgeoning infrastructure, significant volumes of the heavy timbers and railway sleepers were also exported, particularly to India (McGowan 1992).

During the 19th century much of the timber cut from the forests was hauled to the river's edge by bullock or horse teams (and, from the 1920s, by motor lorry) and then lashed to special barges and towed by paddle steamers to sawmills (Figure 14.5). Before locks and weirs were constructed, river transport was restricted to between July and December when the river was navigable. In places, canals called 'pontoon cuts', were constructed between shallow creeks so that logs could be floated out to the river bank on pontoons. Evidence of one of these canals (Figure 14.6) still survives today—for example, the canal known as the 'steamer track' through Barmah Lakes to Cutting Creek. Extension of the rail system caused considerable decline in river transport by the 1900s.

Figure 14.5 Loading wood on the River Murray.

Source: Reproduced with permission of the State Library Victoria (H25256).

The first sawmill based on river red gum timbers was established at Moama in 1856. Arbuthnot Sawmills was established at Koondrook in 1890 and is still operating. Of the 14 sawmills operating in the Barmah–Gunbower region at that time, 12 were located in Victoria, mostly on the riverbank to take advantage of wharf facilities (Dexter & Poynter 2005). Other mills were located at Swan Hill and Mildura. Echuca, with its port facilities and rail link to Melbourne, became the main centre for timber production in the central Murray region.

As well as being produced at the sawmills, railway sleepers were hewn with broadaxes 'at the stump' (in the forest). Records show that from only 1372 sleepers produced in 1898, output peaked at 190,000 pieces in the early 1930s (Dexter & Poynter 2005). Although hewing was economically wasteful, the Railways

Figure 14.6 Cutaway on the Goulburn River near Yambuna.

Department preferred hewn to sawn sleepers (Forest Commission of Victoria 1928), probably because hewers sought out straight-grained logs which were easier to hew, and consequently more predictable in use.

Other species associated with the river red gum forests—the riverine box species and cypress-pine—were also utilised, mainly for small poles, sleepers and fencing materials. Black box woodlands in the west supplied the developing irrigated horticultural areas with several hundred thousand pieces of fencing and vine-trellis timbers each year. For instance, extensive areas of black box woodland were felled on the upper river terraces in the vicinity of Cullulleraine, to feed the boiler of the Millewa irrigation system and little remains of these woodlands. Black box was also useful for carriage building, furniture and house building (Ewart 1925). Because it doesn't split, grey box was used for bridge and wharf decking, tool handles, carriage shafts and mauls (Ewart 1925). Cypress-pine timber is resistant to insects and easily worked and polished. It was used for flooring, wall linings, weatherboards and other joinery in buildings. A firewood mill operated at Picola between 1946 and 1950 and sent firewood to Melbourne by rail (Dexter & Poynter 2005).

The ready access from the river meant that the forests were heavily exploited with selective and uncontrolled cutting. Cutting continued even when the forests were flooded, with fellers standing on specially designed punts anchored either side of the tree (a practice leaving large stumps sometimes up to three metres high). Although official figures were not regularly published before 1890, the average annual consumption of Victorian river red gum in the late 1870s was said to total 48,000 cubic metres, of which 30,000 cubic metres was sawn timber.

Production increased during the Second World War when wood was also cut for charcoal to be used for gas production on vehicles and gas masks. In 1941, some 50–60 charcoal retorts were operating in the Barmah forest (Dexter & Poynter 2005). The post-war years saw a sharp increase in demand for posts and vine-trellis timbers for irrigation areas and building timbers for soldier settlements.

During the 1890–1900 depression, gangs of men were employed after harvesting to thin the 1870–1880 regrowth and ringbark competing larger trees that were unsuitable for sawlogs or sleepers. The aim of this work was to improve growth of sawlog-quality trees (Jacobs 1955). By 1928, more than 16,800 ha of river red gum forest had been thinned or ringbarked (Forest Commission of Victoria 1928). Similar silvicultural treatments were continued throughout the 1930–1940 depression (Figure 14.7) (Jacobs 1957; Lutze et al. 1999). The forest structure today is partly a result of that work but is also due to ongoing utilisation and silvicultural works, grazing by stock and rabbits, changed flood regimes, and fire.

Figure 14.7 Evidence of ringbarking of trees in the 1930–1940 depression is still evident today.

Forest Reservation and the 1897 Royal Commission

The first Parliament of Victoria met in November 1856. The *Land Act 1862* was Victoria's first legislation to create reserves for 'the growth and preservation of timber' to prevent their alienation (conversion to private ownership) and to provide for future timber supplies. The Act was strengthened in 1865 and, within a few years, more than 400,000 ha of land in the state had been set aside as permanent forest or timber reserves (by 1926 this had risen to more than 1,752,500 ha). Permanent dedication of 72,700 ha of river red gum forest was achieved in 1924.

While the Land Act reserved many of the more densely forested areas along the River Murray in Victoria, it offered little protection from exploitation other than from clearing for agriculture. A series of reports from the 1870s detailed ineffective management and waste of forest resources (McGowan 1992). Forests Bills were drafted regularly but were 'usually consigned to oblivion' (Forest Commission of Victoria 1928). A short Forests Act was put into operation in 1876. Bills were presented to Parliament in 1879, 1881 and 1892, but none was enacted, although a royalty system was adopted in 1892. The inaction eventuated in a Royal Commission on Forests, which sat from 1897 to 1901 and produced 14 reports. The Royal Commission drew attention to the anomaly of having the forests controlled and worked under laws primarily designed for the alienation and settlement of Crown lands. It reported that massive timber cutting was occurring under a 'vicious system of indiscriminate licensing' at ridiculously low prices (LCC 1987).

The Royal Commission reported that, if cutting of the river red gum forests was allowed to continue at the then existing rate, the remaining forests would be exhausted within five years. It also saw a need for thinning of large areas of heavily stocked (1870–1880s) regrowth. One outcome of the Commission was to break the monopoly of the portable steam-powered sawmills producing sawn sleepers and to permit sleeper-hewers into the forest to cut 'old and hollow' logs rejected by the sawmillers (Dexter & Poynter 2005).

Forest Administration

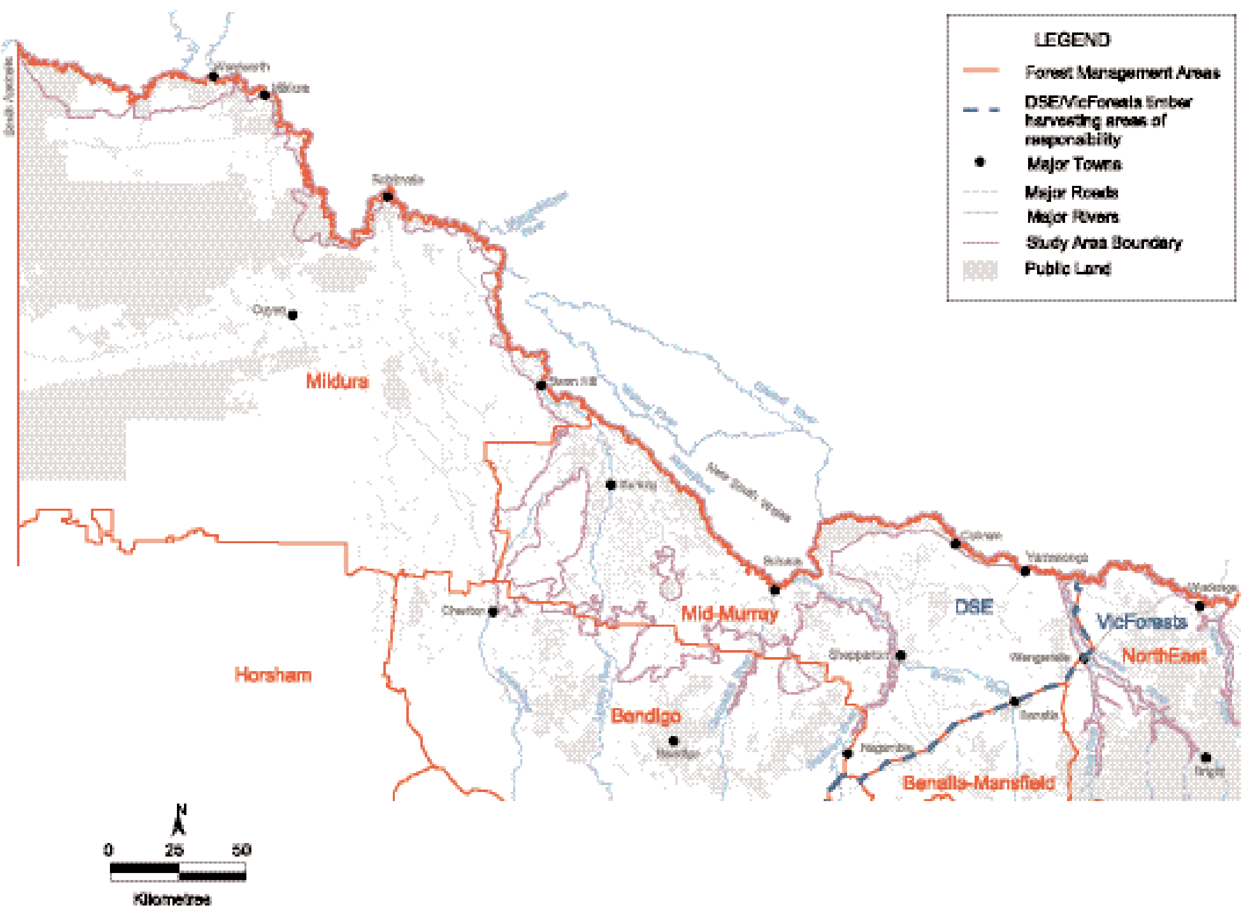
Between 1876 and 1908, administration of Victoria's forests shuttled eight times between three different state departments (Forest Commission of Victoria 1928). A Conservator of Forests had been appointed in 1888, but the position was administratively ineffective. The 1897–1901 Royal Commission led to the *Forests Act 1907*, which established a Forests Department under a Minister of Forests in 1908. It was not until 1919, with the establishment of a separate Forests Commission, that management stability was achieved (Gillespie & Wright 1993).

In 1984, the Forests Commission became part of the new Department of Conservation, Forests and Lands. Forest management was subsequently undertaken through divisions or services within the new department and its successors, now the Department of Sustainability and Environment (DSE).

In 2002, wide-ranging reforms were introduced to the management of Victoria's native forests through the government's policy statement *Our Forests Our Future* (Government of Victoria 2002). These reforms were directed towards a sustainable timber industry and the separation of land stewardship responsibilities from those of the commercial licensing and harvesting of logs.

As a consequence of this policy, and the *Sustainable*

Map 14.1 Forest Management Areas (FMAs) and areas of responsibility (DSE and VicForests) overlapping with the study area.



BOX 14.1 STATEWIDE FOREST RESOURCE INVENTORY

A Statewide Forest Resource Inventory (SFRI) was initiated in 1994–95 with the aim of mapping approximately 3.5 million ha of state forest in Victoria and sampling the timber productive areas to determine the volume of sawlogs they carry. The program was also structured to provide the necessary base data to enable development of new growth models for a number of forest types, thereby enhancing the capacity to forecast timber yields. Specifically, SFRI was designed to:

- update the state's timber resource data, replacing 1960-70s data with information independent of forest product standards;
- be the state's first complete forest resource inventory based on a single inventory design and standard;
- provide a consistent classification of all vegetation on public land across the state;
- enable new growth and yield models to be developed for many of the state's native forests;
- enable resource estimates to be made to a uniform standard of utilisation;
- have the capacity to adjust to new utilisation standards; and
- provide a basis for resource estimates, sustainable yield forecasts and management planning well into the 21st century.

Other products of the SFRI included:

- environmental data (slope, aspect, tree hollows) collected at each sample plot and digital elevation model information, that would be applicable for biodiversity and habitat modelling;
- information about disturbance of the forest stands by factors such as timber harvesting, fire and disease; and
- crown cover and crown form information, which could assist old-growth analyses for the purposes of Regional Forest Agreements.

Forests (Timber) Act 2004, responsibility for commercial timber harvesting in eastern Victorian state forests devolved to VicForests, a state-owned enterprise regulated under the *State Owned Enterprises Act1992*. VicForests' area of responsibility overlaps with those parts of the River Red Gum Forests study area in DSE's North East Forest Management Area (Map 14.1) but the 15-year allocation order issued in 2004 does not provide access to any river red gum forest stands. The *Sustainable Forests (Timber) (Amendment) Act 2006*, provides for DSE (i.e. not VicForests) to continue to manage commercial harvesting in western Victoria (i.e the rest of the River Red Gum Forests study area).

DSE remains the custodian of all Crown land, and is responsible for ensuring that all uses of the state's forests are sustainable. This includes managing the entire range of forest uses and values, including conservation of natural and cultural values, recreation and protecting forest ecosystems from wildfire, disease, pests and weeds, as well as managing forests for timber production. DSE also retains management and the licensing of a range of commercial activities other than timber harvesting, such as apiculture, as well as the sale of other wood products, including domestic firewood, throughout Victoria's state forests.

Map 14.2 shows the history of timber harvesting in the River Red Gum Forests study area, to the extent that it has been mapped to date.

Forest Inventory

The first assessment of the timber resources of Barmah forest was undertaken in 1929–30 and was directed at the preparation of a 'working plan' for the river red gum forests. That assessment identified relatively low volumes of trees of sawlog quality compared to the total merchantable volume, which included the volume in smaller trees—'growing stock' (Dexter & Poynter 2005).

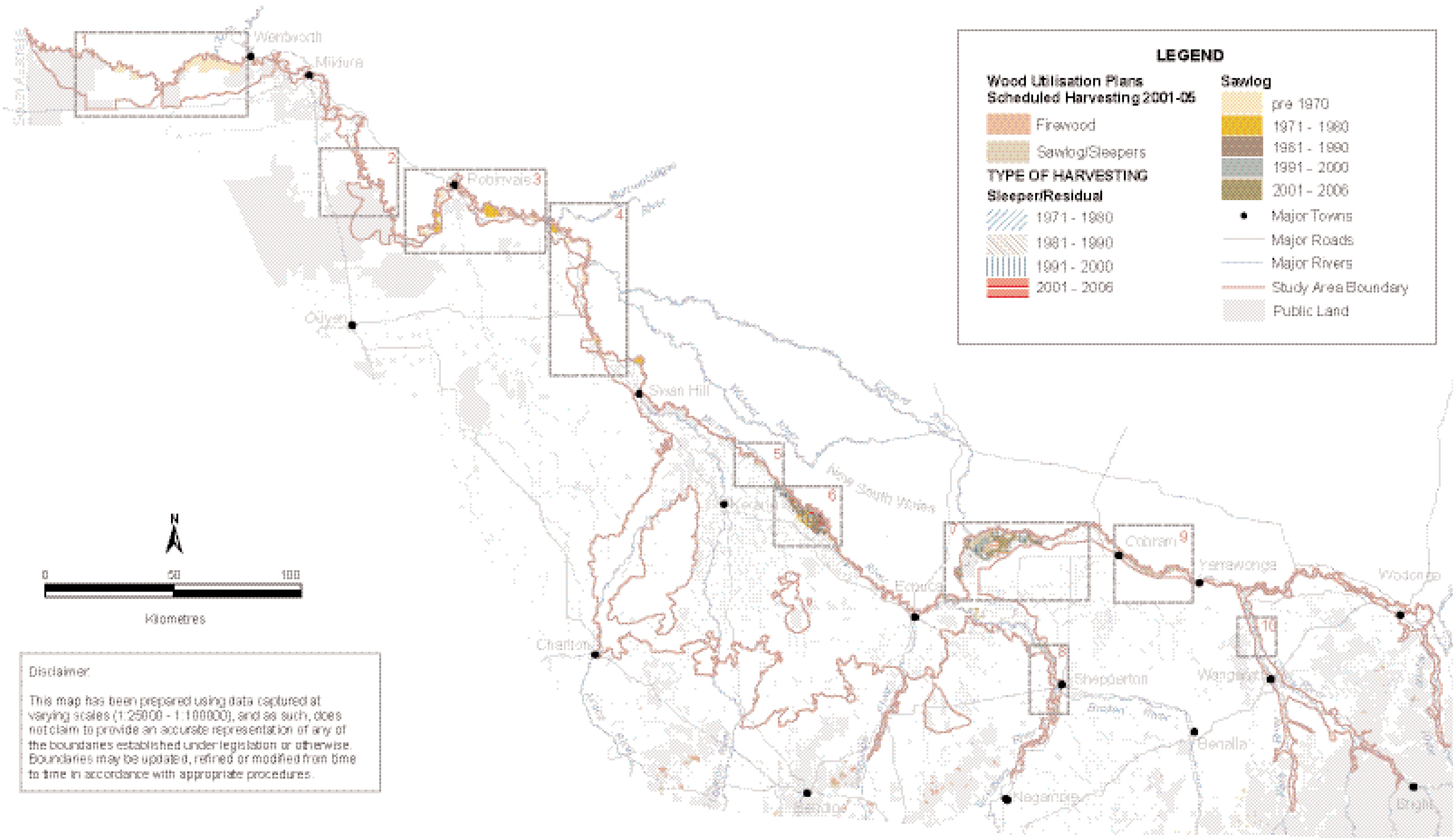
Mapping, classification and intensive assessment of stands in the Barmah forest in 1960–61 found a considerable increase in growing stock and total sawlog volume since the 1930s, notwithstanding that significant volumes had been harvested in the intervening period. Individual forest stands were allocated to one of three site quality classes (SQ) based on the height of the dominant mature trees (SQ I, > 30 m, highest quality; SQ II, 21–30 m, medium quality; SQ III, < 21 m, lowest quality). Site quality is a surrogate measure of the growth potential of a site, which is determined by the soil, climate and water.

During the late 1980s, assessments were again conducted in the Barmah forest as well as Gunbower forest and the larger areas of forest along the Goulburn River (Cuddy et al. 1993). Earlier assessments had covered the forests along the River Murray upstream of Barmah and along the Ovens River. The current legislated sawlog sustainable yield (see below) and permitted levels of harvesting of sleepers derive from these assessments.

Permanent Continuous Forest Inventory (CFI) sample plots enable systematic measurements of timber volumes and forest growth over time. Periodic measurement of trees in CFI plots in river red gum forests began in 1961. As this followed the completion of most major river regulation structures (with the exception of Dartmouth Dam), the initial data would reflect the reduced growth rates caused by the altered flooding regimes up to that time. Although there has been some subsequent measurement of many of the plots, there has been little if any systematic analysis of existing data, or systematic planning for future data collection.

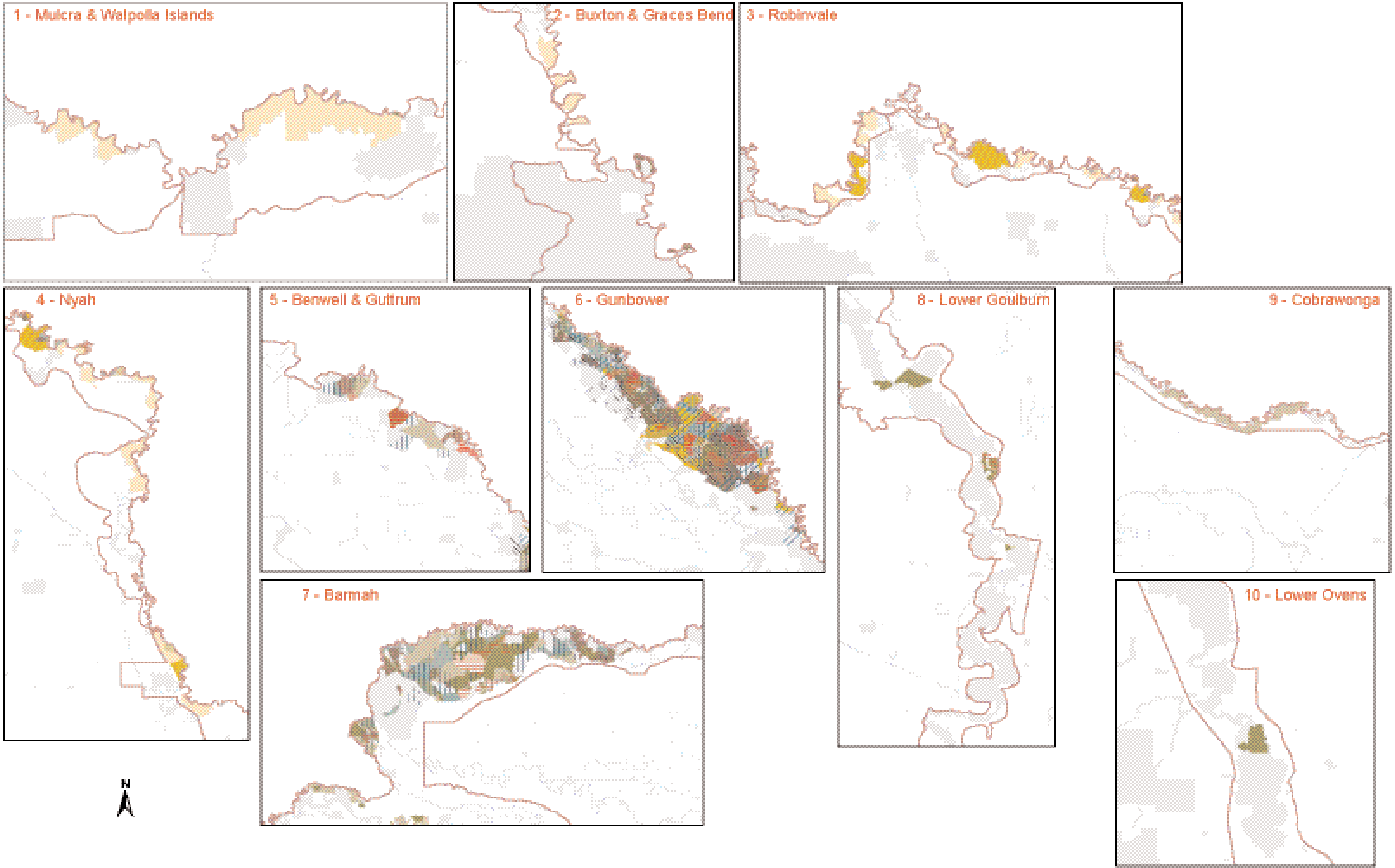
A Statewide Forest Resource Inventory (SFRI) program commenced in 1994 to provide the first systematic, comprehensive and standardised statement of Victoria's native forest resources. The SFRI used a consistent forest

Map 14.2 Logging history of the River Red Gum Forests study area.



Disclaimer

This map has been prepared using data captured at varying scales (1:25000 - 1:100000), and as such, does not claim to provide an accurate representation of any of the boundaries established under legislation or otherwise. Boundaries may be updated, refined or modified from time to time in accordance with appropriate procedures.



Source: DSE (2006b)

Notes: This map shows all relevant DSE digital mapping data as at September 2006, but is far from comprehensive as a depiction of the full extent of logging in the study area. Virtually no record was kept of the geographic extent of the early decades of logging, during which time nearly all forested areas are likely to have been logged to some extent—including such places as freehold land that has since returned to the public estate. Except for recent decades, mapping—and particularly digitising—have been patchy at best. Even in the recent decades shown here, mapping is not comprehensive. For example, DSE advises that—in addition to that shown on the map—there has been harvesting (1) at Mulcra and Walpolla Islands until at least 1990, (2) near Robinvale until 2000, (3) for sawlogs and sleepers over all of Benwell and Guttrum forests, and (4) along the lower Goulburn from 1990 to the present.

stand classification system across the state. Tree measurements were independent of the particular forest products that they may be able to produce, allowing for accurate volume estimation even if sawlog and other timber product specifications change. The inventory also included the collection of biodiversity information, such as numbers of tree hollows (see Box 14.1).

Mapping of the river red gum forests has been completed but it has not been used for strategic planning, to identify the relative sawlog productivity of stands or to forecast sustainable yield of wood products. Reallocation of priorities within DSE means that such inventory will be unlikely in the short term.

FOREST MANAGEMENT, PLANNING AND CONTROL

To facilitate management of its forest estate, Victoria is divided into three forest management regions (FMR). These regions—North East, Western and Gippsland—are further divided into 15 geographic regions, known as Forest Management Areas (FMAs). Forest Management Areas are defined under the *Forests (Timber Harvesting) Act 1990* as areal bases for determining sustainable yield of sawlogs. They are also used for planning the management of the forests. As shown in Map 14.1, the River Red Gum Forests study area encompasses appreciable parts of three FMAs—North East, Mid-Murray, and Mildura—and small parts (containing very little public land) of the Bendigo Forest Management Area.

A hierarchy of planning, set out as a flow chart in Appendix 13, exists for the management and control of forest operations in the state. The principal elements are described below.

Strategic Level

Code of Forest Practice for Timber Production

The Code of Forest Practice for Timber Production (DNRE 1996a) establishes goals, guidelines and minimum standards of environmental care to be observed during all commercial timber production activities in the state (including growing and harvesting of public and private native forests and softwood and hardwood plantations and associated roading operations).

Although public and private land in Victoria are governed by different legislation, the Code applies across both public and private forests and compliance with it is required under the *Sustainable Forests (Timber) Act 2004* and the Victorian Planning Provisions.

The Code's purpose is to ensure that these activities are carried out in a way that:

- promotes an internationally competitive forest industry;
- is compatible with the conservation of the wide range of environmental values;
- promotes ecologically sustainable management of native forests for continuous timber production.

The Code was last reviewed in 1996, with a commitment to undertake a review at least every 10 years. A full review of the Code is due for completion in 2006 (the public comment period for the draft revised Code closed in April 2006). As well as public consultation, the review will evaluate advances in forestry science, while considering community and industry expectations for an economically and ecologically sustainable timber industry.

Forest Management Plans

A forest management plan is the fundamental plan for the management of environmental, cultural and resource values of state forests within a region. It establishes broad strategies for integrating the sustainable production of timber and other uses with the conservation of natural, cultural and aesthetic values. A long-term goal of forest management is to sustainably manage all forest values, including the supply of wood. Accordingly, areas of state forest are allocated to one of three zones according to priorities in management for the range of intrinsic and community values and uses, including nature conservation and recreation as well as timber harvesting. The zones represent a hierarchy in the levels of protection:

- general management zone (GMZ)—managed for a range of features, with timber production a major use;
- special management zone (SMZ)—managed to conserve specific attributes (such as sites important for nature conservation, historical or archaeological artefacts or recreation sites), with timber production or other land use practices permitted although constrained or modified (rather than excluded) to avoid conflict with the maintenance of the attributes. This zone contributes to the conservation of important species, particularly fauna, as well as encompassing landscape and water management issues;
- special protection zone (SPZ)—managed for conservation and to minimise disturbances or processes that threaten the respective natural or cultural values, with timber production excluded.

Although the strategies set out in forest management plans apply only to state forest, they are framed in the context that conservation is integrated across all native forests on the permanent public land estate. As such, they are designed to build on and complement the protection provided by the system of dedicated conservation reserves established following studies into public land use by the Land Conservation Council and its successors (see chapter 10 Nature Conservation). Special

protection zones, for instance, complement formal reserves and contribute to the development of Australia's comprehensive, adequate and representative forest reserve system (Commonwealth of Australia 1992).

Forest management planning also considers other forest uses, including recreation and silviculture as well as the impact of grazing, water management and pest plants and animals on forest health. The plans provide guidelines for protecting and managing specific values or uses, such as protecting large old trees and promoting the development of maturing trees across the timber-productive forests, developing grazing strategies based on ecological requirements of the forest and the preparation of pest-control programs.

Public input is integral to the forest management planning process. Members from the community with particular interests in the area contribute to discussions on particular issues and assist in decision-making. Similar to the processes followed by VEAC, input is sought from the broader community from the outset of the planning process and comment is invited on discussion papers and draft plans.

Forest management plans for the respective Forest Management Areas that overlap the River Red Gum Forests study area have been completed. From the east these are:

- *Forest Management Plan for the North East* (2001)—the River Red Gum Forests study area encompasses only a relatively small portion of the total planning area, which covers the North East FMA (an operational amalgam of the Wangaratta FMA and the majority of the Wodonga FMA) and Benalla–Mansfield FMAs, and part of the Central FMA;
- *Forest Management Plan for the Mid-Murray Forest Management Area* (2002a); and
- *Forest Management Plan for the Floodplain State Forests of the Mildura Forest Management Area* (2004)—the Mildura FMA covers extensive areas of mallee and chenopod vegetation types which occur to the southwest of the floodplain state forests to which this plan is restricted; these floodplain state forests are entirely contained within the VEAC River Red Gum Forests study area.

Currently, the overwhelming majority of wood product harvesting, and especially sawlog and sleeper harvesting, occurs in the Mid-Murray FMA.

Operational Level

Management Procedures

The Code of Forest Practice provides for regional prescriptions for timber harvesting and associated activities in state forests. Previously, the regional prescriptions combined the requirements of the Code and strategic forest management plans and accounted for the ecological and growth characteristics of the particular forests found in each Forest Management Area. They were more detailed than the actions and guidelines set out in the forest management plans and provided practical, detailed operational instructions that were applicable at the Forest Management Area level.

In October 2005, the various regional prescriptions were consolidated into *Management Procedures for Timber Harvesting Operations and Associated Activities in State Forests in Victoria* (DSE 2005e) to facilitate consistent statewide implementation of environmental standards in all operational aspects of commercial timber harvesting.

The Management Procedures do not duplicate or replace either the Code or the relevant forest management plan and all three documents need to be considered together.

The objectives of the Management Procedures are to:

- provide detailed prescriptions for forest management activities for specific Forest Management Areas, as required by the Code;

- standardise, where appropriate, management prescriptions across the state;
- set out best practice at a state level;
- provide a comprehensive reference for use by DSE and VicForests staff involved in the planning, management, implementation and monitoring of timber harvesting operations and associated activities;
- prescribe minimum operational standards for VicForests.

The Management Procedures (DSE 2005e) require that the felling of trees to yield only products other than sawlogs and sleepers be permitted only:

- where sawlog productivity and stand health are not compromised;
- for silvicultural treatment;
- where required for seed collection purposes;
- where the trees are a safety risk; or
- for approved fence line clearance or track construction or maintenance.

Trees may also be felled for these products as a follow-up treatment to a sawlog operation.

Wood Utilisation Plans

Schedules of coupes selected for harvesting each year and associated access roading must be set out in Wood Utilisation Plans (prepared by DSE) or Timber Release Plans (prepared by VicForests). VicForests is not responsible for timber harvesting in the study area so Timber Release Plans are not discussed further.

Wood Utilisation Plans (WUPs) are prepared in accordance with the *Wood Utilisation Planning Guidelines for State Forests in Victoria* 2005. They are prepared by DSE annually, on a three-year rolling basis, for all commercial forest operations it manages (including where material is to be used locally by DSE, such as for bridge timbers). The three-year Wood Utilisation Plans provide detailed specifications for the first year and indicative specifications for the following two years. Harvesting of all wood products in the River Red Gum Forests study area is currently managed by DSE under these plans.

As well as commercial production areas, domestic firewood collection areas in which trees are to be felled with firewood as the only product (as occurs with stand thinning), must be identified in the respective plans. Such areas are identified in the Mildura and Mid-Murray Wood Utilisation Plans (DSE 2006e, f, g).

Preparation of these plans involves consideration of each proposed logging coupe individually to comply with the relevant forest management plan, the Code and related Management Procedures to conserve forest values (flora, fauna, landscape, cultural heritage, water, soil and recreation opportunities). Individual timber harvesting areas (coupes) must be selected on the basis that they contain the required quantities and mix of wood products that can be supplied using sound silvicultural practices and in consideration of all environmental care requirements. The plans must provide coupe details, maps and supporting information identifying the location and timing of harvesting and construction works and the silvicultural system to be applied.

Preparation of Wood Utilisation Plans involves public submissions on proposed operations and the final documents are available to the public.

Coupe Plans and Management of Coupes

Coupe plans must be prepared for every timber harvesting operation. Each coupe plan contains a map identifying the boundaries of the coupe, a schedule incorporating the specifications and harvesting conditions under which the operation is to be administered and controlled and other management requirements, such as habitat tree retention.

Prior to the commencement of harvesting the following must be accurately located on-site and clearly specified and recorded on the coupe plan or relevant site plan (DSE 2005e):

- all coupe boundaries;
- the location of all excluded areas;
- the location of filter strips and buffers;
- habitat tree requirements (these are also marked where required); and
- trees for retention and/or trees for removal.

DSE advice is that, in practice, an operating coupe in the river red gum forests is inspected at least twice a week and only those trees marked by the forest supervisor may be felled. A coupe is also inspected prior to the departure of the logging contractor to check that all marketable wood has been removed and for any breaches of boundaries or other conditions. Monitoring is also carried out some 18 to 24 months after harvesting is completed to assess the level of stocking of natural regrowth and the need for regeneration works.

Environmental Audits

An environmental audit system has operated in Victoria under the *Environment Protection Act 1970* (EP Act) since 1989. In 2002, the Environment Protection Authority (EPA) became responsible for conducting environmental audits of forest operations on public land to assess compliance of forestry activities with the Code of Forest Practice for Timber Production (Figure 14.8). In accordance with the *Environment Protection Act 1970*, audits are also required to identify 'the risk of any possible harm or detriment to the environment caused by forestry activities as may be assessed by adherence to current controls and operational compliance with the standards in the code' (EPA Victoria 2003b).

The 2003 audit of the 2002–03 timber-harvesting season was the first independent environmental audit of timber production on public land undertaken in Victoria. The independent auditor appointed by the EPA was supported by a team with expertise in forestry, ecology, soil science and engineering (EPA Victoria 2003a). Additional matters may also be referred to the auditor, such as the Special Forest Audit in 2005, which was directed at four logging incidents that occurred in 2004 and 2005 during harvesting operations in East Gippsland and the Mid-Murray FMA (EPA Victoria 2006). This audit found that "a substantial portion of a superb parrot Special Protection Zone has been selectively logged at coupe 105-509-0006 (Flanagans)" (EPA Victoria 2006) and determined that this breach had a number of causes. These included the accuracy and completeness of information held in the Coupe Information System, inadequacies in the coupe plans and modifications to the coupe boundaries without review (EPA Victoria 2006). Flooding prevented the audit team from inspecting the actual site but DSE reported that, although some of the trees in the 100-m SPZ were harvested, no habitat trees were affected by the operation. The audit noted that the DSE has instituted procedural changes to reduce the risk of similar breaches occurring in the future. However, other breaches—such as harvesting of several hectares beyond coupe boundaries—have subsequently occurred.

Outcomes of the audits may include recommendations to improve compliance with the Code and increase environmental performance of timber harvesting operations as well as indications of how the Code may be amended to facilitate compliance. The outcomes of the audit program are expected to be of benefit to the forestry industry and the community as well as DSE and VicForests, by providing an objective and independent assessment of the status of compliance of timber harvesting operations with the Code. DSE's responses to each of the recommendations are recorded in the final audit report.

Area Available for Harvesting

State forest in the study area covers 104,720 ha, or 40 percent of the study area's public land estate (Table 9.1). All state forest is potentially available for timber production. However, not all of the gross area of state forest is actually available or, indeed, suitable for timber production. Some areas in the study area, such as water bodies, open wetlands and grasslands are inherently unsuitable for the growth of trees while others support trees that are unproductive for timber (either because of their species or poor growth). Some species or areas are protected by departmental prescription, while others, although suitable and productive, may be inaccessible or of insufficient size to be commercial.

Protection of Water Quality

Several of the standards established in the Code of Forest Practice for Timber Production (DNRE 1996a) are aimed at protecting water quality and aquatic habitat values. These include:

- retaining a buffer of riparian and other vegetation extending at least 20 m on either side of a permanent stream (i.e. a stream that has open water at minimum flows) and around permanent springs, swampy ground, wetlands or other bodies of standing water;
- retaining a filter strip extending at least 10 m on either side of temporary streams and drainage lines.

Figure 14.8 Auditors, community representatives and Department of Sustainability and Environment staff in Barmah State Forest during an Observation Day designed to consult with the community and improve the audit process.

The Code was primarily developed in relation to mountain and foothill forests where local rainfall is the major influence on water movement, however this is not the case in the floodplain environment. The soils of the floodplains have developed by deposition of sediment from the major watercourses during floods. The presence of sediment in streams is affected more by activities in the catchments than by activities on the floodplains themselves. The topsoils of the floodplains typically consist of silty clay which, if exposed to rapid run-off, is likely to erode. Floods, however, are caused by 'run-on' from upstream events rather than run-off from local rainfall. The low surface profile prevents rapid water movement during river flooding and recession and reduces erosion.

Accordingly, and in line with the Code, the Mid-Murray Forest Management Plan requires the establishment of a 20 metre buffer, from which timber harvesting activities are excluded, on main rivers and anabranches, lakes, billabongs and lagoons that maintain permanent open water at minimum river flows. Further, in the floodplain environment, timber-harvesting activities are not permitted where there is free water or saturated soil and are excluded from within 20 m of the water-line or saturated zone, wherever it may occur at the time of harvesting. Under standard conditions, these latter areas may be harvested when water is absent, however. The Management Procedures also require maintenance of buffer and filter strips (DSE 2005e). These buffers, along with gazetted public land water frontage reserves within state forest, are not available for timber harvesting.

Forest Zoning

The principles behind the designation of forest management zones are discussed above. Zoning

Table 14.1. Area of each Forest Management Zone within the River Red Gum Forests study area.

Forest management zone	Availability for timber harvesting	Total area of each zone in the study area (ha)	Area of each zone in the study area within the respective forest management plans (ha)		
			Mildura	Mid-Murray	North East
Streamside reserves and code of forest practice exclusions	Excluded	1132	522	494	116
Special Protection Zone (SPZ)	Excluded	11,910	143	10,125	1642
Special Management Zone (SMZ)	Permitted, subject to restrictions in excess of standard restrictions	22,569	6671	15,898	0
General Management Zone (GMZ)	Permitted, subject to standard restrictions	67,675	31,494	31,467	4714
Total area of state forest		**103,286**	**38,830**	**57,984**	**6472**

Notes: Includes buffers prescribed through the Code of Forest Practice and gazetted Public Land Water Frontage Reserves within state forests (equivalent to SPZ). 'Management procedures for timber harvesting operations and associated activities in state forests in Victoria' (DSE 2005e) requires the retention of certain numbers of habitat trees; these are considered by DSE to be standard conditions in the river red gum forests.

excludes harvesting from areas (such as Special Protection Zones) or restricts the intensity or timing of harvesting permitted in others (such as Special Management Zones). Table 14.1 sets out the area of state forest in the study area allocated to each forest management zone.

Not all zones are displayed on public maps. In the Barmah Forest, for instance, the nesting sites of superb parrot—protected by both a 250-m radius Special Management Zone (in which activities are restricted during the breeding season) and a 100-m radius Special Protection Zone around each nesting tree—are not reproduced in the maps accompanying the Forest Management Plan to discourage poaching for the bird trade.

Although timber-harvesting operations are generally excluded from Heritage River Areas, they are permitted, subject to restrictions in accordance with the *Heritage Rivers Act 1992* and the *Heritage Rivers (Amendment) Act 1998*, in parts of the Goulburn and Ovens Heritage River Areas. These areas are treated as Special Management Zones in the planning process.

Prescriptions and Other Unmapped Provisions for Environmental Protection

Prescriptions established through the forest management planning processes make special provisions for the protection of such values as the habitats of endangered species, wetlands and large old trees (see below), as well as to promote the development of large trees across the forest landscape. Under the provisions the Mid-Murray Forest Management Plan, for instance, commercial timber harvesting is excluded from all occurrences in state forest of Buloke Woodland, cypress pine, Black Box Woodland and Northern Plains Grassy Woodland, regardless of whether or not they are included in Special Protection Zone. Similarly, any Black Box Chenopod (saltbush) Woodland occurring within the Special or General Management Zones of the Mildura FMA is protected from disturbance, and timber harvesting is excluded from all occurrences of buloke, cypress pine, grey box and black box in this FMA.

Although these areas are not specifically mapped, and therefore do not appear in the area tables above, they nevertheless further diminish the net available productive area.

Retention of Habitat Trees

Guidelines for the protection of flora and fauna values, set out in the Code of Forest Practice for Timber Production, seek the retention of habitat trees (Figure 14.9) and old-age understorey elements in appropriate numbers and configurations, and the recruitment of potentially hollow-bearing trees (see chapter 5) within or around coupes. A major goal of the forest management plans is to ensure that there are sufficient large old trees across the forest, within the constraints of sound silvicultural principles. The presence of large old trees suppresses the recruitment and growth of young trees so, in production forests, a balance is required.

While the emphasis since the 1970s has been on developing a system of reserves to address the strong community demand for environmental conservation and recreation in the forests (Special Protection Zone), there has also been a shift to greater retention of trees for habitat in the timber-productive forests, particularly in Special Management Zones—but also in General Management Zones, albeit to a lesser extent.

An analysis of stand structure in Barmah forest (Appendix 14) shows that the numbers of trees in the larger size classes have increased over time, although the Department of Natural Resources and Environment (2002a) suggests that in many areas of public land the proportion of the forest comprising large old trees would still be lower than would occur naturally.

The Management Procedures (see above) establish guidelines for the retention of habitat trees in each Forest Management Area in the state. For the Mildura and Mid-Murray FMAs these are:

- all trees known to be used for nesting by significant fauna (such as superb and regent parrots) must be retained and protected;
- all trees greater than 100 cm diameter at breast height (DBH) must be retained;
- retain a minimum of 20 live trees within the 50–100 cm DBH range for every 10 ha within the Benwell, Guttrum and Gunbower State Forests in the Mid Murray FMA;
- for every 10 ha elsewhere in the Mildura and Mid-Murray FMAs, 20 trees within the 50–100 cm DBH range and 20 within 100–150 cm range; adjusted so that, if there is a deficiency in numbers in one of the size groups, a total of 40 live trees are retained within the 50–150 cm DBH range (DSE 2005e).

Implementation of these habitat tree guidelines is estimated to lead to at least 24 percent of the area of each coupe in river red gum forests being occupied by retained trees (DNRE 2002a). In the Mid-Murray FMA, retention of habitat trees at these levels was estimated to effectively reduce the area of forest that is potentially available for commercial timber production in the General Management Zone by about 6900 ha (about 36 percent) and approximately 4400 ha in the Special Management Zone.

Bren (2001) noted that, at the current prescribed levels of habitat tree retention, 74 percent of the growth potential on SQ I (highest quality) sites would go onto retained habitat trees, while on SQ II and SQ III (medium and lowest quality) sites, habitat trees would absorb 100 percent—suggesting that the potential of habitat trees to absorb site resources is greater than their relative proportion in a stand.

Net Available Area for Harvesting in State Forest

The area of state forest that is potentially available for timber production in the River Red Gum Forests study area, once exclusions are made for the Code of Forest Practice and legislated reserves, totals 102,154 ha (Table 14.1). After accounting for the area of Special Protection Zones and other sites identified in the respective forest management plans where timber production is excluded, a total of 90,244 ha remains; this is defined as the *net available area*.

The Statewide Forest Resource Inventory (see above) was designed to determine the actual extent and indicate the relative timber productivity of stands within the net available area. Using the SFRI data, the *net available*

Figure 14.9. Large tree retained for habitat values in Benwell State Forest.

productive area would then be determined by subtracting from the net available area, the areas of forest that are of low inherent productivity, inaccessible or of insufficient size to be commercial. However, the SFRI data are not available to indicate the extent of the other factors. Therefore, the total area of General and Special Management Zones (90,244 ha) in Table 14.1 does not, by itself, indicate the actual area that is both available and suitable for commercial timber production.

Non-State Forest Public Land Available for Timber Production

Commercial timber production was permitted in about 2500 ha of forest in the Barmah State Park (LCC 1985). Licences for timber harvesting here expired in 2003.

Limited extraction of timber products is permitted in about 3103 ha of the River Murray Reserve in the Mildura FMA (in accordance with approved Land Conservation Council recommendations: LCC 1989a) where consistent with protecting natural and scenic values, conserving of native flora and fauna and the protecting of sites of archaeological, cultural and historical importance. This incorporates areas at Spences Bend, Police Bend, Pound Bend, Buchanans Bends, Camerons Bend, Burra Forest and Vinifera Forest (but excludes the 60-m Murray River Public Purposes Reserve). Some small-scale thinning operations that produced firewood have been undertaken within these portions of the River Murray Reserve. LCC (1985) also provided for limited timber production within the Loch Garry Wildlife Management Cooperative Area and in about 790 ha of the River Murray Reserve within the Murray Valley Area. The Mid-Murray Forest

Management Plan excludes timber harvesting from the River Murray Reserve in that Forest Management Area. These areas have not been included in the estimate of sustainable yield for sawlogs.

Timber Production on Other Lands

Wareing (2002) lists about 23,000 ha of the river red gum forest type on private property in northeastern Victoria (as far west as Echuca). The bulk of these areas are on higher ground than the more productive forests and overall productivity is likely to be similar to that of the SQ III sites on public land. A negligible volume of timber is harvested from these forests. Further, the Native Vegetation Retention Controls (introduced in 1989 under the provisions of the *Planning and Environment Act 1987*) reduced the amount of commercial timber harvesting that occurred on private land.

The New South Wales (NSW) river red gum timber industry is based on the floodplain forests of the Murrumbidgee, lower Lachlan and Darling Rivers as well as those along the River Murray. The river red gum forests here total several hundred thousand hectares—probably several times their extent in Victoria. In addition, a much higher proportion of these forests—and the wood products sourced from them—and are on private land than is the case in Victoria. Nonetheless, privately–owned native forests in NSW may be subject to native vegetation retention controls.

Silvicultural Practices

Silviculture is the management of forests through establishment, composition and growth, and describes the harvesting and regeneration system used to achieve specific objectives for an area of forest. The particular silvicultural system applied depends on the object of management—for example, to return the forest to a more natural structure or to sustainably harvest the largest amount of timber, or a combination. One or more silvicultural systems may be applied to an area of forest, depending on its structure, condition and management objective and can be used to produce a mosaic of different stands of various structures within the area. Timber harvesting can be used as a silvicultural system to develop the desired forest structure, for example, firewood harvesting while thinning small, dense stems.

Forest management for timber production needs appropriate silvicultural system to ensure a sustainable yield of merchantable products within sound environmental and economic constraints. Accordingly, successful silvicultural systems in native forests aim to (DNRE 2002a):

- ensure the long-term conservation of the ecosystem (at the forest level, this requires an age-class structure adequately representing all key successional stages of the respective species—including the understorey and non-merchantable species);
- address the basic requirements of the respective tree species for establishment and growth;
- ensure adequate regeneration of harvested areas with the correct species mix;
- foster subsequent development of the forest stands;
- maximise the yield of merchantable timber, where that is an objective;
- minimise environmental impact;
- incorporate social and economic considerations;
- protect the forest, and particularly the regrowth, from damage through factors such as wildfire, browsing, disease and insect attack;

and, in the river red gum forests:

- integrate water management and silvicultural activities.

The structure and density of forest stands determine their timber productivity and the success of regrowth. Options for the management of regrowth can include such actions as the removal of overwood to reduce competition with the regrowth and thinning of the regrowth to foster development of timber-productive trees.

Although large areas of the river red gum forests comprised even-aged regeneration originating from the 1870–1880s, subsequent harvesting, silvicultural activities and restrictions imposed on gap sizes have lead to the creation of a largely uneven-aged forest. This forest structure is maintained and promoted through the current application of single-tree and (small) group selection cutting systems (these are essentially uneven-aged silvicultural systems—see below), retention of habitat trees and stand thinning. Of the 1230 ha of river red gum forest silviculturally treated in 1997–98, for example, 10 percent was subject to group selection, 40 percent to single-tree selection and 50 percent was thinned (Lutze et al. 1999).

This situation is reinforced by the Management Procedures (DSE 2005e), which specify that group or single-tree selection systems should be applied in the riverine forests, and that the seed tree systems may be applied to areas of between 2 and 5 ha where the existing stand is even-aged. The Wood Utilisation Plans for the Mid-Murray FMP exemplies application of these procedures, where, except for regrowth management work, the silvicultural system planned to be applied is exclusively uneven-aged (DSE 2006e, f).

Single-tree Selection System

This system is applicable in naturally uneven-aged stands. Single-tree selection involves removal of scattered individual trees from a stand, with their selection determined by the objectives for stand management and the timber products sought. The period between successive harvests from the one stand is usually between 10 and 15 years and can be repeated indefinitely. Regeneration of the site is usually achieved through coppice or lignotubers as the survival of seedlings in such small gaps can be problematic because of competition from surrounding trees (see above). Single-tree selection is recommended for the lower site-quality areas of the river red gum forests where floods are less common and regeneration less reliable and for sites managed primarily for environmental conservation (Lutze et al. 1999).

Group Selection System

This is the most common silvicultural system currently applied in the river red gum forests. It comprises scattered fellings of either individual trees or small groups to produce gaps of sufficient size, generally less than a hectare, so that natural or induced seedfall from the surrounding trees can be used and to foster seedling development. While, in most forest types, the gaps are usually no more than two tree-heights across, in the river red gum forests, where seed is dispersed on flood waters, larger gaps sizes can be employed. As mature river red gum trees compete strongly for soil water, and trees surrounding a gap readily expand their roots and branches to occupy the site, the size and shape of the gap produced in a harvesting operation is important for successful establishment and growth of the seedlings. The Department of Natural Resources and Environment (2002a) considers this system to be appropriate for the more productive river red gum stands and where seedling regeneration is more reliable.

Under this system, a range of timber products may be harvested from an area of forest on cycles of between 10 and 30 years depending on stand structure, the growth of the trees in the period between harvests, and the products sought.

Seed Tree System

Under this system, all live trees in a coupe are felled, apart from a number of uniformly distributed trees retained to provide seed (seed trees), and those required for environmental (habitat) purposes. Seedfall may occur naturally or be induced.

Australian Group Selection System

The Australian group selection system (Jacobs 1955) can be used to create gaps of 5–10 ha (clear-felling small patches) within which substantial areas of even-aged regeneration can establish, with habitat trees grouped rather than dispersed throughout the coupe. This system is not currently applied in the river red gum forests in Victoria, but is applied to some degree in NSW state forests. Dexter and Poynter (2005) suggest that this system meets the requirements of the Code of Forest Practice better than the systems currently applied in the river red gum forests. They contend that the uneven-aged silvicultural system that is applied to the river red gum forests, superimposed by the prescriptions for retention of habitat trees, appear to meet neither the Code of Forest Practice requirements for sustainability of timber production nor its principles of sound environmental practice.

Regeneration

As current timber harvesting operations produce many small sites requiring regeneration each year, provision must be made to regenerate them to prescribed stocking levels (numbers) within a reasonable time. Native Forest Silviculture Guideline No.10 (DNRE 1997a) requires stocking surveys in areas subject to regular flooding to be undertaken 18 to 36 months after the first flood event following harvesting. In areas not subject to regular flooding, the surveys are to be undertaken 18 to 36 months after the completion of harvesting. If natural regeneration is shown to be inadequate, remedial action is required.

In general, regeneration of river red gums in the floodplain forests is achieved through natural seedfall and seeds are dispersed during flooding. However, seedbed preparation and artificial seeding may be required to produce regeneration on specific sites (Di Stefano 2002). The seedbed may be prepared through soil disturbance or by burning of the logging debris and may be timed to take advantage of natural seed-fall in spring.

Although germination of river red gums seed is usually prolific in the floodplain forests, the longer term survival of the seedlings is often compromised by a lack of water at the appropriate times. Coordination of harvesting and regeneration operations with water management could benefit the establishment and survival of seedlings and subsequent forest growth.

Stand Thinning

Millions of river red gum seeds germinate on the forest floor most years, but the majority die in the first few years through flood, drought, insects or browsing. High seedling losses also occur through soil drought caused by competition from grass or surrounding trees. Subsequent competition between the saplings produces a gradual reduction in the numbers of surviving stems as they grow. At age 8, for instance, SQ I (highest quality) river red gum stands can carry 3600 saplings per hectare, but by age 108, this will have reduced to some 90 trees per hectare. SQ II (medium quality) stands can support some 3000 saplings per hectare at age 8 and about 70 trees at 108 years (Dexter & Poynter 2005). It usually takes about 100 years or more to produce sawlog-sized trees in river red gum forests.

Thinning of young stands removes some trees, most of which are usually already suppressed with poor form. Such management techniques makes more of the site's resources available to the retained trees. The growth potential of the site is thereby concentrated in the retained trees, which grow faster and reach the required dimensions sooner. Thinning does not aim to establish regeneration.

The periodic thinning of regrowth and removal of unmerchantable trees (where not required for habitat) are considered essential to maintain the timber productivity of the river red gum forests. Ecological thinning may also be undertaken to specifically improve biodiversity values, such as by enhancing conditions for understorey growth, the habitat of certain species of wildlife or for forest health. For example, Harris (1975) found that thinning dense stands of 28-year-old river red gum regeneration significantly reduced the level of defoliation caused by the larvae of the gum leaf skeletoniser moth in 1965–66. The recent drought conditions have imposed excessive water stress on many areas of forest, particularly in the west of the study area. Thinning operations have been undertaken to alleviate some of this stress on the retained trees.

Thinning treatments can be 'pre-commercial', in which no timber products are harvested. Such treatments are normally carried out in younger stands. Thinning of older stands can yield commercial wood products (such as poles, sleepers, posts and firewood).

The high costs of labour have meant that the necessary thinnings have generally not been carried out in the river red gum forests (Figure 14.10). As a consequence, the on-growth of larger-sized trees suitable for sleepers, piles, sawlogs and, indeed, large habitat trees is delayed. This problem was evident at the earliest stages of forest management (Forest Commission of Victoria 1928) and persists today.

Sustainable Yield

The fundamental principle of sustainability in wood production from forests is that the resources should not be harvested at rates faster than they are growing. The volume of logs to be supplied from each Forest Management Area is specified in log licences and is based on forecasts of the sustainable levels at which trees of a suitable size can be harvested. In practical terms, sustainable yield is a forecast of the rate of harvesting that can be maintained for a given period without impairing the long-term productivity of the land. It must take into account the structure and condition of the forest, predicted growth and the diverse range of forest-based activities.

Forecasting the long-term sustainable yield from forests managed under selection harvesting systems is complex compared with the process used for even-aged systems. Mixed age forests are harvested for a range of products at different times in the life of a stand resulting in a varying levels of competition between trees and regrowth is continuous, depending on their age and condition and the productivity of the site.

To forecast sustainable yields of sawlogs data are required on the following range of factors. The Statewide Forest Resource Inventory was designed to capture these data.

Area Available and Suitable for Sawlog Production

The respective forest management zoning schemes establish the area of state forest in each Forest Management Area that is available for timber harvesting, while assessments, such as the SFRI, identify areas actually suitable for sawlog production (see above). For the purposes of counting the available wood resources in the Special Management Zone, only a proportion of the total area is considered available for harvesting—this is to account for the restrictions that are generally imposed in Special Management Zone that exceed those standard across the General Management Zone.

Existing Sawlog Utilisation Standards

The definition of a 'sawlog' changes with technology and industry acceptance. The introduction of the 'residual' log standard (as described in Squire (1992), and see Glossary) is an example.

Figure 14.10 Dense regrowth from a fire at Barmah State Forest.

The volume of sawn products that a log can yield varies with size and quality. While some defects (solid knots, for instance) may be marketed as an attractive natural feature, hardwood logs, particularly, can contain defects that diminish the desired qualities (strength or appearance) of the wood or render the section of log unusable. Many defects are hidden and are only revealed when a log is 'opened up' at the sawmill. Hidden defects are a particular problem in river red gum and a healthy looking tree can have a high degree of internal defect, such as gum veins or pockets (caused by insect attack, fire or flood/drought stresses), occluded fire scars, heartwood, rot or double-hearts, rendering it unsuitable for sawn timber. Some gum veins and other defects may be acceptable in structural grades of timber but not where high-grade timber is required. Sweep, or a gradual bend in the wood, may mean a log cannot produce straight lengths of timber. Sapwood, while not necessarily a defect, is undesirable in higher quality timbers as it performs poorly in the seasoning kilns and is susceptible to borers. However, sapwood is acceptable to a greater degree in railway sleepers, enabling relatively small (38–40 cm diameter) logs from the heads of sawlog trees and thinning operations to be used.

These hidden defects make assessment of the relative grades of timber resources on river red gum coupes difficult. In practice, timber resources of a coupe are assessed visually and comparison is made with recorded product yields from previous coupes in similar forest types. Until recently, grading of river red gum logs for the purposes of royalty determination varied between Forest Management Areas, between supervisors and in relation to the products (sawn timber, sleepers etc) being sought. From 2005, logs have been allocated to three grades only (Appendix 15), leaving it to the purchaser to decide the product yield. The grades are determined by size (diameter and length) and the amount of defect—where the proportion of defect exceeds the maximum allowable, the log is consigned to a lower grade. The allowable proportion of defect increases with the size of the log.

Grading of logs in this way:

- reflects the nature of river red gum logs;
- reflects timber quality, value and potential markets;
- is objective;
- can be consistently applied across all Forest Management Areas (DSE 2005f).

Productivity Class and Site Quality

The capacity of different parts of the forest to support sawlog trees depends on the inherent qualities of the site, such as soil type and fertility, climate and availability of water. As a consequence, site quality is 'measured' in terms of the height of the dominant trees at a particular age.

As documented above, productivity of river red gum forests is intimately related to the availability of water in their floodplain environment. Forest health, which is reflected in long-term sustainable timber production, depends upon near-natural flood regimes.

Indicators of Existing and Future (Regrowth) Resources

Many of the current (now mature) stands of the river red gum forests come from the regeneration events of the 1870–1880s while their condition is a product of subsequent management activities. In Barmah forest there has been an increase in the numbers of trees in the larger size classes and a reduction of the smaller sizes over time (Appendix 14). The competitive pressure exerted by the larger trees is discussed above. While the increased number of larger trees corrects an earlier deficit, increasing numbers of larger trees in selectively harvested uneven-aged stands will reduce the numbers and vigour of growing stock for future timber production.

The Growth Rates of Trees within each Productivity Class

Jacobs (1955) noted that the river red gum forests responded well to selective fellings and, once the veteran trees are removed, would be good examples of the Australian group selection system. He suggested it would be possible, under this silvicultural system, to achieve annual growth rates of 3.5 m^3/ha/yr of sawlog-quality timber and at least as much again of fuel, posts and poles in the high quality (equivalent to SQ I) sites. The yield of SQ II areas would be about half this amount and the poor areas (SQ III) less still. However, Jacobs' data was based on water regimes greater than that now experienced by the forests. Dexter and Poynter (2005) note that, under the current forest management regime, an average sawlog productivity of only 1.48 m^3/ha/yr can be achieved, even under an 'ideal' watering regime. Under current watering regimes, values of the order of 0.22 m^3/ha/yr are being observed (Appendix 16).

The river red gum forests are uneven-aged as a result of the long history of single-tree silviculture which compromises the success of subsequent regrowth through competition from retained trees. Dexter and Poynter (2005) suggest that tall straight trees suitable for high-value uses will become rarer if harvesting continues under this system and through stunted tree growth as a result of the substantially reduced frequency of flooding. Appendix 16 displays the combined influence of silvicultural system and associated management decisions, and water availability on timber productivity.

Current (standing) Volume of Sawlogs

Standing log volume data derive from assessments such as the Statewide Forest Resource Inventory and on-going local assessments. With the discontinuation of the SFRI inventory of river red gum timber resources, estimation of the standing log volume for individual coupes must now be undertaken at the local level prior to harvesting.

Legislated Sustainable Yield

The Third Schedule to the *Forests Act 1958* lists the rate of sustainable yield of sawlogs for each Forest Management Area in Victoria. Legislatively, sawlog sustainable yield must be reviewed every five years (beginning in July 1991), or when there is significant change in the available sawlog resource, or at any other time the Minister considers appropriate. Changes to the legislated sustainable yield rate are effected by Orders in Council.

Table 14.2 River red gum wood volumes available, not including contingencies, for the first year under the 2006–07 to 2008–09 Wood Utilisation Plans in each Forest Management Area that produce river red gum in the study area.

Wood grade	Short code in the WUPs	Mildura (m^3)	Mid-Murray West (m^3)	Mid-Murray East (m^3)
River red gum sawlog	U		1195	5790
River red gum sleeper log	S		790	4100
River red gum residual log	R		4650	5370
Firewood	F	6330	850	7750
TOTAL VOLUMES		**6330**	**7485**	**23,010**

Source: DSE (2006e, f, g)

Notes: These wood grades pre-date the standardised grading system established in 2005. Under the conditions of the new grading system, the total available volume indicated in the table would not have changed but the distribution of wood between grades would better reflect the new grading standards—principally from sleeper log to the standard log or residual log grades. Parts of North East and Bendigo FMAs area also in the River Red Gum Forests study area but there is no river red gum harvested in these FMAs. The Horsham FMA area (outside the study area) also has 3080 m^3 available in 2006–07, mostly as firewood (DSE 2006a). The amount of firewood collected illegally is unknown but may be as high as 60,000 m^3 annually.

A review of the availability of sawlog resources was conducted in 2001 as part of the licence renewal process. Based on existing information (no new assessments were undertaken) this review indicated that an annual sawlog licence level of up to 5200 m^3 was possible from the Mid-Murray FMA (reduced from the scheduled level of 5600 m^3) and 600 m^3 nett from the Mildura FMA (reduced from the scheduled level of 700 m^3). These figures do not include the volumes of logs that do not meet sawlog standard, and which produce sleepers and residual wood.

Vanclay and Turner (2001) argue that the overall data quality and methodological rigour used to determine the sawlog yield estimates for the Mildura FMA was inadequate for making long-term licence commitments and that, for the Mid-Murray FMA, the 'estimates do not provide an adequate basis for making long-term commitments, because of subjectivity in the data and simplistic assumptions inherent in the method (see also DNRE 2002b).

Future adjustments of the legislated licensed levels from the respective Forest Management Areas must take into account forest management plans and new assessments of wood availability as well as any government decisions on land use, including those made after this River Red Gum Forests Investigation.

Determining sustainable yields of timber from the river red gum forests still depends on data collected in the 1980s. The discontinuation of the Statewide Forest Resource Inventory process means that up-to-date and superior data on standing volumes and wood productivity are unavailable to assist determination of the long-term sustainable yield from these forests and legislative commitments. In light of all the above, the ability of river red gum forests to sustain current levels of sawlog production into the future under continuing and possibly worsening conditions of environmental stress is unknown (see chapter 19). The continuing greatly reduced frequency of natural forest flooding—and longer term predictions of further deterioration as a result of climate change (see chapter 4)—may be a major threat to long term wood product harvesting in the River Red Gum Forests study area.

Current Timber Availability

Table 14.2 sets out the wood volumes listed for harvesting in the 2006–07 to 2008–09 Wood Utilisation Plans for the Mid-Murray and Mildura Forest Management Areas (DNRE 2002a; DSE 2004f). Although these plans describe different products to those set out under the standardised grading system established in 2005 (see Appendix 15), total wood volumes are consistent.

Although the *Forests Act 1958* lists 600 m^3 of sawlog resource available from the Mildura FMA and several people have sought sawlogs from there, the volume is not currently allocated and DSE is not willing to consider recommencing commercial sawlog operations until there is some certainty about the ongoing availability of the resource. The absence of sawlog harvesting has affected the availability of firewood in the region. It is more expensive for DSE to produce from its own silvicultural thinning than as a by-product of commercial harvesting for high-value sawlogs. Should the availability of the resource be confirmed, the Mildura Forest Management Plan sets out the process, which includes community engagement, for the recommencement of sawlog harvesting.

Licensing of Wood Production

Harvesting of timber in state forest requires a licence from DSE—granted under section 52 of the *Forests Act 1958*. That Act also permits the sale of timber from public land by auction or tender. The Forest (Licences and Permits) Regulations 1999 requires all licence

Table 14.3 Volume and price for wood licensed from the Mid-Murray Forest Management Area (2006–07).

Log grade or product (see Appendix 15)	Volume available under licence (m^3 gross equivalent)	Price range ($\$/m^3$ incl. GST)
River red gum sawlog	6110	56.38–64.87
River red gum standard log	4428	36.25–46.35
River red gum residual log	4618	14.40
River red gum firewood	4380	13.80

Source: DSE, 2005 (unpublished data)

holders to comply with the Code of Forest Practices. Three types of licence currently apply to the removal of wood from state forest in the River Red Gum Forests study area. Overall there are 41 licences for 22 licensees in 2006–07 (sawlogs, standard logs and residual logs, of various grades, and firewood).

S-licence

Up until 2005, long-term S-licences were issued, with Governor-in-Council approval, for commercial timber harvesting for periods of up to 15 years. Transitional processes are in place but, eventually, the traditional system of commercial sawlog licensing will be replaced and no long-term licences will be granted or renewed. At present, and pending transfer of the management of commercial timber harvesting to VicForests (see above), on expiry of each long-term S-licence, it is re-issued on an annual basis. Royalty and other fees and charges are payable on invoice.

Five S-licences for the harvesting of river red gum sawlogs are current in the River Red Gum Forests study area for 2006–07 (Appendix 15 provides a definition of the log grades). Two expire in 2007 and three in 2009.

B-licence

Anyone wishing to harvest forest produce on a commercial basis must apply for a Forest Produce B-licence. These are issued for up to one year and royalty and other fees and charges are payable on invoice.

B-licences are issued through a combination of direct allocation and tender. Many B-licence holders have a long history in the industry and have built up businesses based on ongoing access to resources. Each of these established licensees usually receives a direct allocation of volume based on the quantity they have cut previously. In 2005, the volumes issued to established B-licence applicants were based on their average cut over the three previous years. Nevertheless, they must still apply for the licence each year.

Because established industry takes up most of the available resource and the present level of uncertainty about the ongoing availability of the resource, licences are not issued to 'new' applicants other than through the process of tendering. For example, wood made available as a result of thinning operations (for improvement of forest health) is advertised for tender on a location basis (from Barmah or Gunbower State Forests, for instance). If an established licensee quits the industry, some of the resource freed up would most likely be advertised for tender.

In the River Red Gum Forests study area, a total of 26 B-licences have been issued for the harvesting of river red gum standard logs and river red gum residual logs (for definition, see Appendix 15) and 10 B-licences for commercial firewood collection for the 2006–07 year.

All commercial timber harvesting on public land in Victoria is subject to the Code of Forest Practices. Further, under the Timber Harvesting Regulations 2000, those involved in commercial harvesting are required to hold a Forest Operator's Licence and sign a Forest Coupe Plan before commencing work.

C-licence

C-licences are issued for the harvesting of forest produce for domestic use only. They apply for periods of from one to five days. Royalty and other fees and charges are payable upfront. Between 8000 and 10,000 C-licences, mostly for firewood, are issued each year from the study area, the actual number depending in part on the extent of flooding and the weather.

Royalties

Royalty rates are the means by which government sets prices and sells wood products to processors. While the royalty rate is only a small proportion of the total cost of a sawn product, considerable effort goes into gearing schedules of royalty rates to market prices. Differentials apply for log quality and location and a loading is applied for the use of state roads and to encourage the use of residues.

Table 14.3 sets out the major products, the volumes licensed and the price (which includes royalty, production roading charges and licence fees) paid by commercial licensees to take these products from state forest in the Mid-Murray Forest Management Area.

CURRENT COMMERCIAL WOOD PRODUCTION

River red gum is now the only species available for commercial harvesting from public land in the River Red Gum Forests study area. However, the timber is used by such a diversity of people for such a wide range of applications that it is difficult to collate comprehensive and consistent data on end products and production levels. While large integrated sawmilling companies

Table 14.4 **Wood volumes harvested recently from the River Red Gum Forests study area.**

Product grade	Approximate equivalence to current grading system	Volume harvested by year (cubic metres gross)	
		2003–04	2004–05
RGA	River Red Gum Sawlogs	5200	4308
RGB	River Red Gum Sawlogs	2839	1706
RGS	25% River Red Gum Sawlogs 75% River Red Gum Standard Logs	1694	1879
RGH	River Red Gum Standard Logs	1853	2090
RGRA	River Red Gum Standard Logs	2002	2557
RGRB	River Red Gum Residual Logs	4151	9352
RL	River Red Gum Residual Logs	658	1011
RGF	firewood	4339	11,638
RGFC	firewood	1888	1507
Total volumes		**24,628**	**36,051**

Source: Department of Sustainability and Environment, Forest Resources Branch

with drying and planing facilities within the study area are theoretically easy to monitor, data on domestic and commercial firewood collectors and individuals with portable mills (barrow saws) cutting sleepers and garden timbers either at the stump or on private property are more difficult to attain, particularly when they have links with similar operations in other areas of the state or interstate.

Licensed Commercial Production

Table 14.4 sets out the volumes of wood harvested from the River Red Gum Forests study area by commercial operators in 2003–04 and 2004–05. As the classification of the product grades in this table predates the rationalisation of 2005, an indication of the approximate equivalents in the current grading system is provided. Some commercial firewood was also sold under C-licence during this period.

Contemporary Uses of River Red Gum Timbers

The characteristic durability of river red gum timber means that it still used for many of the products for which it was first sought. River red gum timber is resistant to white ant. It has the highest rating for fire retardance of all Victorian timbers. As a result, local governments recommend it as appropriate housing timber in fire-prone areas (advice from Arbuthnot Sawmills). These characteristics, coupled with its strong colour, often interestingly figured grain and ability to take a high polish, also mean that the wood is finding increasing applications in furniture and other joinery.

River red gum timbers present unique opportunities for value adding. The river red gum timber industry has invested in drying facilities and other timber processing equipment and developed new products to capitalise on the wood's intrinsic values.

Sawlogs are processed in sawmills and the timber may be marketed as 'green sawn' or kiln dried. Little is wasted, as off-cuts and other residual material are also sold—accordingly, the industry considers that it achieves almost 100 percent in added value. Sawn timber products include:

- *green sawn:* bridge, railway sleepers and crossing timbers, fencing (posts and droppers) timbers, house stumps, guide posts, survey pegs and garden landscaping timbers and stakes.
- *kiln dried*: indoor and outdoor furniture, parquetry, traditional tongue-and-groove flooring and 'floating floors', laminated bench tops, feature panelling and mouldings, craft timbers and other applications where appearance grade timbers are required. There is a small, but increasing market for river red gum veneers for both furniture and joinery.

Fence posts, poles, garden landscape timbers, firewood, chips (for landscaping purposes or mulch) and, occasionally, charcoal for barbecues, industrial filters or cosmetics are produced as by-products of river red gum sawmilling and sleeper-cutting operations and from residual logs. Sawdust is used mainly for horticultural applications while some is also used to generate heat for the timber-seasoning kilns.

A demand exists for specialty river red gum timbers for the maintenance of heritage buildings and bridges, to retain consistency with the original construction materials. For example, a planned major upgrade of the Port of Echuca may require river red gum timbers (advice supplied by Arbuthnot Sawmills). River red gum timbers continue to be used for the cladding and fuelling of the river steamers that feature amongst the attractions for local tourism.

Sawmilling Industry

The river red gum timber industry along the Murray River comprises six major fixed processing facilities (as distinct from small mills producing sleepers and other products

at the stump or on private property) in both Victoria and NSW. Three are established on the Victorian side: Murray River Sawmill at Echuca, Arbuthnot Pty Ltd at Koondrook and Merbein Sawmilling at Merbein. On the NSW side, sawmills are located in Deniliquin, Barham and Darlington Point.

While all of Murray River Sawmill's sawlogs are harvested in Victoria, Arbuthnot receives logs from both Victoria and NSW and Merbein Sawmilling's sawlogs are harvested in NSW. Conversely, the mill at Barham in NSW draws its river red gum sawlogs from both NSW and the Horsham Forest Management Area in Victoria (outside the study area). Neither the Deniliquin nor the Darlington Point mills draw logs from Victoria.

Ryan and McNulty at Benalla (outside the study area) is also licensed to harvest river red gum logs from the study area and buys green-sawn river red gum timbers from other mills. The bulk of the river red gum sold by this company is dried and reconditioned for supply to markets in Victoria, New South Wales and Queensland; a small volume of lower grade material is sold to local markets for such applications as outdoor furniture. This company also holds licences for mountain ash and other species logs from Victorian state forests.

The relative proportions of the various products yielded by commercial operations from river red gum logs supplied from Victorian state forests are estimated to be:

- 25 percent kiln-dried products and sawn specialty products (furniture, heritage restoration, veneer flitch);
- 26 percent other sawn products (housing, infrastructure timbers, etc);
- 49 percent 'fall down' products (material that fails to meet the grade) from the production of higher value sawn timbers and from thinning undertaken to improve forest health (this includes firewood, landscape timbers, etc) (Department of Sustainability and Environment, unpublished data, 2005).

As an example of the industry, Arbuthnot Pty Ltd, averaged 47 percent in sawn timber products recovered from the round logs over the five years to 2004–2005 and utilised 100 percent of every log. All by-products, including sawdust, mill ends (firewood) and chips from bark and edges, were sold (see Table 14.5).

While the proportion of kiln-dried timber produced is relatively small, it claims a high mill-door price, reflecting the cost of production and its high market value—it is sought after by many specialist 'high-end' furniture manufacturers. General industry data suggest that dried 800 mm-wide river red gum slabs (for such applications as table or bench tops) can sell for up to \$4000 per m^3, while kiln-dried select and feature grade river red gum timber can claim about \$2400 per m^3 and that for general furniture and flooring applications sell on average for about \$1750 per m^3. Average mill-door prices for structural timbers are about \$750 per m^3 and railway timbers about \$650 per m^3. Low-grade timbers are sold at about \$360 per m^3 (advice provided by Ryan and McNulty Sawmills and Arbuthnot Sawmills Pty Ltd).

The presence of 'cottage industries' based on forest products, such as locally produced furniture featuring natural defects, provides the added benefit of attracting tourists to explore local enterprises and purchase local produce. At Koondrook, tours and an associated 'Redgum Forest to Furniture Showcase' profile the relationship between the forest, primary processing (sawmilling) and the end products. The overall profile of the timber industry, including its employment levels and downstream markets will be investigated by VEAC through a socio-economic study of the various industries in the River Red Gum Forests study area.

Table 14.5 Average annual production (by product) from Arbuthnot Sawmills Pty Ltd, 2000–2005.

Product	Proportion of Total Output	Proportion of Sawn Output
Firewood, other non-mill products	53%	-
Structural, including bridge timbers, heritage structure timbers, building sections, suburban fence posts, drop-bars for water management structures	27%	58%
Low grade, such as landscape timbers and shorts for survey pegs, stakes and fence droppers	12%	25%
Railway timbers, including sleepers and crossing timbers	6%	13%
Kiln-dried for furniture and flooring	2%	4%

Source: Arbuthnot Sawmills Pty Ltd, 2006, unpublished data.

Sawmilling Industry Trends

A decline in traditional markets for unseasoned hardwood has led to a general restructuring in the timber industry. Investment by the industry in air-drying facilities, seasoning kilns (for humidity controlled drying of fresh-sawn timber), reconditioning plant and equipment to finish (plane and shape) the dried timber, means that an increasing proportion of total sawn output is seasoned and processed into higher value products. Appearance-grade river red gum finds a ready market in the building joinery and furniture trades.

While this trend has required significant additional capital investment it has provided benefits in terms of increased value of production and employment. Ryan and McNulty Pty Ltd at Benalla is one example. Established in 1949, the company faced increasing competition in the 1990s from plantation softwood in the house framing market. Following the installation of new green and dry sawmilling equipment, seasoning kilns and air-drying facilities, together with the purchase of additional sawlog resources (some of which was to compensate for a reduction in supplies as a result of adjustments in the sustainable yield from state forests) and green sawn timber from other producers, the company achieved a five-fold increase in annual turnover. The company now supplies kiln-dried ash species (mountain ash, alpine ash and shining gum) and river red gum timbers into the Victorian and interstate markets, ash species to international markets as well as traditional unseasoned hardwood timber to the local building industry (McNulty 2005).

Although river red gum is only a small proportion of the total sawn timber output from Ryan and McNulty as, indeed, the river red gum timber industry is small by statewide standards, the company is supplying 'select' and 'natural features' kiln-dried river red gum into a niche market.

Arbuthnot Sawmills, similarly, is a modern timber processing company with automatic equipment which, in 1994, added a kiln-drying plant to add value to the river red gum timber resource. With kiln dried timber readily available, the furniture industry in the region has grown to now include four substantial businesses (Figure 14.11) (Arbuthnot Sawmills Pty Ltd 2006).

Figure 14.11 Furniture workshop.

Murray River Sawmill has similarly installed a kiln-drying plant and, following considerable market testing, the sawmill at Barham (NSW) now produces river red gum veneer timbers. This process required the installation a kiln to condition the flitched timber and equipment to slice, dry and clip the veneer.

Railway Sleeper Industry

Railway timbers for the Victorian rail network—sleepers and crossing timbers—are produced in sawmills, at small static mills on private property or by mobile mills at the stump. These timbers are now almost exclusively river red gum and are produced by about 12 businesses (sawmillers and sleeper-cutters) in the state. Two sleeper-cutters prepare their sleepers at the stump, the others use small static mills established on private land (as advised by Arbuthnot Sawmills).

The railway sleeper market is valuable to the river red gum sawmilling industry. Although the proportion of sleepers compared to total mill output is small (Table 14.5, for example), sawing them is relatively straight-forward, the market is large and payments are reasonably guaranteed; they are an important component of the total revenue stream. Sleeper production enables utilisation of timbers that fail to meet structural or kiln-drying standards and logs from stand thinning operations that are too small and would otherwise be sawn into lower value products—although the extent to which sleeper production competes with higher value products (including for these smaller logs which could be left in the forest to grow into sawlogs) remains an issue (see chapter 19).

Under the wood grading system now in place in Victoria, timber is no longer sold from state forest according to the expected product, such as sawn timber or sleepers. Rather, the logs are graded according to their quality and size, leaving the purchaser to decide on the product yield. Accordingly, contemporary figures on the actual output level of railway timbers are difficult to derive. Based on the previous licensing system, however, average total production of sleepers by licensed cutters in the Mid-Murray Forest Management Area from 1991–92 to 2000–01 was 3523 m^3 nett per annum (about 38,750 sleepers per annum). Output in the later years fell well short of this average, largely following privatisation of the contracts for maintenance of the rail network in the mid-1990s (DNRE 2002b).

Sleeper Industry Trends

Much of southeastern Australia's railway network still sits on river red gum sleepers and river red gum crossing timbers were used in the recent works at Southern Cross (Spencer Street) Station in Melbourne. Of the approximately 7500 km of rail track in rural Victoria (which includes the interstate system in Victoria, totalling about 770 km), some 6000 km is fixed to hardwood timber sleepers. Similarly, of the 875 km of track in the Melbourne metropolitan network, some 612 km is on timber sleepers. Based on an average of about 1500 sleepers per kilometre, the total rail network in Victoria currently rides on some 9,910,000 hardwood sleepers (advice supplied by Redgum Timbers Producers (Australia)).

River red gum sleepers generally have a 30-year service

life. In the Melbourne metropolitan rail network, this translates to between 35,000 and 40,000 sleepers requiring replacement annually (DoI 2005). The current lessee of Victoria's regional broad-gauge rail network, Pacific National, replaces about 100,000 hardwood sleepers annually as part of normal maintenance. Further, Australian Rail Track Corporation Ltd (ARTC), which leases the two interstate standard gauge corridors from the Victorian Government—Melbourne to Wolseley (in South Australia) and Melbourne to Albury (in NSW)—also requires sleepers both for maintenance and upgrades.

The sawmilling industry and Forests NSW developed an Australian Standard for railway sleepers, which specifies, amongst other things, the acceptable slope of the grain across each piece and sets the acceptable levels of sapwood and fault to ensure safety in operation. Passing of sleepers in accordance with these standards is done either by a recognised contracted sleeper-passer or, in the case of the permanent sawmills, self-assessment. Establishment of this standard has provided some stability in the demand for sleepers as relative consistency in the quality of the sleepers supplied is assured.

Substitutes for Hardwood Sleepers

Only timber sleepers have been used in the Melbourne metropolitan rail network replacement program to date. Concrete sleepers were considered to be unsuitable for interspersion with in-situ timber sleepers, as their deeper profile (28 cm compared to 12–13 cm for timber) makes them much more rigid than timber sleepers. Interspersing conventional concrete sleepers with timber has also caused problems with the overall life of the track (DoI 2005). A lighter, low-profile, pre-stressed concrete sleeper has been designed specifically to be interspersed with timber sleepers in existing tracks. These are under trial on the Frankston line and indications are that they will be suitable but will require approval by the line operator—Connex—before they can be used in the routine annual maintenance program across the metropolitan network. However, hardwood sleepers will continue be used in maintenance of the rural network (DoI 2005). Furthermore, hardwood crossing timbers are required to ensure strength and stability across the converging/diverging rail lines.

Concrete sleepers require significantly more ballast than timber sleepers and their weight (three to four times that of timber sleepers) makes them expensive to transport and difficult to handle with conventional sleeper replacement technology (University of Southern Queensland 2006). Nevertheless, with a life span of some 50 years under normal operating conditions and being fire-resistant, concrete sleepers are gaining increasing acceptance. About two million were used in Australian National's 1420 km trans-continental AustralAsia railway, completed in 2003 and, in 2005, ARTC invited tenders for the supply of another two million. Concrete sleepers will be used in all new lengths of line in both the metropolitan and regional rail systems in Victoria (DoI 2005). Recently, ATRC announced that concrete replacement sleepers would be used on the Melbourne–Brisbane route.

Steel sleepers are also widely used in Australia. Various configurations are available, depending on the intended application (Townsend 2002). There has been some concern that steel sleepers are generally too light to maintain stability, particularly on curves, have poor bearing characteristics, move where there are significant variations in ambient temperature and require high maintenance. The selection of steel sleepers requires a good knowledge of track duty, both current and future, and of environmental conditions under which they are to operate. Townsend (2002) notes that steel sleepers generally fail as a result of fatigue cracking, corrosion or a combination of both. While unprotected steel does corrode, long-term observation of steel sleepers under general environmental conditions has shown the total loss of thickness due to corrosion may be as low as 1 mm over 40 to 50 years. Where corrosive locations are identified (such as the salinity affected areas of northwestern Victoria), it is usual to increase the thickness of the sleeper section, although corrosion protection coatings may also be applied. Australian Standard AS1085 Part 17—Steel Sleepers has been developed as a guide to the selection of steel sleepers.

Successful in-track performance of steel sleepers depends not only on the selection of a suitable configuration but also on the methods of installation and tamping of the ballast. This is especially important where they are interspersed with timber sleepers and differential settlement on the ballast may occur. The pattern of interspersion is important to avoid rail movement and stresses. Steel sleepers have been interspersed into existing timber-sleepered tracks during maintenance programs on a number of rail lines within Australia (Townsend 2002).

A fibre composite railway sleeper, made from polymer concrete and glass-fibre reinforcement, is also being developed. It is approximately 120 mm deep and weighs about 63 kg, although designs can accommodate local conditions outside of these parameters, and can be fitted with standard rail fasteners. The shape of the sleeper provides resistance against lateral movement and it is designed for both interspersion with existing timber sleepers and for new sections. A trial with 500 sleepers is to be established in a track near Toowoomba, Queensland (University of Southern Queensland 2006).

Fencing

A small, but steady demand for fencing materials continues, reflecting the need for replacement fencing and the increasing intensity of local agriculture. Alternatives to fencing material from native forests include treated plantation pine, concrete and steel. Electric fences are also used and, although usually fitted to timber posts, they use less material than traditional post-and-wire fences.

Firewood

Firewood is an important component of state forest management and wood production. This section discusses the details of firewood collection and consumption with regard to Victorian state forests but also examines some of the wider issues that influence the patterns of firewood use in Victoria.

Firewood is a valuable source of renewable energy. Burning wood to warm homes and fuel industry has been part of Australian culture since European settlement. Many Victorians consider firewood an essential fuel for heating and wood fires have a strong aesthetic appeal. Woodfires may be the most cost-effective heating available for people in regional areas, including many towns in the study area, who do not have access to reticulated natural gas (see chapter 17). It is reported that elderly people and pensioners often rely on firewood as their primary source of heating as other fuels are too expensive. Approximately half of the DSE domestic firewood permits (see below) are issued to concession holders (DNRE 2002c). Socially, many people consider firewood collection to be at least partly a recreational activity and, particularly, an integral part of the ritual and fun of camping out in the bush.

Current Firewood Use

The percentage of households using firewood as primary heating fuel increased rapidly after the price of heating oil doubled in 1978. The development of controlled-combustion heaters since the 1980s also increased the demand for firewood with the percentage of households using firewood as primary heating fuel peaking in 1992. Between 1992 and 1999 the percentage declined but the number of households using firewood stabilised due to increasing population numbers (Todd 2003). Consequently, current sales of firewood from state forests are similar to levels in the 1970s (DNRE 2002c).

Each year in Australia, an estimated 4.5–5.5 million tonnes of timber are harvested for domestic firewood use. When industrial fuelwood is included, the total increases to 6–7 million tonnes, which is roughly double Australia's annual hardwood woodchip export (Driscoll et al. 2000). An average of about 3 tonnes of firewood is consumed per firewood-using household each year although the amount varies across the country, ranging from Queensland with an average of 1.3 tonnes per year to Tasmania where 5.8 tonnes on average is burned each year (DNRE 2002c).

Harvesting occurs predominantly in the cooler southeast of the country with more then half consumed in New South Wales and Victoria. Two-thirds of the firewood consumed is burned in regional Australia, reflecting the limited availability of alternative sources of heating, such as natural gas (Driscoll et al. 2000).

In Victoria in 2002, an estimated 268,350 households (17.1 percent of the total) consumed about 620,000 tonnes of firewood, about half of which was consumed in the greater Melbourne area. Of the 134,500 tonnes of firewood sold in Victoria through firewood merchants, around 107,600 tonnes (80 percent) is river red gum (see Figure 14.12). This high proportion may reflect either the ready availability of river red gum through the merchants or consumer preference for dense, heavy wood.

Figure 14.12 River red gum is a popular firewood species.

Firewood Sources: Collection and Sales

The firewood consumed in Victoria comes from private land, state forest and other public land including roadsides, and also from interstate. Box 14.2 gives details of the estimated amount of firewood from each of these sources. Only about 10 percent is collected legally from Victorian state forests (DNRE 2002c). River red gum firewood is also produced as by-product from sawmills in the study area.

Domestic firewood is collected by two distinct groups: firstly, the commercial firewood cutters (including firewood merchants, sawmills and other groups such as arborists) and secondly, the consumers. In Victoria, about 34 percent (210,800 tonnes) of firewood is purchased from commercial operations such as sawmills with 134,500 tonnes coming from firewood merchants. Most of the firewood bought from merchants is brought from interstate—mostly from New South Wales, in the regions of Balranald, Hay and Deniliquin (Driscoll et al. 2000). Retailers of firewood are generally located between 180 and 330 km from the source (Driscoll et al. 2000). Indicative figures suggest that about 40 percent of interstate firewood comes from NSW state forests with the balance from private property (DNRE 2002c).

The remaining 66 percent or 409,200 tonnes is collected by consumers directly. However, the proportion of consumer-collected wood in some areas is much higher, for example, in the North East, Mildura and Mid-Murray Forest Management Areas in 1999–2000, nearly 100 percent of the firewood sold by NRE was to consumers rather than commercial cutters (DNRE 2002c). Most of the firewood collected by consumers is collected within 20 km of the location where it will be consumed (DNRE 2002c).

In Victorian state forests, firewood can be collected by commercial operators or by domestic collectors through the issue of permits (see above). Firewood permits from state forests in Mid-Murray and Mildura Forest Management Areas in 1999–2000 totalled 6819 tonnes, principally river red gum, representing 11.8 percent of the total firewood sales from Victorian state forests at that time. In that year NRE also sold river red gum firewood (amongst other species) from the Benalla–Mansfield and North East Forest Management Areas, as well as from Horsham FMA which is outside the River Red Gum Forests study area. In total, almost 12,800 tonnes (22 percent) of the firewood sold by the department across the state in 1999–2000 was river red gum (DNRE 2002c; DSE 2005h).

In 2002/03, 1015 m^3 and 2121 m^3 of firewood were sold to domestic and commercial cutters, respectively. An estimated 2000 m^3 is illegally collected from state forest annually (DSE 2004f).

There is not presently any sawlog, sleeper or post harvesting in the Mildura FMA. The two commercial firewood cutters present in 2004 were cutting firewood from sawlog coupes harvested between 1999 and 2002. However, this resource declined quickly (DSE 2004f). At present, there are no commercial firewood cutters in the Mildura FMA and DSE are cutting dead standing trees to supply firewood for consumer demand in the area.

In the Mid-Murray FMA, commercial operators cut firewood from residual wood (heads of trees and logs felled during sawlog and sleeper harvesting but not taken) and also from thinning operations. In 2000–2001 just over 12,000 m^3 of firewood was taken from Mid-Murray including 3984 by commercial cutters and 8505 by domestic cutters (DNRE 2002a). The largest amount came from Gunbower, Guttrum and Benwell state forests (5730 m^3). The amount collected illegally from state forests is unknown but thought to be substantial (DNRE 2002c).

Very little firewood is taken from public land in the two remaining Forest Management Areas partly within the River Red Gum Forests study area, i.e. Bendigo and North East FMAs.

Domestic firewood collectors (those seeking to collect firewood for their own use) on public land must hold a 'C' licence (see above). These are generally limited to one trailer load, for one day, with conditions and a map specifying the area from which the wood may be taken. Retail outlets in some regions of the state are authorised to sell firewood permits to domestic collectors on behalf of DSE. Firewood for domestic use from state forest is usually licensed by the cubic metre, and the cost (non-concession) ranges between \$9.50 and \$25.25 per m^3 (2005–2006 prices) depending on the Forest Management Area and the zone (DSE 2005d).

Recreational users of the forest (particularly campers) also collect firewood for use *in situ* and large volumes are collected from state forest in the study area, particularly from sites close to the Murray River. For the Barmah forest, for instance, an estimated 5000 tonnes is collected by campers over the summer holiday period (DNRE 2002a). In some cases, campers have used vehicles to drag large-dimension wood to their campsites. Some firewood may also be produced in parks and other reserves in the course of infrastructure, fire prevention and safety works. In parks, visitors are usually requested to bring their own firewood or alternative heating; although this is limited in effectiveness (DNRE 2002c).

More than 181,000 people (both commercial and domestic) collect firewood each year from both public and private land in Victoria, some 99 percent of whom are domestic collectors who collect about 66 percent of the firewood consumed (DNRE 2002c). Only 8.8 percent of people involved in domestic firewood collection carry a departmental permit—about half of these are concession card carriers (pensioners, war veterans and widows and holders of health care cards).

Factors Affecting the Amount of Firewood Burnt

A number of factors affect the amount of firewood burnt, and hence, the amount and species collected. Hardwoods are the current firewood of choice in all Australian cities, even where there are large softwood resources and almost no local hardwood supplies (Driscoll et al. 2000). The quality of firewood can vary and the popularity of river red gum firewood indicates that many purchasers prefer dense, dry wood.

The type of wood will affect how much heat it releases. In terms of heat released per kilogram of wood ("calorific value"), hardwoods produce slightly more

BOX 14.2: FIREWOOD SOURCES IN VICTORIA

Of the estimated 620,000 tonnes of firewood consumed in Victorian households each year:

- 50% (310,000 tonnes) comes from private property
- 10% (62,000 tonnes) is collected legally from Victorian state forest; of which:
- 4% (23,600 tonnes) is under commercial licence, and
- 6% (38,400 tonnes) is under domestic licence
- 10% (62,000 tonnes) is collected illegally from public land
- 30% (186,000 tonnes) comes from other sources, including interstate (DNRE 2002c).

A significant volume is also collected and burned *in situ* at campsites throughout public land in the state—in Barmah forest alone, an estimated 5000 tonnes is collected by campers over the summer holiday period (DNRE 2002f).

than softwoods (20 MJ/kg v 19 MJ/kg) (Todd 2003). Plantation-grown sugar gum has similar calorific values as natural-grown river red gum and could be used to complement or substitute for firewood production from native forests (DNRE 2002c). However, the moisture content of the firewood is also a contributing factor. Poorly dried river red gum (hardwood) can release the same amount of energy per kilogram as well-dried radiata pine (DNRE 2002c).

Wood density varies between species, between provenances of a particular species and with growth rates and tree age. Density of Tasmanian blue gum wood, for example, ranges between 550 kg/m^3 and 600 kg/m^3 for 12- and 20-year-old plantation-grown trees respectively, and to 800 kg/m^3 in natural forest-grown wood (DNRE 2002c).

The amount of firewood burnt is in part determined by the design of the heater and home. On average, an open fire will burn five times the amount of wood per year as a combustion heater to heat an average house (DNRE 2002c). There are around 800,000 woodheaters and 700,000 fireplaces in Australia (Driscoll et al. 2000). Some, but not all, combustion heaters are designed to heat efficiently with both hardwood and softwood fuel provided they are used appropriately (Todd 2003).

The Impact of Emissions

Woodheaters and fireplaces are the major sources of particle emissions in the southern cities in the colder months and are responsible for those cities regularly exceeding the National Ambient Air Quality Standard for particles set under the Ambient National Environment Protection Measure (Todd 2003). In 1995–96, wood heaters and open fires contributed an estimated 70 percent of fine particulate emissions (DNRE 2002c). Human exposure to elevated particle levels is linked to heart and lung disease. Wood-smoke pollution may reduce the amenity of small town living. The key factors contributing to the inefficient use of firewood relate to incomplete combustion arising from:

- use of unseasoned firewood—excessive moisture contained in green or wet wood
- less-efficient woodheater technology—slow combustion woodheater models vary greatly and open fireplaces are much less efficient
- poor operating behaviour—insufficient air intake can lead to insufficient air mixing (DEH 2006).

The Australian Standard for wood heating appliances (AS 4013) was introduced in 1992 to reduce impacts on air quality and the environment (DEH 2004). In 1994 in Launceston, approximately 66 percent of households used wood for heating and, although the percentage had dropped to 45 percent in 2000, woodsmoke pollution was still above acceptable limits. Programs to reduce wood smoke pollution by increasing the conversion rate from wood heaters to gas heaters and educating wood heater users were put in place. The percentage of households using woodheaters reduced to approximately 30 percent in 2004 and have been successful in reducing pollution in some areas (CSIRO Atmospheric Research 2005). This reduction was driven by an increased awareness of the problems of woodsmoke and by a desire for more convenient sources of heat.

Burning firewood also results in greenhouse gas emissions. The extent of the net impact on those emissions depends largely on the source of the firewood. Cutting firewood from private property without replacing the trees, for instance, makes a 100 percent contribution to greenhouse gases. However, the amount of carbon dioxide released is "at least matched" by the amount of sequestered carbon as a replacement tree grows (DNRE 2002c). Thus, plantations established for firewood production can be regarded as carbon sinks for as long as the plantation area is increasing; once the final area is achieved, they would be close to emission-neutral. Firewood from sustainably managed forests could be reducing net greenhouse emissions if replacing fossil fuel based heating sources.

Firewood and Habitat Degradation

Fallen timber is an important structural element in forests. Many animals, plants and fungi species rely on fallen timber for shelter, foraging habitat and nutrient cycling, refuge from predation and the larger pieces provide a structure to trap fine debris, sediments and nutrients providing microhabitat (Mac Nally et al. 2002). Fallen timber is also important during floods as it provides vital habitat for fish and aquatic invertebrates. The removal of fallen timber for firewood impacts greatly on many species and is one of the major threatening processes for threatened carpet pythons and grey-crowned babblers (Davidson & Robinson 1992; Heard et al. 2004). Strategies have been devised to reduce the impacts of firewood collection on the environment (see below). The impacts of firewood collection on faunal habitat are further discussed in chapter 5.

Future Demand for Firewood

The demand for firewood is based on the level of heating required to warm homes. Improved home energy efficiency would reduce the need for heating and, in the case of woodheaters, firewood consumption (DEH 2006). All levels of Australian governments have initiated actions to improve the energy efficiency of homes for a range of reasons, including reducing greenhouse gas emissions. Actions include incorporating energy-efficient measures into the Building Code of Australia and energy efficiency ratings schemes, which provide requirements or incentives in relation to factors such as insulation and house orientation (DEH 2006).

Reticulation of natural gas continues to be extended providing a cheap alternative to woodheaters. Nevertheless natural gas is a fossil fuel and contributor of greenhouse gas emissions. Despite large reserves, natural gas resources are ultimately limited and Australia is currently exporting natural gas overseas.

Greater use of alternative fuel sources, such as softwood or manufactured fuels, would lessen the amount of firewood collected. However, at present, most woodheater models are certified to meet the Australian Standard (AS 4013) for flue gas emissions on the basis of burning hardwoods only. Given the limited demand for 'softwood certified' heaters, there is currently no incentive for manufacturers to invest in extra tests, which cost about $5000 each, for other fuel types (DEH 2006).

A number of factors, including the cost and availability of firewood and of alternative fuels, will influence future firewood demand. However, it seems clear that demand for firewood will continue into the future. To ensure an ecologically sustainable supply, a broad range of options needs to be considered, including increased use of firewood from plantations, wood waste (from sawmills, manufacturing, demolition sites, arboriculture and households) and residues from silvicultural operations. Although value-adding in the timber industry is continually finding new products, waste will always be generated. Whereas sawmill waste was previously burned, the strong market for river red gum firewood means that these wastes are now sold. In many areas, current demand for firewood outstrips sustainable supplies and the development of alternative fuel and/or heating systems is likely to be needed in the future.

Policy

Firewood collection in state forest comes under the policies and legislation discussed earlier in this chapter. However, the combination of a high proportion of firewood collected from private land and the high proportion being taken by individuals and part-time operators makes the firewood industry very difficult to regulate. Recently, two strategies have been released with the objective of reducing the impacts of firewood collection.

The Australia and New Zealand Environment and Conservation Council developed a *National Approach to Firewood Collection and Use in Australia*. It aims to 'ensure that all firewood collection occurs on an ecologically sustainable basis and is not a cause of loss and degradation of remnant and woodland ecosystems or the habitats of threatened species' (ANZECC 2001). This document recognises six major strategies to achieve its objectives:

- improve the information base
- educate the community
- implement market mechanisms
- increase effectiveness of regulations
- develop a sustainable firewood industry, encouraging plantations, sustainable management of native forest and use of residues
- improve efficiency of firewood use and encourage alternatives.

Following consultation with firewood merchants and state and territory governments, the Natural Resource Management Ministerial Council, on 1 August 2005, endorsed a revised voluntary code of practice for firewood merchants. The code promotes a more environmentally friendly firewood industry and will underpin a sustainable future for the industry. Merchants who sign up to the code will:

- ensure firewood they sell is collected in accordance with relevant legislation and regulations
- promote firewood sourced from plantations and sustainably managed forests
- ensure firewood will not be collected from areas where collection may have a significant impact on listed threatened species or listed threatened ecological communities
- promote good storage and burning practices and the use of seasoned firewood to minimise air pollution (NRMMC 2005).

PLANTATIONS

On-farm timber plantations in lower rainfall areas provide economic benefits as windbreaks and shelterbelts for livestock and for lowering groundwater tables and reducing salinity. They provide environmental benefits through greenhouse gas abatement and the provision of faunal habitat, as well as general amenity. Extensive areas of private property in the Murray River hinterland are suited to agroforestry systems and community based woodlots for the production of substitutes for some of the small-dimension products yielded from native forests, such as fence posts and firewood. But sawlog production requires a much longer timeframe and, in the north of the state, tree growth is slow and productivity is low.

Establishment of commercial plantations necessitates detailed economic analysis. Important considerations in such analyses would include water volumes and costs, irrigation infrastructure costs, land costs, site productivity, values of the products and proximity to markets and the competitive position relative to alternative crops or land uses. The effect of insect predation on the growth rates of native species is also an important factor (Arnold et al. 1999).

The quality of relatively fast-grown, pruned, plantation timbers is likely to differ markedly from that of slow-grown, older, natural forests and would probably be directed to different applications. The density of timber from fast-grown trees is lower, for instance, and knots are larger than in comparatively sized trees from natural forests (Yang & Waugh 1996a, b). Nevertheless, Yang and Waugh (1996a) found that the strength properties of clear wood from plantation-grown blue gum were not inferior to those from mature forests when differences in tree size and age are taken into consideration. They believed that it could be used for structural sawn products in applications where plantation-grown softwoods are now used. The strength properties of plantation-grown shining gum and mountain ash, however, were lower than that of these species from native forests (Yang & Waugh 1996b).

Several investigations into the ability of plantation-grown eucalypts to produce quality sawn timbers have been undertaken. Plantations of species other than river red gum can achieve better productivity values than those for native river red gum forests but even the more productive species grown on 30-year rotations have thus far been found to be economically unviable for sawn products. The following are examples of the range of values for wood productivity measured or estimated for eucalypt plantations in southern Australia:

- 20 m^3/ha/yr (estimated) for Tasmanian blue gum grown in Gippsland (DNRE 2002c);
- 17.8 m^3/ha/yr (measured) for Tasmanian blue gum grown under an intensive thinning and fertilisation regime near Busselton in southwest Western Australia—with more than 800 mm per annum rainfall (Brennan et al. 2004);
- 16 m^3/ha/yr (estimated) for hardwood plantations east of the Hume Freeway in the upper catchments of the Murray and Goulburn rivers where the annual rainfall is more than 700 mm (Wareing et al. 2002);
- 12 m^3/ha/yr (estimated) for a Sugar Gum plantation growing in the 600–650 mm rainfall zone in Victoria (DNRE 2002c);
- 4.5–4.9 m^3/ha/yr (measured) for Sugar Gum plantations growing at the You Yangs in Victoria in the 450–500 mm rainfall zone (Dexter & Poynter 2005).

For comparison, softwood plantations in the north east of Victoria can grow at about 19 m^3/ha/yr (Wareing et al. 2002).

River red gums are inclined to branch (the species has poor apical dominance) rather than being dominated by a single central stem as is the case in many other eucalypts. The bole tends to beak into branches early, leading to short trunks, multiple stems and large branches (Jacobs 1955). This effect is pronounced at the conventional plantation stocking rate of 1000 stems per hectare (Dexter & Poynter 2005). To achieve a well-stocked plantation of trees of good form, river red gum plantations would need to be at close spacing or direct seeded (natural stands carry more than 3000 stems per ha at age eight—see above) to discourage side branching. Planting at such densities requires thinning and stem selection, which is labour intensive and expensive.

Because it is adapted to arid and semi-arid environments, river red gum has been planted widely in countries around the world where it is used as a source of posts, poles, firewood, pulp and to a lesser extent saw timber (Mazanec 1999). As with plantations of exotic species in Australia, river red gum can be much more productive when planted overseas. This is principally because exotic species are less affected by endemic insects and diseases. Plantation species overseas, however, are also selected for their desired characteristics and are more intensively managed. In California, for example, river red gum planted for fibre production is yielding up to 45 m^3/ha/yr on eight-year rotations (Arnold et al. 1999). This particular plantation was subject to intensive site preparation, fertilisation and frequent drip irrigation scheduled on the basis of evapotranspiration estimates and tree age, and comprises tissue-cultured clones that were intensively selected and tested for vigour, straightness, cold tolerance and wood quality. In contrast, following investigation of the potential of river red gum for farm forestry in Western Australia, Mazanec (1999) concluded that, to date, relatively poor growth rates and poor form have rendered it a non-commercial proposition.

Even under optimal watering conditions, stands of river red gum managed primarily for timber production (similar to plantation conditions) would yield only 4.35 m^3/ha/yr (2.5 m^3/ha/yr in sawlog-quality material) (see Appendix 16). It would also take at least 40–50 years to produce sufficient trees of merchantable size and wood quality to warrant economic harvesting (Dexter & Poynter 2005). To be commercially viable in the 250–450 mm rainfall zone of northern Victoria, timber plantations would require access to water, which is a limited resource in the region and in strong demand for more profitable short-term crops (see chapter 15).

In recognition of the poor plantation potential of most species grown under low rainfall, hybrid eucalypts that can combine an ability to tolerate drought and salinity with the superior growth characteristics of noted plantation species are being developed. A river red gum–blue gum hybrid is under trial in north-central Victoria but plantings are too young to indicate its success and it will be decades before its ultimate survival, growth and wood quality are known (Dexter & Poynter 2005).

However, although there has been increasing interest in the prospects of commercially irrigated eucalypt plantations in the southern Murray–Darling Basin, few such plantations exist in that region which can provide instructive models. The high rates of evapotranspiration associated with dense rapidly growing plantations has led to their use for reducing soil moisture, such where sewage and other urban and industrial effluent is discharged, irrigation drainage sites and where the groundwater table is shallow. Sydney blue gum and flooded gum species have relatively high water requirements due to their high rates of growth and have been established on such sites in the northeast of the state to reduce the environmental impact of nutrient-rich runoff on river systems. These plantings are generally owned by either private landowners in irrigation areas or water management authorities. Plantations for effluent disposal have been established at Shepparton, Wangaratta and Wodonga and further plantings can be expected (Wareing et al. 2002). Plantations established for the re-use of industrial, agricultural or other effluent are often simply allowed to grow with little management.

Small plantations (averaging 10–15 ha) of mainly blue gum and shining gum are scattered through the central and northeastern parts of Victoria's Murray and Goulburn river catchments (600–800 mm rainfall zone). Totalling about 1600 ha, most are owned by private individuals (members of the FFORNE Hardwood Growers Co-op) and were established with the assistance of financial incentives from the Victorian Government through the 1996–98 North East Farm Forestry Project. These plantations will probably be managed for sawlog production and, although they may produce some pulpwood from thinnings, are not expected to be ready

for final harvesting until at least 2020. The largest concentrations of FFORNE plantations are located in the Delatite (now Mansfield and Benalla) and Murrindindi Shires and Wangaratta Rural City. The rate of expansion appears to have lost impetus, however, in the absence of further financial incentives and the establishment of plantations for pulp-log production closer to port facilities (Wareing et al. 2002).

Environmental Services

Many of the substitutes for wood products are demanding on energy and water and the wastes and other emissions produced in their manufacture have further environmental impacts. Timber, on the other hand, is an environmentally friendly resource. It is energy-efficient, recyclable, biodegradable and a naturally renewable resource and requires less energy to process than other building materials such as bricks, cement, plastic, glass, steel and aluminium (Pearson 1989).

The value of thinning and other silvicultural practices to, for example, reduce the severity of insect attack or to reduce the numbers of trees in stands that are stressed and dying from salinity, inappropriate watering and drought is discussed above. The potential benefits of firewood for reducing greenhouse gas emissions are also described above.

Specific silvicultural regimes can be applied in the river red gum forests to maintain or improve habitat value, by:

- improving structural diversity;
- promoting river red gum regeneration to provide or restore roosting sites for colonially nesting waterbirds;
- improving roosting and nesting opportunities for birds, through thinning of dense stands to accelerate the development of heavier branching in the retained trees;
- preventing or reversing forest encroachment onto moira grass plains, through suppression or removal of river red gum regeneration.

Each of these can be undertaken through specific silvicultural operations and, in some cases, wood products may be harvestable (DNRE 2002a).

As with plantations, native forests have a substantial role in reducing the greenhouse effect through the sequestration of carbon from the atmosphere. Regenerating forests absorb a greater amount of carbon than senescent forests (DSE 2005h). This effect continues for as long as they are growing but the rate reduces as the forests mature until the stage when growth and decay are in balance. During senescence, when the rate of decay exceeds that of growth, the forest becomes a net emitter of carbon dioxide.

Forests managed sustainably for the production of timber are regarded as greenhouse 'sinks' as the amount of carbon they sequester exceeds that released during harvesting. Further, following harvesting, carbon remains in the wood for the lifespan of the end product (DSE 2005h). The wooden frame of a brick veneer house stores up to 7.5 tonnes of carbon while a steel frame for a similar house adds 2.9 tonnes of carbon to the atmosphere through the use of fossil fuels for energy to produce the steel (Turner 1989). High quality river red gum furniture is thought to have a service life of 200 years, general construction timbers might remain in use for 80 to 100 years, while sleepers have a 30-year service life, after which they may be used in landscaping for a further 20 years (Dexter & Poynter 2005).

Australia imports some $4.9 billion of forest products, an estimated $450 million of which derives from illegal logging operations and almost half of that (about $214 million) is in the form of furniture (Hopkins 2006). Furniture produced from timbers grown within Australia reduces some of the demand for imported timbers and, although the volume is small compared to that from other native timbers, quality furniture produced from river red gum reduces some of the demand for imported red timbers, such as merbau.

15 Water Resource Use and Environmental Flows

This chapter considers the regulation of the River Murray for irrigation, the consequential impacts on the environment, and the use of managed water flows to achieve environmental outcomes on public land.

The hydrology of the River Murray basin under natural conditions is outlined in chapter 4. That chapter also describes how the natural systems of the river and its floodplain evolved with the unique flow and flood regimes of the river—cycles of wet and dry and different flood types.

During the last 100 years the River Murray and its Victorian tributaries have been modified extensively by humans for economic development and expansion—mostly agriculture (see chapter 13). Most of this economic activity is on private land and is therefore outside the scope of this study. However, modifying natural river flows for water consumption on private land has resulted in significant ongoing environmental, social and economic costs for public land in the study area (see chapters 5, 6, 11, 13 and 14). It has also meant the development of a highly complex network of water regulation infrastructure and management systems and processes around the consumption of water. Current approaches to addressing environmental degradation of the river red gum forests involve utilising that existing river regulation infrastructure.

In previous investigations, VEAC and its predecessors have focused principally on recommending the appropriate category for each area of public land under consideration. Relatively little emphasis has been given to processes and other factors that are not specific to particular public land areas. This Investigation differs significantly from many earlier studies, because river flows and flooding regimes play an important role in the sustainability of ecosystems and local economies. In particular, the provision of environmental flows to sustain the study area's forests, wetlands and waterways is perhaps the most significant determinant of environmental health of public land, and cannot be disregarded by VEAC. At the same time, the ppossibility of reduced availability of water for irrigation—especially as a result of climate change—is perhaps the largest potential economic issue in the study area.

Understanding how the River Murray and its tributaries are regulated for water consumption is important because regulation influences and constrains how managed flows for environmental outcomes are delivered to the floodplain forests and wetlands. This chapter (to be read in conjunction with chapters 4 and 5) therefore examines:

- how the River Murray is regulated,
- the administrative arrangements associated with river regulation within the context of the River Murray being owned by New South Wales (NSW) and the water shared by NSW, Victoria and South Australia (SA),
- the use of environmental flows as a management tool to achieve environmental outcomes,
- the administrative arrangements associated with environmental flows, and
- briefly, the issues of water accounting and climate change in the context of environmental flows.

The issues under discussion relate primarily to the study area and this chapter is not a comprehensive description of water arrangements in Victoria or the Murray-Darling Basin.

ADMINISTRATION OF WATER USE

The River Murray and its Victorian tributaries is managed by a complex set of administrative arrangements to deliver water to consumers. This Investigation is mainly interested in the administrative arrangements around how water is allocated to consumptive users and how these arrangements impact on water allocations for the river red gum forests in the study area.

Murray-Darling Basin Agreement

Underpinning all arrangements for allocating water from the River Murray is the *Murray-Darling Basin Agreement*. This Agreement (1992) details the roles and responsibilities of the Murray-Darling Basin Ministerial Council and the Murray-Darling Basin Commission, as well as the monitoring and investigation requirements, operational management arrangements, financial management responsibilities and water distribution including water accounting arrangements. The Agreement clearly spells out each state's entitlement and the obligations of NSW and Victoria to SA. This detailed and lengthy document is available on the Murray-Darling Basin Commission website.

As well as the *Murray-Darling Basin Agreement* there is also the National Water Initiative Agreement (2004), signed by the Commonwealth, NSW, Victorian, Queensland, South Australian, Australian Capital Territory and Northern Territory governments. The agreement is intended to be consistent with the *Murray-Darling Basin Agreement* and specifies a set of outcomes and commitments that focus on achieving more efficient and effective water planning and allocation arrangements, building knowledge and capacity and community partnerships and adjustments for jurisdiction associated with the Murray-Darling Basin. It also articulates an integrated management approach to water to ensure environmental and other public benefit outcomes are gained.

Murray-Darling Basin Diversion Cap

As well as these two agreements water from the River Murray system is subjected to the Murray-Darling Basin Cap. This was introduced in 1995 by the Murray-Darling Basin Ministerial Council following a water audit of all rivers in the basin. The Cap limits the amount of water that can be extracted from the Murray-Darling Basin rivers. In regulated rivers diversion is limited to what would have been diverted under 1993-1994 levels of development. In unregulated rivers the Cap is expressed as an end-of-catchment flow regime. The Cap attempts to balance economic and social benefits obtained from water resources and the environmental uses of water in the rivers (MDBC 2002).

For Victorian rivers, the long term diversion Cap is:

- Goulburn, Loddon and Broken Rivers, 2,084 GL per year. These rivers are important sources of inflows for the River Murray system;
- Upper Murray, Kiewa and Ovens Rivers, 1,656 GL per year. These rivers are important sources of inflows for the River Murray system;
- Campaspe River, 122 GL per year; and
- Wimmera and Mallee Rivers, 162 GL per year. These rivers (refer to chapter 4) contribute little or no water to the River Murray system (MDBC 2002).

Although the Cap prevents increases in water diversion, it does not constrain new developments provided the water is obtained by using water more efficiently from an existing entitlement or by purchasing someone else's entitlement. The Cap is a ten year rolling average that allows extracted volumes to be adjusted to take account of water traded between river basins and states. Compliance is assessed by the Murray-Darling Basin Commission's Independent Audit Group, which prepares an annual review of Cap compliance containing preliminary findings, followed by a Water Audit Monitoring Report.

Water Allocation Framework

The principles upon which water allocation is based are described in Box 15.1.

Victoria's water allocation framework includes a three tiered allocation system. The first tier nominates that government retains the overall right to the use, flow and control of all surface and groundwater on behalf of all Victorians. Under the new water legislation the rights of the Crown are extended to include stormwater and recycled water.

The second tier relates to the Minister making large scale or bulk entitlements for both consumption and environmental uses. This tier incorporates the allocation of water for consumption through bulk entitlements and ceilings on total water use from each catchment or aquifer and for the environment through the new Environmental Water Reserve (see below). It allows for other non-consumptive uses to be taken into account, such as recreation.

The third tier is the allocation of rights to private individuals for consumption. These include water entitlements such as water rights, licences and private rights and allocation for households and for rural domestic and stock uses. Figure 15.1 illustrates this three tiered arrangement for water allocation.

Agencies Involved in the Water Allocation Framework

National Level Agencies

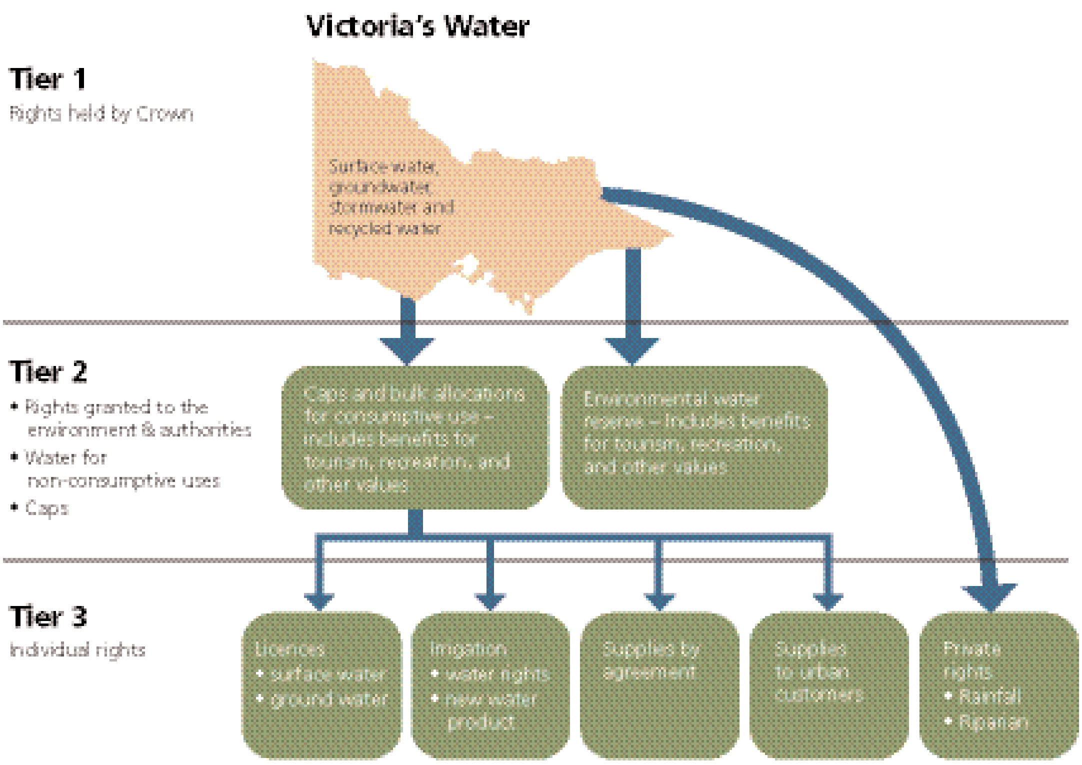
The Murray-Darling Basin Ministerial Council whose membership includes ministerial representation from the Federal, NSW, Victorian, South Australian, Queensland and Australian Capital Territory governments provides overall strategic direction and decision making around the natural resources of the Murray-Darling Basin. The Murray-Darling Basin Commission is the agency responsible for managing the water resources of the Murray-Darling Basin on behalf of Victoria, NSW and SA. River Murray Water is the operational arm of the Commission and undertakes most of the modelling and decision making processes around the three operation modes described below. The operation of Lake Dartmouth, Lake Hume, the Menindee Lakes and Lake Victoria is managed by River Murray Water.

Box 15.1 Victoria's Principles for Water Allocation

In Victoria, the *Water Act 1989* and more recently the *Water (Resource Management) Act 2005* provides the legislative framework for the allocation of Victoria's water resources. Allocation is based on a set of principles that include:

- The Victorian Government is responsible for:
  - the sustainable management of the state's water resources;
  - the allocation of water resources for irrigation, urban use, the environment and for all other purposes; and
  - establishing and maintaining the integrity of the state's water allocation system.
- The state's water allocation system encompasses all water resources, including surface water, groundwater, recycled water and stormwater.
- Water will be set aside in an Environmental Water Reserve (outlined below) that will:
  - maintain the environmental values of the water system and the other environmentally dependent water services;
  - sustain biodiversity, ecological functioning and water quality; and
  - have legal status and be held by the Crown.
- In establishing the initial Environmental Water Reserve, the rights of existing entitlement holders will be recognised.
- Water entitlements for consumption will:
  - have secure tenure;
  - aim to provide reliable water supplies;
  - link the entitlement to a share of the total amount of water available for consumption at any time;
  - specify the obligations associated with holding the entitlement; and
  - be allocated by market mechanisms, wherever possible, and be allowed to trade between entitlement holders.
- All water allocation decisions will take into account the availability of water for the diversity of non-consumptive water uses valued by the community.
- Management of the water allocation system will be adaptive – responding to changing demands, community expectations and new knowledge, whilst ensuring the objectives of Environmental Water Reserves are being met.

Figure 15.1 Victoria's water allocation system.



Source: DSE (2004i)

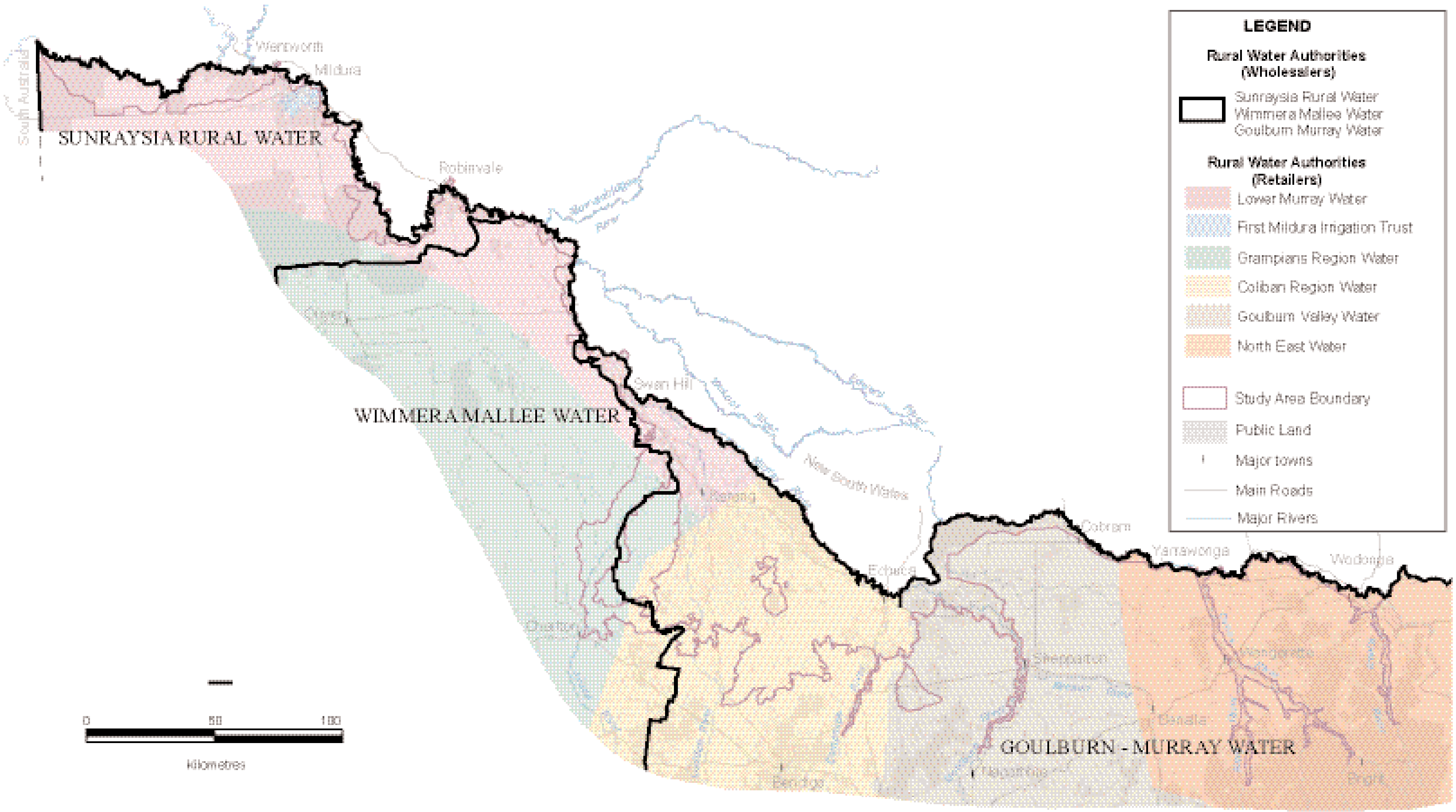
State Agencies

Various water authorities operate the water supply storages in the Murray Basin on behalf of River Murray Water. Goulburn-Murray Water (GMW) operates Dartmouth Dam in Victoria, Yarrawonga Weir (Lake Mulwala), Torrumbarry Weir and Mildura Weir (Lock 11) on behalf of River Murray Water. State Water in NSW operates Lake Hume and the Menindee Lakes and the South Australian Water Corporation operates Lake Victoria and locks downstream of Lock 11.

Victoria shares the volume in the storages with New South Wales under the Murray-Darling Basin Agreement, which grants Victoria a share of the total reservoir capacity to store and release its share of inflows. GMW is responsible for allocating water to bulk entitlement holders from Victoria's share of the water supply storages in the River Murray system. GMW also manages the storages on Victorian tributaries to the River Murray in its own right.

In terms of irrigation systems GMW is responsible for the Murray Valley, Torrumbarry, Tresco and Nyah irrigation areas, and is the licensing authority for groundwater and surface water on the Victorian side of the River Murray basin as far downstream as Nyah. Lower Murray Water (formerly Sunraysia Rural Water Authority) is responsible for managing Red Cliffs, Robinvale and Merbein Irrigation Districts, and is the licensing authority for private diversion of irrigation between Nyah and the South Australian border. The First Mildura Irrigation Trust supplies irrigation water within its district near Mildura.

Map 15.1 **Water authorities in the study area.**



Various urban water authorities manage town water supplies drawn from the River Murray. North-East Water manages water supply to towns upstream of Lake Mulwala, including Yarrawonga. Goulburn Valley Water manages water supply to towns in the Murray Valley Irrigation Area, while Coliban Water supplies towns in the Torrumbarry Irrigation Area. Lower Murray Water supplies towns from Kerang to the South Australian border (DSE 2006i). Map 15.1 shows the location of water authorities in the study area. Water authorities are also referred to in chapters 9 and 17.

Waterway management functions of Victorian River Murray tributaries reside with the North East, the Goulburn Broken, the North Central and the Mallee Catchment Management Authorities, with the Department of Sustainability and Environment (DSE) and the Murray-Darling Basin Commission coordinating and integrating waterway management along the length of the River Murray. Catchment management authorities (CMAs) also play a major role in floodplain management, environmental flows and in biodiversity management.

Local governments use zoning under the *Planning and Environment Act 1987* to exclude certain land uses that may impact on water quality or where land is subjected to regular flooding. They are also involved in floodplain management activities and stormwater management, including drainage, protection of water quality and restoration of degraded rivers.

Water Accounting

In 2004 the Victorian Government published the Water White Paper to guide the future use of water in Victoria. A major platform of the White Paper is the delivery of water in a more efficient and effective manner, particularly with respect to irrigation practices, but also for environmental flows.

A key aspect of this water delivery involves the development of water accounting systems to clearly identify the stock of water, where it is available from and how much is delivered and where. Efforts are being made at both the national and state level to develop a water accounting system. The Federal Government's National Water Initiative proposes a water accounting framework for the whole of the terrestrial phase of the water cycle, to enable aggregation to a national level. Work is also being conducted into developing national water accounting standards, which are being incorporated into Victoria's State Water Accounts. However, given the many complexities in water resource management, there are many challenges involved in establishing a meaningful state and national water accounting system (DSE 2006i).

Water accounting is used to describe the record keeping and reporting of all water flows and water entitlement transactions associated with the management, allocation and use of water resources. Accounting for water parallels financial accounting in that there are equivalent seasons and year end statements and reports (DSE 2006i).

For accounting purposes the environment's rights to water in rivers falls into two classes, each of which needs to be treated separately in order to develop a consistent accounting system:

- extractive rights. These are entitlements to discrete volumes of water in regulated water systems that can be used at the discretion of the environmental manager for, say, watering a wetland; and
- in-stream rights. This component of the environment's share of flow in a river includes flows maintained by a water authority as an obligation, and above-cap water. The timing of these flows is determined by rules in water authorities' bulk entitlements and flows in river systems, for example in response to rain when a reservoir spills (DSE 2006i).

A limitation of any water accounting system is its inability to report on the ecological effectiveness of environmental flows for rivers, wetlands and aquifers, particularly across time. As well, the State Water Report does not cover reporting of ecological effectiveness and outcomes on environmental flows. In response to these reporting gaps DSE has commissioned the Water Co-operative Research Centre to initiate an ecological monitoring program to assess the outcomes of the use of environmental water. These outcomes will be reported on separately to the current State Water Report once the ecological monitoring program is implemented (DSE 2006i).

Long-term benefits and improvements in the health of Victoria's rivers through environmental flows should, however, be evident in the 5 yearly state of the environment report produced by the Victorian Commissioner for Environmental Sustainability and the Victorian Catchment Management Council's 5 yearly catchment condition report. Such improvements should also, over the long term, contribute to improvements in the health of the River Murray system.

An accounting system may assist with clarification in situations where environmental flows are used to water wetlands (an amount taken from the water system), but where the excess water flows back into the main river system and may be available for other uses downstream. An accounting system may also be a useful management tool to determine environmental flow allocations and where there are multiple or joint beneficiaries such as

Figures 15.3 Lake Hume.

timber production (DSE 2006i).

REGULATION OF THE RIVER MURRAY

History of Regulation

Since European settlement in the River Murray Basin area, people have actively modified the natural flooding and flow of the river on a large scale. First efforts at regulation included construction of levees in the early 19th century for flood control and basic irrigation. This was followed around the early 1850s by flow regulation to enable commercial navigational use of the river. In the 1870s, the first use of the river for major irrigation systems began around Kerang, Victoria (see chapter 7 for details of the history of irrigation and its role in land development in northern Victoria).

However, further expansion of irrigation was difficult because of the variability of river flows and serious droughts in the late 1890s and early 1900s. The problem of drought needed to be overcome by levelling out the natural flow peaks and troughs across the seasons and years and making more water available during summer and times of drought—in effect an 'insurance policy'. Construction of permanent infrastructure systems to hold greater volumes of water over seasons and years and deliver water in a more reliable and predictable manner provided the answer to this problem.

Figure 15.2 The renowned Furphy water cart used to transport water.

The history of river regulation is closely tied to the use of water to promote closer land settlement across northern Victoria during the 1930s depression years and following the two World Wars. Implementation of these land settlement patterns was dependent on a readily available and long-term secure water supply (see chapter 7).

The expansion of irrigation in northern Victoria and southern NSW increased the demand by both states for reliable access to water from the River Murray. To manage the competing demands of the two states the *River Murray Waters Agreement* (the Agreement) was signed in 1915. In 1996 Queensland also signed the Agreement which remains in place today, with amendments in 1987, and 1992 (Gippel & Blackham 2002).

The basis of the initial Agreement was for NSW and Victoria to agree on river flow quantities at Albury for the purposes of irrigation development and navigation along the River Murray. Specifically the Agreement ensured that water flow was to be shared equally between NSW and Victoria and that Victoria and NSW retain control of their respective tributaries below Albury. In addition, Victoria and NSW agreed to supply SA with a minimum agreed 'entitlement'. Much of Adelaide's water is supplied from the River Murray via a pipeline from Morgan.

The Agreement also provided for construction of a

Table 15.1 Characteristics and capacities of key storages associated with the River Murray in Victoria

Storage Facility	Capacity	River	Purpose	Irrigation region serviced	Completion date
Hume Dam	3038 GL	Murray	Major storage for overall management of River Murray water levels Irrigation Hydro-electricity generation Flood mitigation Recreation	All regions sourcing water from the Murray system	1936
Yarrawonga Weir	118 GL (largest diversion weir on the River Murray system)	Murray	Irrigation - diverts around 1900 GL per year (17% of river's average annual flow) Power generation Recreation	Murray Valley Irrigation region of Victoria Distributes water to an area of 128,000 ha	1939
Torrumbarry Weir	36 GL	Murray	Navigation Irrigation Recreation	Torrumbarry Irrigation System around Cohuna, Kerang and Swan Hill	Reconstructed in 1996
Mildura Weir and Lock 11	36 GL	Murray	Navigation Irrigation		1927
Dartmouth Dam	3906 GL (largest capacity dam in Victoria)	Mitta Mitta	Irrigation Assists with maintaining base levels of overall flow of river Salinity flushing Recreation	All regions sourcing water from the Murray system	1979
Lake Eildon	3390 GL	Goulburn	Flood mitigation Power generation Irrigation Recreation	Goulburn-Murray Irrigation District	1955
Goulburn Weir	25 GL	Goulburn	Irrigation Flood mitigation Recreation	Goulburn Irrigation District	1891, redeveloped in 1987
Waranga Basin	411 GL	Goulburn	Irrigation Recreation	Goulburn Irrigation District	Re-development completed 1926

Notes: All storages in this table are operated by Goulburn-Murray Water. The power station at Yarrawonga Weir is now owned and operated remotely from New Zealand by Meridian Energy with a network link to the Goulburn-Murray Water weir office. Power was first generated in 1994 with a maximum power generation of nine megawatts.

system of storages, locks and weirs. The large storages were intended to capture and store the large flows generated in late winter and spring, for use in summer and autumn and to increase security of water supply. The smaller structures were to make the river navigable across seasons and years during times of low flows and by providing pools for gravity fed and pumped irrigation diversions. Later, the Agreement was amended to give preference to irrigation infrastructure rather than navigational needs as the latter declined. Since the first Agreement the following dams and structures have been constructed on the River Murray and its southern tributaries:

- Torrumbarry Weir
- Hume Dam
- Yarrawonga Weir
- Lake Eildon
- Lake Eppalock
- Snowy Mountain Scheme
- Dartmouth Dam
- Goulburn Weir (constructed 1891, redeveloped 1987)
- weirs for irrigation and navigational purposes at Mildura, and
- banks, weirs and channels on Menindee Lakes (NSW) to increase the capacity and prevent drainage and back flow up the Darling River.

Figures 15.4 Lock 7 weir between Mildura and the SA border.

Information including details on the capacity and completion dates of these structures is summarised in Table 15.1.

The Snowy Mountain Scheme was completed in 1974 and the Dartmouth Dam in 1979, both having been built to capture higher surface water run-off levels in the headwaters (see chapter 4), and increase the reliability of the flows over the seasons and across years along the entire length of the River Murray.

Dams and weirs on the Victorian tributaries of the River Murray include Lake Eildon (1955) and Goulburn Weir (1987) on the Goulburn River and Lake Eppalock (1964) on the Campaspe River. The Ovens River, with a small storage on each of its tributaries the Buffalo and King Rivers, remains the only substantial, unregulated tributary of the River Murray in Victoria. Dams and weirs are designed for the same purposes as those on the River Murray, to provide a secure and reliable water supply over time, principally for irrigation. The major dams, weirs and locks involved in the provision of water for irrigation along the River Murray and its tributaries are shown in Map D and briefly described in Table 15.1.

Major Victorian irrigation regions serviced by regulation of the River Murray and its tributaries include, the Rochester, Pyramid-Boort, Robinvale, Red Cliffs, Merbein and Mildura Irrigation districts and the Campaspe, Murray Valley and Torrumbarry Irrigation Areas. These irrigation areas are located in close proximity to the study area. The Murray Valley Irrigation Area is one of Victoria's largest irrigation regions and a major agricultural production area, including the Shepparton Irrigation Region. The Torrumbarry Irrigation Area is the only one in this list supplied by direct pumping from the River Murray rather than through gravity-fed delivery. Torrumbarry Weir is also the most upstream lock on the River Murray.

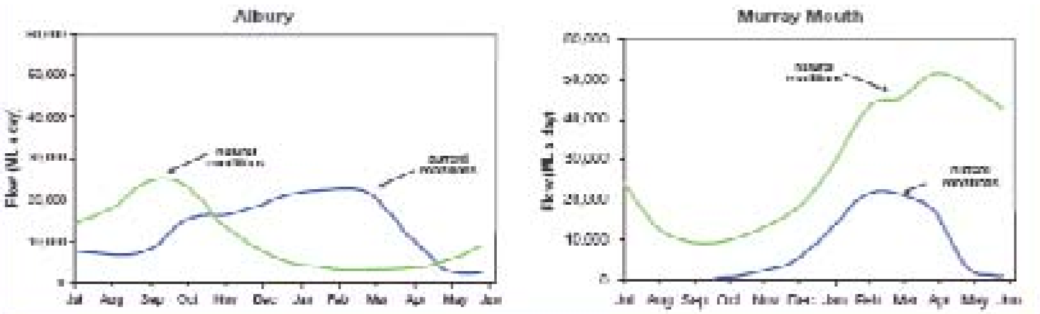
Economic Benefits of River Regulation

The extensive river regulation infrastructure developed across the Murray-Darling Basin has benefited both the communities of the Basin as well as Australia as a whole (see chapters 8 and 13). The Murray-Darling Basin produces around $10 billion of agricultural produce of which $3 billion is from irrigation. Around $75 billion a year is generated from the Basin towards the national economy (MDBC 2002).

As well as providing the basis for agriculture, river regulation provides natural assets for a range of recreation and tourism activities. For example, Lake Mulwala provides a water body well suited to water skiing and motor boat racing and the greater water flows in summer enable water leisure activities to occur in the warmer summer or early autumn months when natural flows would usually be too low. These activities and other tourism-associated activities are important to the Basin's economy and the River Red Gum Forests study area (see chapter 11).

While contributing overall to the region's economy, river regulation involves competing economic interests for water in terms of access by different water users, including the environment, and the timing of that access. For example, irrigators in the upstream regions of the River Murray may feel they have a priority to all water flowing past their region at any point in time,

Figure 15.5 River Murray flows under natural and current conditions at Albury and Murray Mouth.



Source: MDBC (2002)

however irrigators around Mildura or indeed, the population of Adelaide, believe that they too have an equal right to a reliable supply of water from the River Murray system throughout the year. Similar competing views exist between NSW irrigators compared with Victorian irrigators. Most of the organisational arrangements around water allocation discussed in this section relate to the management of these competing interests. Over recent decades, water for environmental purposes has become an increasingly important player in this competitive context.

Surface Water Diversion and Storage Operations

Water Diversions

The extensive network of dams, weirs and channels along the River Murray and its tributaries has the capacity to divert around 10,000 to 11,000 GL of water per year (see Map 15.2) from the rivers of the Murray-Darling Basin. This is twice the current average flow at the South Australian border. Its also provides a total storage capacity of approximately 29,500 GL which is more than double the average natural annual discharge at the river Murray mouth (see Figure 15.5).

Table 15.2 compares the natural and current median annual flows for the River Murray and its major Victorian tributaries. The table highlights the significant diversions of the natural water flows from the Goulburn, Broken, Loddon and Campaspe Rivers. The high percentages of the first three rivers result from high use of accumulated flows (Broken River), diversions from the Snowy River Scheme (Murray River at Albury) and relatively little regulation (Kiewa and Ovens Rivers) (Gippel & Blackham 2002). As mentioned in chapter 4 the Goulburn River was, under natural conditions, one of the major rivers contributing to the flows of the River Murray and a major source for the flooding of the River Murray floodplain below Barmah and for the lower Goulburn floodplains.

Surface run-off is at its maximum during late autumn through to early spring (see chapter 4). This is also the optimal timing for diverting surface water for storage purposes. Stored water is then released during the drier periods of the year—usually in late spring through to early autumn, resulting in changed flow regimes. These changed flows and flood regimes between natural and current conditions are shown is Figure 15.5. These figures highlight the shifts of peak flow periods in the River Murray in the upper reaches under natural conditions compared with regulated flows as well as illustrating the decline in flow volume for the river at the River Murray mouth. It also shows that the flow pattern over the seasons has not changed significantly with river

Table 15.2 Comparison of natural and current median annual flows for selected locations on the River Murray and its tributaries.

Location	Natural median flow (GL/yr)	Current median flow (GL/yr)	Current as percentage of natural flow %
Murray at Albury	4324	4832	112
Kiewa	566	560	99
Ovens	1399	1395	100
Murray at Yarrawonga	5590	3904	70
Goulburn	3208	1035	32
Broken	90	159	176
Campaspe	242	77	32
Loddon	188	50	27

Source: Gippel and Blackham (2002).

regulation at the River Murray mouth.

Water Storage Operations

Across the River Murray system there are eight major storages relevant to this Investigation (Table 15.1). Four are located on the River Murray itself. One, Dartmouth Dam, is on the Mitta Mitta River in Victoria and three are on the Goulburn River system (see Map D for the location of these storages).

There are two other lake systems associated with the River Murray regulation network—both of which were natural lakes—Lake Victoria and the Menindee Lakes. Lake Victoria has a capacity of 677 GL. Its major role is the delivery of uniform water supplies to South Australia in accordance with the requirements of the Agreement. Lake Victoria is downstream of all major tributaries of the River Murray and is therefore able to store water coming from any of these tributaries. This allows for SA's water needs to be met from Lake Victoria while other water in the River Murray system is used to supply consumers in Victoria and NSW during peak demand times. Lake Victoria also provides flexibility in the system to overcome some of the problems associated with the Barmah Choke as it is used to meet the flow shortfalls resulting from the physical constraints imposed by the Choke (as explained in chapter 4). The Lake is also used as a tool in the management of salinity levels in water for South Australia.

The Menindee Lakes system is on the Darling River. The Lakes system was developed and owned by the NSW government. In 1963 the NSW government agreed to lease the storage to the Murray-Darling Basin Commission to be used as part of the River Murray network. Its nominal full volume is 1731 GL but this is subject to the highly variable flow rates of the Darling River. Amongst other functions the Menindee Lakes system is used to augment flows in the River Murray to assist the supply of water to NSW, Victoria and South Australia.

All storages located on the River Murray are overseen by the Murray-Darling Basin Commission with River Murray Water having responsibility for operations. At an operational level decisions are made daily on what releases will be made from the various storages along the river. Release volumes and timing are based on meeting the needs of irrigators and flows for SA while also ensuring minimum flow requirements, dilution of salinity, maximum rates water level changes, and river channel capacity requirements. Goulburn-Murray Water implements these decisions as the water manager within Victoria for the Murray-Darling Basin Commission.

The three operating modes involved with running the River Murray system are described in the following paragraphs. This first is **supplying mode**. This mode occurs for most of the irrigation season, with releases occurring from early November through to mid-May each year (the irrigation season commences in August). During this time flow is set to meet consumptive water demands, including those of SA with little surplus over and above these demands. Factors influencing the level of supply to users include:

- river transmission losses and dilution flow requirements,
- the ability to use tributary flows such as flows coming down the Goulburn River,
- the feasibility of releasing water from Lake Victoria and transferring water from the Menindee Lakes to Lake Victoria to supply South Australia's entitlement flows, and from Dartmouth Dam to Hume Dam,
- channel capacity—a factor that varies considerably along the entire river system,
- maximum rates of rise and fall of river levels set to minimise bank slumping and other problems,
- maintaining minimum flows at key points in the river system,
- water reductions at upstream storages, while maintenance works are underway, so as to temporarily reduce flows at downstream storages, and
- releasing water for environmental purposes, such as maintaining flows to wetlands for waterbird breeding.

Storing mode is where the objectives of river operations are to manage excess flows in the system over above those required to meet diversions, water supply and minimum requirements. This mode also relates to maintaining released flows within the river channel. Storing usually occurs during winter and spring. During this time the majority of water in the River Murray originates from high flows in tributaries such as the Ovens, Kiewa and Goulburn Rivers. Decisions on whether to store or release water from storages are based on:

- the ability to capture surplus flows in Lake Victoria for subsequent release during supplying mode,
- making minimum releases from each storage,
- operation of forest regulators for forest watering purposes,
- monitoring tributary inflows, and advising stakeholders within sufficient time if channel capacity will be exceeded, and
- pre-releasing from Dartmouth Dam, Hume Dam and Menindee Lakes at rates up to the downstream capacity.

The third mode is **spilling,** where water is released from storages when they are full or nearly so and inflow rates are high as a result of rain. Such events usually occur in late winter and spring. Where these spills occur the resulting flows usually exceed the river's channel capacity. Decisions on whether to spill or not to spill are complex as flows vary depending on the volume of water already in the system and the capacity of the River Murray channel along its entire length (see chapter 4). For example, the channel capacity of the River Murray downstream of Dartmouth Dam is approximately 10 GL per day, between Hume Dam and Lake Mulwala (Yarrawonga Weir) it is approximately 25 GL per day, immediately downstream of Yarrawonga Weir channel capacity is approximately 60 GL per day and for Barmah Choke it is about 8.5 GL per day. As explained below channel capacity is a major factor influencing the scale of possible environmental flows.

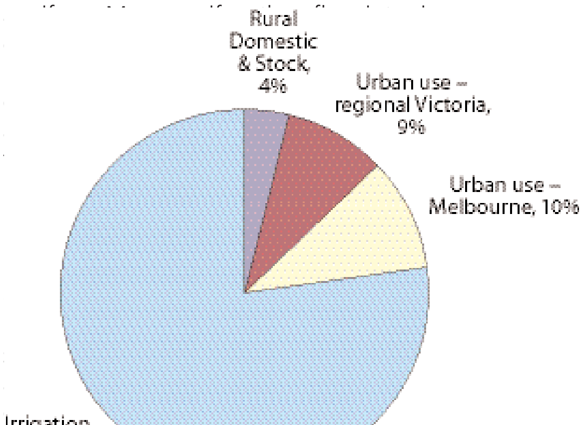
Groundwater

The groundwater systems of the Murray-Darling Basin are undergoing change. Groundwater levels are rising over most of the southern part of the basin as a result of two activities. Firstly, regional recharge rates are increasing as native vegetation is replaced with introduced species with shallower roots that do not utilise as much groundwater. And secondly, irrigation allows excess water to filter through beyond the plant root zone. This increase in infiltration causes aquifer levels and therefore pressures to rise.

The consequences of these processes have been the re-activation of natural groundwater discharge systems and an increase in groundwater flows to river and streams. This is accompanied by an increase in discharge of saline water into the rivers and streams and the development of salt scalds and pans in low lying depressions.

High quality groundwater reserves are being increasingly tapped to supplement or replace surface water supplies during periods of low rainfall and drought. Today, groundwater is viewed as a primary water source, particularly where surface water diversions are limited, lacking or expensive compared to groundwater (despite high energy costs for pumping). The exact extent of groundwater reserves across northern Victoria and southern NSW is not precisely known.

Access to groundwater is usually through a licensing system issued by the Victorian government and its authorities under the *Water Act 1989*. This usually falls under the responsibilities of water authorities. While not directly relevant to the Investigation, groundwater systems are closely linked to surface water movements. Much rain falling on the land percolates into the soil and



Today, 95 percent of water diverted from rivers within the entire Murray-Darling Basin is used for irrigation (MDBC 2002). In Victoria around 77 percent or about 4019 GL of total water harvested each year is used for irrigation (see Figure 15.6). Urban and industrial uses account for 17 percent or 860 GL of total use and rural supplies for 5 percent or about 286 GL. The environment is not included in this breakdown as a "use category".

Figure 15.6 Consumption of water in Victoria, 2004–05.

Source: DSE (2006i), Water Report.

Compared with surface water resources, Victoria's useable groundwater resources are small (around 10 percent of surface water resources). The major uses of groundwater resources across Victoria are irrigation at 60 percent, stock and domestic at 20 percent, mine dewatering and urban use at 16 percent and in-situ uses 4 percent. For areas closely associated with the River Red Gum Forests Investigation irrigation and stock are the major users of groundwater supplies. The use of groundwater is likely to increase as surface water availability decreases due to climate change and increased demand.

Constraints on River Regulation

A range of economic benefits is derived from the regulation of the River Murray for water supply and navigation. However, physical barriers, such as dam outlet capacity and river channel capacity variations such as the Barmah Choke, constrain the operations of the regulated system. Constraints are also placed by increasing competition for water resources between different users and the extent to which different users interests are compatible (particularly in the context of climate change). Environmental degradation resulting from changes to flow and flood regimes, is a third limitation on the benefits of river regulation, such as salinity, eutrophication and blue-green algal blooms, river bank slumping, loss of biodiversity and changes in the movement of energy and nutrients between the river and floodplains (see chapters 4, 5 and the environmental flows section in this chapter).

Environmental Consequences of River Regulation

Regulation of the River Murray has changed the natural flow conditions of the river significantly with major impacts on biodiversity of the riverine environment. Today, flow regimes are characterised by the reduced frequency, duration and extent of winter-spring floods and alterations of the timing of floods from late winter to late spring and early summer. Smaller summer floods, particularly around Barmah forest, have increased in frequency because of so-called 'rain rejection' events. The River Murray now flows at a more constant rate for the entire year and water temperatures are more

Box 15.2 Key elements of the First Step Decision

1. An initial focus will be on achieving outcomes for six Significant Ecological Asset (SEA) sites: Barmah-Millewa Forest; Gunbower and Koondrook-Perricoota Forests; Hattah Lakes; the Chowilla Floodplain and Lindsay-Wallpolla Islands systems; the Murray Mouth, Coorong and Lower Lakes; and the River Murray Channel—see Map 15.2.
2. Statements of specific ecological objectives and outcomes for each SEA will be developed.
3. These objectives will be achieved through:
   - recovering water, built to an average of 500 GL per year of "new" water after five years, with the volume to be used each year depending on a range of factors such as droughts and flood events;
   - funding commencing from 1 July 2004; under the $500 million to address water over-allocation in the Murray-Darling Basin announced by the Council of Australian Governments (COAG); and
   - realignment of the previously announced capital works programs of an additional $150 million to effectively manage the water to the six Significant Ecological Assets.
4. An adaptive management approach will be employed.
5. A commitment is given to identifying opportunities for Indigenous partnerships in planning and management under the Living Murray.

Source: MDBC (2005b)

constant across all seasons. Improving these environmental flows is the primary area of VEAC's interest in water, and the subject of the next section of this chapter.

ENVIRONMENTAL WATER FLOWS

This section describes the administrative arrangements associated with environmental flows and how they are used as a management tool to achieve environmental outcomes on public land in the study area.

The Living Murray and the First Step Decision

Since the 1970s there has been increasing awareness by community and governments about the consequences of changed river flow regimes for riverine ecology. Implementation of the Murray-Darling Basin Cap on Diversions is, in part, a response to the decline in river health due to reduced river flow regimes of both the River Murray and its tributaries.

However, over the last two decades there has been increasing pressure placed on governments at both the national and state levels to address the ecological consequences of these changed river flow regimes by returning water to the environment. In response, the Murray-Darling Basin Ministerial Council initiated a number of projects; one involving the establishment of a Scientific Reference Panel to provide advice to the Ministerial Council. Their advice, provided in 2002, indicated that:

- the overall health of the River Murray is in decline;
- the river could no longer be considered healthy; and
- any restoration to improve the river's health would need to involve "major improvement in river management".

In 2002 the Ministerial Council also established The Living Murray Initiative (TLM) with a vision that the River Murray be a healthy working river. This initiative is underpinned by the following principles:

- action will be taken to restore a healthy working river system;
- action taken will be fair and reasonable;
- a range of measures will be used in an integrated and adaptive manner; and
- there will be both government and community (including Indigenous) responsibilities for The Living Murray decisions and outcomes.

While this Initiative is designed to address the health of the River Murray and its associated ecosystems it also has the objective of maintaining the long term sustainability of agricultural industries and communities within the Murray-Darling Basin—that is, its focus is not entirely on biodiversity conservation.

The First Step Decision emerged from The Living Murray Initiative in 2003. This decision by the Murray-Darling Basin Ministerial Council outlined how the decline in the River Murray's health will be addressed initially. The key elements of the First Step Decision are listed in Box 15.2 (MDBC 2005b).

The location of the six Significant Ecological Assets is shown on Map D and Figure 4.5.

The Living Murray Initiative and its First Step Decision is the principal policy instrument guiding all activities by Victoria (and other Basin states) on restoring the health of the River Murray. As such it is crucial for guiding water management and ecological protection on Victorian public land along the River Murray. In this Initiative the Ministerial Council specifies ecological objectives and outcomes for each of the Significant Ecological Asset (SEA) sites. As a signatory to this Initiative, Victoria is required to work towards achieving these objectives and outcomes. Table 15.3 lists the objectives and outcomes for each site. For this Investigation, relevant SEA sites are Barmah-Millewa Forest, Gunbower and Koondrook-Pericoota Forests, Hattah Lakes, Chowilla Floodplain including Lindsay Wallpolla Islands and the River Murray channel.

Murray-Darling Basin Intergovernmental Agreement

Water Recovery

In June 2004 relevant Ministers of NSW, Victoria, SA, the Australian Capital Territory and Commonwealth

Table 15.3 Interim ecological objectives and expected outcomes for the six significant ecological asset sites set by the Murray-Darling Basin Ministerial Council in 2003.

Significant Ecological Asset	Ecological objectives	Expected outcomes
Barmah-Millewa Forest	Enhance forest, fish and wildlife values	• successful breeding of colonial waterbirds in at least three years in ten • healthy vegetation in at least 55% of the area of forest
Gunbower and Koondrook-Pericoota Forests	Maintain and restore a mosaic of healthy floodplain communities	• 80% of permanent and semi-permanent wetlands in a healthy condition • 30% of River Red Gum Forests in a healthy condition • successful breeding of colonial waterbirds in at least three years in ten • healthy populations of resident native fish in wetlands
Hattah Lakes	Restore healthy examples of all original wetland and floodplain communities	• restore the aquatic vegetation zone in and around at least 50% of the lakes to increase fish and bird breeding and survival • increase successful breeding events of threatened colonial water birds to at least two in ten years • increase the population size of and breeding events of the endangered Murray hardyhead, Australian smelt, gudgeons and other wetland fish
Chowilla Floodplain including Lindsay and Wallpolla Islands	Maintain high biodiversity values of the Chowilla Floodplain	• high value wetlands maintained • current area of River Red Gum maintained • at least 20% of the original area of Black Box vegetation maintained
Murray Mouth, Coorong and Lower Lakes	A healthier Lower Lakes and Coorong estuarine environment	• open Murray mouth • more frequent estuarine fish spawning • enhanced migratory wader bird habitat in the Lower Lakes
River Murray Channel	To increase the frequency of higher flows in spring that are ecologically significant. To overcome barriers to migration of native fish species between the sea and Hume Dam. To maintain current levels of channel stability.	• expanded ranges of many species of migratory fish • similar levels of channel erosion to those currently existing

Source: MDBC (2005b)

governments signed the *Intergovernmental Agreement on Addressing Water Over Allocations and Achieving Environmental Objectives in the Murray-Darling Basin*—known as the Murray-Darling Basin Intergovernmental Agreement (MDB-IGA). This Intergovernmental Agreement gives effect to the 2003 decision by governments to commit $500 million over five years to address water over-allocation in the Murray-Darling Basin and recover "water for the environment". The indicative water recovery targets for each jurisdiction set under the MDB-IGA are: NSW, 249 GL; Victoria, 214 GL; South Australia, 35 GL; and ACT, 2 GL.

Water recovery relates to acquiring "new water" through a range of practices from water wholesalers, distributors, retailers and individuals. Practices include the following either in isolation or jointly:

- infrastructure improvements and rationalisations;
- regulatory changes;
- on-farm initiatives such as switching from spray irrigation to drip irrigation techniques;
- efficiency gains in water delivery and use;
- market-based approaches such as water trading; and
- voluntary water purchases.

Water gained through these practices is to be re-directed to water for environmental flows across all Living Murray SEA sites. Under the MDB-IG and the First Step Decision the target for water recovery is an annual average 500 GL by June 2009. There is limited information available on what criteria were used to decide on the 500 GL for the First Step Decision. For example, the Murray-Darling Basin Ministerial Council discussion paper, 2002 presents three reference points for consideration: 350 GL; 750 GL and 1500 GL. The 500 GL agreed upon is therefore, at the lower end of these points.

Some proponents argue for greater amounts of water for environmental flows to the SEAs. For example, conservation groups suggest an additional annual flow of 1500 GL is required, to have any impact or success. These groups are also arguing that water recovery practices will, by themselves, not achieve the 500 GL amount for environmental flows to the six SEAs. Other groups, such as the Wentworth Group argue that for the River Murray system to be restored to a healthy working condition around 2000 GL to 4000 GL per year are required combined with profound changes in river management. This raises the issue of whether there is sufficient knowledge available to determine volumes of water required to successfully mimic environmental flows across a diverse natural system such as the River Murray.

In the Living Murray process, the Victorian Government's approach is to recover water via water savings projects, system management changes and strategic water purchased in Victoria. A case in point is the Lake Mokoan Water Recovery Package with water savings in the vicinity of 44 GL going into environmental flows for the River Murray and the Snowy River (DSE 2006i).

Living Murray Environmental Watering Plan and the Asset Environmental Management Plan

The Intergovernmental Agreement provides the framework for the development and implementation of the Living Murray Environmental Watering Plan (LMEWP) and the Asset Environmental Management Plans (AEMP) to achieve the specific objectives of the First Step Decision. The Environmental Watering Plan must be consistent with or complement other actions of the MDB-IGA and other actions being undertaken by the Murray-Darling Basin Ministerial Council and the Murray-Darling Basin Commission.

The Living Murray Environmental Watering Plan is developed and implemented by the Environmental Watering Group (EWG), which is made up of eight people appointed by the Murray-Darling Basin Commission from a list of up to two people nominated by each jurisdiction and two *ex officio* people (River Murray Water Production Manager and Environmental Manager of the Murray-Darling Basin Commission). The Environmental Watering Plan coordinates the volume, timing, security and application of water necessary to achieve the ecological objectives of The Living Murray for each SEA. The plan is updated annually to reflect improved information and knowledge regarding the relevant river and wetland systems and improvements in delivery practices.

Each year the updated Environmental Watering Plan is submitted to the Murray-Darling Basin Ministerial Council for approval. The Living Murray Environmental Watering Plan is based on consideration of:

- ecological objectives and outcomes for the six Significant Ecological Assets agreed to by the Ministerial Council in 2003;
- potential actions for each asset consistent with the Murray-Darling Basin Agreement and The Living Murray First Step Decision's objectives;
- triggers for these actions and expected outcomes;
- assessment of the likelihood of meeting conditions to trigger actions;
- methods for prioritising between actions competing for water;
- estimated water availability over the year—volumes and locations;
- implementation roles and responsibilities;
- identification of priority actions for the year;
- links to The Living Murray Environmental Works and Measures Program;
- monitoring, evaluation and reporting measures to be undertaken; and
- adaptive management measures.

The Environmental Watering Plan is linked with the Asset Environmental Management Plans (AEMP), developed for each SEA. Developed by the EWG, these plans are agreed to each year by the Murray-Darling Basin Ministerial Council. They are designed to adapt the ecological objectives prescribed in the First Step Decision for each significant site and specify the water regime (volume, timing and security) required for each of the sites to meet the objectives. In effect, they establish the demand side of water allocations under the First Step Decision. The supply side of the equation (the Environmental Watering Plan) is developed through the different states and other parties identifying water volume amounts through their water recovery practices as accredited by the Murray-Darling Basin Ministerial Council. The demand and supply sides of The Living Murray watering requirements across all significant sites and individual sites are coordinated by The Living Murray Business Plan.

Indigenous Involvement in the Living Murray Environmental Watering Plan

An objective of the Living Murray Environmental Watering Plan is to actively involve Indigenous communities in all levels of natural resource management. As such, Indigenous input is sought on all aspects of environmental flow management to ensure the aspirations, interests and contributions of Indigenous people are recognised. Responsibility for achieving Indigenous involvement resides with the EWG. Where the interests of Indigenous groups apply to significant sites on either side of the River Murray, such as Barmah-Millewa then arrangements must be agreed upon between the relevant Asset Managers to develop a consistent approach to those groups, and gain consistent input to the Asset Environmental Management Plan.

Managers of Significant Ecological Assets

Table 15.4 lists the Asset Managers for each of the six SEAs and their agencies. It should be noted however, that the head Asset Manager role is rotated between states where sites cross jurisdictions. Detailed descriptions of the management arrangements for each of the sites are found in the Asset Environmental Management Plan for that site—refer to the Murray-Darling Basin Commission website.

Figure 15.7 Relationship of the asset environmental management plan to the broader Living Murray and associated planning strategies and agreements.

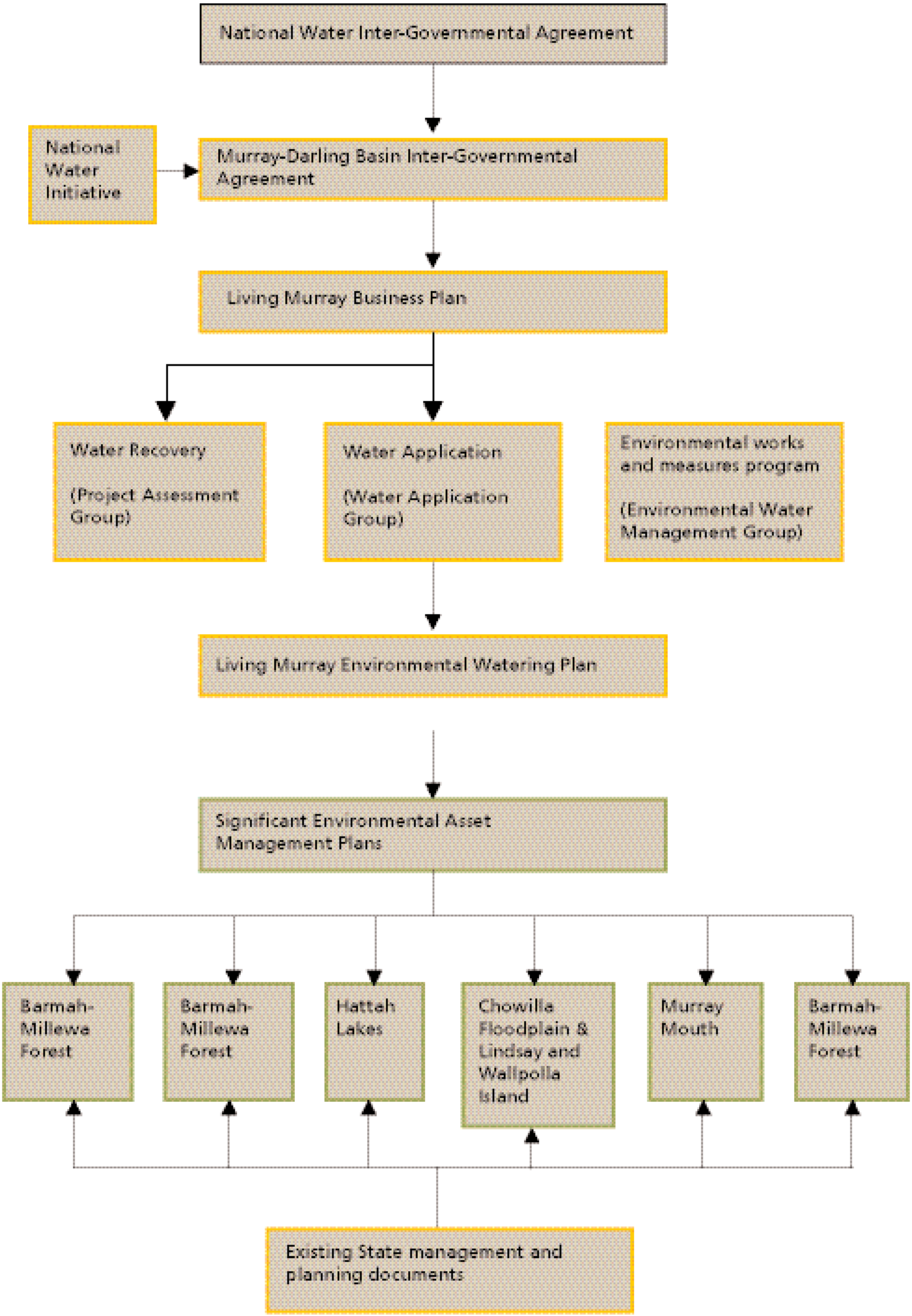


Table 15.4 Asset managers and their agencies for the six Significant Ecological Assets.

Significant Ecological Asset	Organisation	Position
Barmah–Millewa Forest		
NSW	State Forests of NSW	Regional Manager, Riverina
Victoria	Victorian Department of Sustainability and Environment	Regional Manager, North East
Gunbower–Koondrook–Perricoota Forests		
NSW	State Forests of NSW	Regional Manager, Riverina
Victoria	Victorian Department of Sustainability and Environment	Regional Manager, North West
Hattah Lakes		
Victoria	Victorian Department of Sustainability and Environment	Regional Manager, North West
Chowilla, Lindsay–Wallpolla		
NSW	NSW Department of Infrastructure, Natural Resources and Planning, Albury	Regional Manager, Murray and Murrumbidgee
Victoria	Victorian Department of Sustainability and Environment	Regional Manager, North West
South Australia	SA Department of Water, Land and Biodiversity Conservation	Program Leader Environmental Flows, Strategic Policy Division
Lower Lakes, Murray Mouth and Coorong		
South Australia	SA Department of Water, Land and Biodiversity Conservation	Program Leader Environmental Flows, Strategic Policy Division
River Murray Channel		
NSW component of the River Murray Channel	NSW Department of Infrastructure, Natural Resources and Planning, Albury	Regional Manager, Murray and Murrumbidge

Source: MDBC (2005a)

Significant Ecological Asset Water Allocation Arrangements

Potential Actions and Triggers

The allocation of water for environmental flows for the six SEAs requires matching appropriate actions to specific sites and times prior to water being allocated.

Potential actions for environmental flows are also influenced by whether the action can be undertaken as part of a routine river operation associated with bulk water allocations or coordinated by environmental managers for more regionally-based one-off operations—see Table 15.4. Specific actions for achieving environmental flows at the ecologically significant sites include:

- enhancing natural flush—typically, these enhance above channel capacity flows (see chapter 4) but can also be used to enhance flows just below the channel capacity. An example, includes piggy-backing off increased flows down the Goulburn River to assist with topping up the flows coming down the River Murray to achieve a medium flooding event of

Gunbower and Koondrook-Perricoota forests;

- weir manipulation—or increasing the volume of water by raising weir heights to increase variability within a channel. Weir raising is a common action for allowing water to enter wetlands that normally would not be inundated with water via in-channel flows. This action is more efficient as a flow delivery mechanism than releasing large volumes of water down the river;
- infrastructure use—for example, infrastructure has been used to pump water into wetlands at Hattah Lakes. Temporary levees are also used as a technique to hold water into wetlands once filled. Figure 15.8 is an example of a levee bank used to manage water flow;
- works expansion—involving the construction of weirs and regulators such as those at Hattah Lakes to hold water in wetlands for longer periods to ensure completion of bird breeding events or the construction of fish passages as shown in Figure 15.9;
- site specific actions—such as the management of rain rejection flows at Barmah-Millewa through a range of engineering approaches or policy instruments such as water pricing; and
- pre-releasing water—move adequate volumes from storages to allow a subsequent release when further inflows are expected to spill the dam. The advantage of this action is the release is controlled thereby limiting possible risks. The released flows generally remain within the river channel.

Box 15.3 Criteria for assessing environmental water across Significant Ecological Asset

Criteria are based on a two step process.

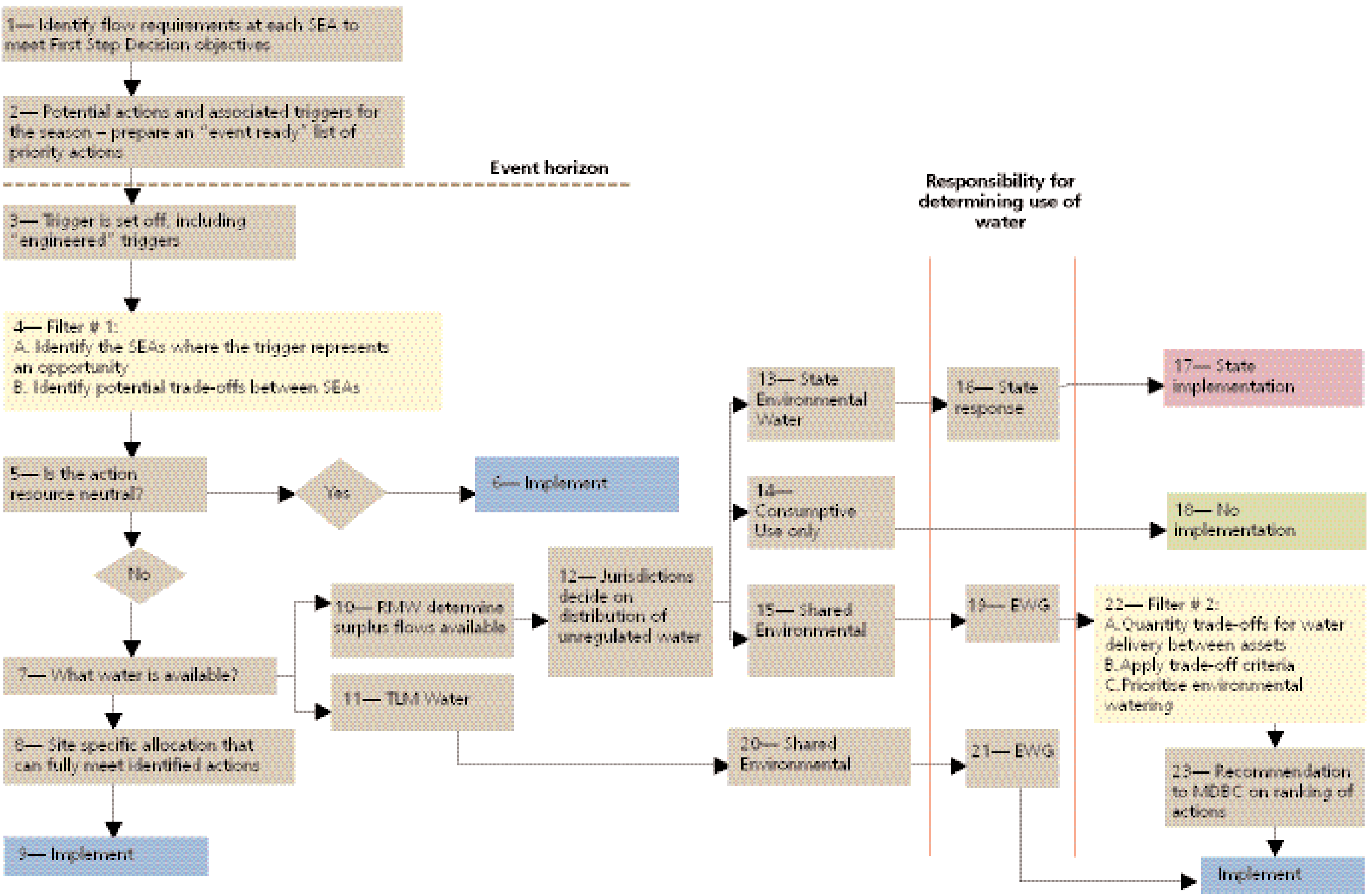
Step One assesses whether competing environmental watering actions are consistent with The Living Murray First Step decision objectives.

Step Two applies the following criteria to assess the proposed actions:

- significance of the predicted ecological outcomes;
- watering history of a site, including the number and magnitude of recent watering events;
- identification of any ecological costs of the action, including off-site impacts such as salt mobilisation and whether the use of water at one site will limit the water available for actions at downstream sites;
- distribution of water between competing actions on consumers (mainly irrigators); and
- financial costs associated with a proposed action, for instance the cost of pumping.

Source: MDBC (2005a).

Figure 15.10 Decision framework for distributing water to the six significant ecological assets.



Source: MDBC, 2005a.

Notes: RMW = River Murray Water; TLM = The Living Murray; EWG = Environmental Watering Group; MDBC = Murray-Darling Basin Commission.

Figure 15.8 Levee bank.

Figure 15.9 Torrumbarry Weir Fish Ladder.

All of the above actions are only implemented when a flow trigger point is reached. Triggers include flows of a particular size and duration that might initiate part or all of an ecological response to the environmental flow. A non-flow trigger is set off by other factors such as dryness of wetland, where a "health warning" is breached for a given area. The scale and impact on the river system of actions identified can vary considerably. For example, enhancing natural freshes or flush (refer to glossary) and floods depends on receiving above channel capacity flows at key points for each site across the river system. In contrast, other actions may only involve flows remaining within the main river channel and its anabranches.

Decision Making Framework for Implementing Environmental Flows

The allocation of water to the six SEA sites is influenced by complex administrative and operational arrangements for water management at both the state and Commonwealth levels, some of which existed prior to The Living Murray Initiative. Implementation of The Living Murray First Step Decision is based on a decision-making framework, which identifies the various decision making groups such as the EWG, the Murray-Darling Basin Commission and their responsibilities as well as the relevant jurisdictions and their responsibilities. The framework is designed to:

- identify if an action proposed is resource neutral or otherwise—that is, there is no increase or decrease in the resource as a result of the proposed action;
- identify the amount of environmental water available for application at the SEAs;
- establish a clear relationship between the EWG and existing jurisdictional arrangements; and
- provide an approach for allocating water between competing actions.

Figure 15.10 outlines the decision making framework for identifying water available for delivery to a significant site and for prioritising the delivery of water between sites where a trade-off arises. This framework identifies the different types of water and the responsibilities of the EWG for implementation of the decisions. Each Asset Environmental Management Plan must identify the flow requirements that have the potential to meet The Living Murray First Step objectives and a set of actions that can be instigated if an opportunity arises to water a significant site. Triggers signal where an opportunity exists and then activate an assessment of which site would benefit most from the type of flow volume.

Once a trigger is activated a series of decision points identify the type of water available and where responsibility lies. As part of this process the water is assessed as to whether it is The Living Murray Water and available for use at SEAs. River Murray Water determines the type and volume of surplus flows available (decision point 10, Figure 15.10) and works with the EWG to determine the environmental water requirements. Water is then classed as either state environmental (decision point 13), consumptive water use only (decision point 14) or shared environmental water (decision point 15) (MDBC 2005a).

When The Living Murray Water is available each SEA site may compete for this water. In these situations trade-offs are made between the sites and are based on a set of trade-off criteria—see Box 15.3 below. Environmental water is **only supplied** where an opportunity to achieve environmental outcomes is clearly identified—even if water is available. This may be due to the volume of water not being adequate to water the site or the pattern of delivery being insufficient to meet a flow requirement. In some situations, no trigger may be set off.

Victorian Arrangements for Environmental Water Flows

River health is a fundamental factor determining water allocations for environmental outcomes in Victoria. River health is a term used to describe the ecological condition of a river and is more than just the river's flora and fauna and the quality and quantity of the water—see Victoria's *River Health Strategy, 2002*. Determining the health of a river system involves consideration of the diversity of the habitats and biota, the effectiveness of connectivity (see chapter 4) and the maintenance of ecological processes. All are influenced by the flow regime of a river.

Environmental Water Reserve

The *Water (Resource Management) Act 2005* provides the legislative framework for water management in Victoria. The Environmental Water Reserve (EWR) is established under this legislation (see above for Victoria's allocation framework and rights to water) which formally defines it as water set aside for the environment through:

- **environmental entitlements**—volumes of water in regulated river systems to be granted to the environment. Under this legislation new entitlements are held by the Minister for Environment with existing bulk entitlements that are held by the Minister for

Table 15.5 Victorian Environmental Water Allocations (EWAs) available in the River Murray system and Victorian tributaries.

Allocation name	Year approved	Volume and main conditions	Main purpose
Barmah–Millewa Forest EWA	1993	100 GL/yr annually plus 50 GL about 8 years in 10 shared by NSW and Victoria (provision to carryover up to 700 GL)	Barmah–Millewa Floodplain watering
Barmah–Millewa Overdraw	2001	100 GL can be overdrawn to extend an environmental release when there is sufficient water in Vic-NSW storages	Barmah–Millewa floodplain watering
Victorian Murray Wetlands Bulk Entitlement	1987	27.6 GL/yr (2.6 GL/yr allocated to Hird and Johnsons Swamps)	Wetland watering along the Murray and salinity control
Goulburn River Bulk Entitlement	1995	80 GL in November in wet years between Lake Eildon and Goulburn Weir. Minimum passing flows released below Lake Eildon and Goulburn Weir	Spring flush In-stream habitat maintenance, water quality
Campaspe River Bulk Entitlement	1999	Minimum passing flows released below storages and weirs	In-stream habitat maintenance, water quality
Loddon River Environmental Reserve Bulk Entitlement	2005	2 GL/yr Minimum passing flows and summer freshes released below storages and weirs	Loddon wetlands in the Boort-Appin area In-stream habitat maintenance, water quality

Source: DSE (2004i)

Environment to be given equivalent legal status as a result of amendments to the *Water Act 1989*;

- obligations on entitlement holders—relating to flow volumes that an entitlement holder must allow to flow pass before they can divert any water. In most cases these are flows that are in excess of entitlement holders' needs and/or rights. This component of the Environmental Water Reserve does not include water set aside for future consumptive purposes in a river basin and which is not yet allocated under a formal entitlement;
- management plans—such as a streamflow management plan; and
- other legislation—such as the *Murray-Darling Basin Act 1993* and the *Groundwater (Border Agreement) Act 1985*.

The Environmental Water Reserve is designed to maintain the rights of existing consumptive entitlement holders. As such the water reserve:

- maintains the environmental values of the water system and the other water services that depend on environmental condition;
- sustains biodiversity, ecological functioning and water quality; and
- holds equivalent legal status to that of consumptive water entitlements and is held by the Crown.

A substantial portion of the Environmental Water Reserve is achieved through limiting the volume of water for consumption. These limits take various forms—conditions on bulk entitlements, surface and groundwater licences, rules established in water management plans, caps on water use such as permissible annual volumes and sustainable diversion limits. In some regulated rivers, these limits may be extended with a specific water allocation for the environment. Where this is the case, the environmental allocation is held as a bulk entitlement. The water reserve is enhanced by recovering water from consumptive use (see above).

Management of the Environmental Water Reserve

Under the *Water (Resource Management) Act 2005* the Environmental Water Reserve must be managed in accordance with the objectives specified in the Act, which are:

- achieving ecological objectives for the protection and/or restoration of priority river, wetland and aquifer assets,
- integrating programs of river, wetland, and aquifer restoration aimed at achieving ecological objectives,
- achieving the most effective use of environmental water, the greatest level of environmental benefits possible and minimising as far as possible any adverse

impacts on water users, and

- engaging communities, particularly where these are likely to be affected by the water management regime.

Under the *Water (Resource Management) Act 2005* Catchment Management Authorities are responsible for the operational management of the Environmental Water Reserve within their catchment region. Catchment Management Authorities jointly oversee the development of long-term operating strategies for water recovered and held in storage to optimise use of the water for their catchment region. In the case of this Investigation the Catchment Management Authorities with this responsibility are North East, Goulburn Broken, North Central and Mallee. Overall coordination across the six SEAs sites resides with the Murray-Darling Basin Ministerial Council. Each of these strategies identifies the ecosystem for the watering event such as a river reach or individual wetland areas, how and under what conditions the ecosystem will be watered, how much (if any) of the allocation is tradeable and the circumstances under which it could be traded. In developing an operating strategy, Catchment Management Authorities liaise with the ecosystem managers, neighbouring authorities, DSE and other key stakeholders. Strategies require the approval of the Minister for Environment and the Minister for Water.

Management of the Environmental Water Reserve differs depending on how the water reserve is provided. When provided wholly or partly through conditions on a bulk entitlement or licence or through sustainable diversion limits, the input of management is relatively passive. It involves integrating environmental flows that are provided into a more substantial program of river management. In contrast, where the water reserve is provided through bulk entitlement for the environment held in storage, management input is more active and extensive.

Victorian Environmental Flow Allocations

Environmental flows operate within two contexts, both of which can occur separately or concurrently. Some environmental flows operate under Victorian conditions prior to the development of The Living Murray while others operate within the framework provided by The Living Murray and the First Step Decision. Table 15.5 outlines Victorian environmental flow allocations over recent years, with some such as the Barmah-Millewa allocations are frequently used in association with The Living Murray water.

Over the last two decades Victoria has instigated a number of environmental flows outside the allocations of The Living Murray framework. Table 15.5 provides a summary of environmental water allocations, the locations for those flows and the purposes for the flows. In Victoria, the Minister for Environment holds an allocation of 27.6 GL a year to provide water for flora and fauna maintenance for areas such as at Hird Swamp, Johnson Swamp, Lake Elizabeth, Lake Murphy, McDonald's Swamp, Cullens Lake, Round Lake, Golf Course Lake and the Cardross Basins. The water allocated under the environmental water entitlement varies from year to year with natural fluctuations in environmental water requirements.

Environmental Flow Events in Victoria

Each year, subject to the seasonal allocation, Victoria contributes 50 GL of its entitlement to the River Murray water resource to the Barmah-Millewa Forest Environmental Water Allocation for the purposes of periodically enhancing natural flood events in the forest. If the seasonal water sales to Victorian Murray irrigators reach 30 percent of their entitlement, the state contributes an additional 25 GL of sales entitlement to the Barmah-Millewa Forest Environmental Water Allocation account. New South Wales also contributes to this account. After Victoria's 2004/05 contribution, the state had accumulated a total of 175 GL in the account, all of which was carried over for use in 2005/06. This account was used in the late 2005

Table 15.6 Flood frequencies of the major Barmah–Millewa forest floodplain vegetation communities before regulation.

Vegetation community	Flood frequency (% of years with inundation)	Duration (months)	Season (ideal)
Giant rush	1:1 to 1:1.3 (75% to 100%)	2 to 30	May
Moira grasslands	1:1 (100%)	2 to 18	September
River red gum forest	1:1 to 1:1.4 (70% to 100%)	1 to 18	Winter–spring
River red gum forest woodland	1:1 to 1:2 (50% to 100%)	1 to 18	Winter–spring
River red gum forest/black box woodland	1:2 to 1:3.3 (30% to 50%)	0.5 to 1	Winter–spring

Source: MDBC (2005b).

Box 15.4 Changes to flow regimes of the Barmah–Millewa forest from river regulation

Reduced flooding in spring	The frequency, duration and variability of winter–spring flooding have been reduced by river regulation. The frequency of floods in the range 42-78 GL/day peak magnitude has more than halved. The duration of floods that inundate River Red Gum Forests has reduced from 5 months per year to 2 months per year. The mean length of the period between floods has increased 2.5 times, while the maximum length of the dry period has increased six-fold.
Unseasonal flooding in summer and autumn	The forest receives unseasonal flooding due to "rain rejection" events. The Edward River, which flows through the Millewa Forest, has also been affected by river regulation, with flows at or near channel capacity for much of the year.
Reduced variability	Flow is at near channel capacity of 330–350 GL/month (Barmah Choke limit) for approximately eight months of the year. Regulation reduced flow variability (particularly during winter/spring). Under natural conditions, average monthly flows vary between 100GL/month and 980 GL/month, whereas current average monthly flows vary between 110 GL/month and 400 GL/month.
Reduced annual volume	Downstream of Yarrawonga, diversions reduce annual flow by 25% compared to natural conditions.
Increased summer volume	Use of the river for delivery of water to downstream irrigation areas means that summer flow is 19% greater than natural.

Source: MDBC (2005b).

flooding of Barmah-Millewa Forest.

In 2005–06, unused water entitlements (5.6 GL) by irrigators and water authorities was donated to the environment for Forest Bend/Nangiloc, Johnsons Bend and Nyah State Forest.

During 2004–05 the emergency Red Gum Watering Project was initiated using environmental water from the Minister's allocation (the River Murray Flora and Fauna Reserve Bulk Entitlement) and surplus flows to target trees exhibiting signs of major water stress. This occurred at a number of anabranches and wetland sites along the River Murray including Burra Creek, Lindsay River, Chalka Creek and Potterwalkagee Creek. DSE managed the project in partnership with Parks Victoria and the Mallee Catchment Management Authority.

In 2004–05, a total of 27,590 ML of the River Murray Flora and Fauna Reserve Bulk Entitlement was used to supply water to these areas of environmental significance, including areas that are not classified as SEAs such as native fish habitat (Murray hardyhead) at Cardross Lakes, near Mildura, protection of significant waterfowl habitat and aquatic vegetation communities at McDonald Swamp and Hird Swamp in the Kerang Lakes region. Other areas to benefit from these flows include Round Lake, Lake Murphy, Lake Elizabeth and

Table 15.7 Impact of hydrological changes on vegetation communities of Barmah Forest

Vegetation community	Impact due to river regulation
Rushlands	• Giant rush has established over 1.5% of Barmah forest, in some areas that previously were grasslands. This is largely due to regular summer inundation, and reduced frequency/period of inundation of winter/spring flooding • Suggestions that some wetlands are prone to silting and drying out more readily than they were in the previous 20 years
Grasslands	• Grassland areas declined from 13.5% in 1930 to 5.2% in 1979. This decrease is linked to river regulation and the invasion by river red gums onto grasslands
River red gum forest	• Natural regeneration of red gum dependent on occurrence and timing of flooding. The ideal conditions are on the spring recession of winter flooding • High river levels associated with summer irrigation supplies have led to tree death due to waterlogging

Source: MDBC (2005b).

Box 15.5 Operating rules for the Barmah Millewa Forest Environmental Water Allocation

No.	Agreed rule or Trigger
1.	The GL of high-security water has the same security as Victoria's water right along the Murray. This will be augmented with 50 GL of lower security water (25 GL from each State), which is not allocated until Victoria's seasonal allocations along the Murray reach 100% of water right plus 30% of "sales", and is then allocated fully. It should be allocated in 75 to 80 years out of 100. The use of Victorian allocations to define security will be replaced by the use of independent triggers as soon as these can be developed and agreed to by the two states.
2.	Each state's share of the allocation is stored on their respective sides of the storages.
3.	All the water allocated is carried over if not used, with the maximum volume of the allocation being 700 GL (this could be say 150 GL allocated in the current year, plus 550 GL carried over).
4.	When Hume Dam physically spills, the first water spilt is the Barmah–Millewa kitty, though up to 200 GL, if kitty contains that much, will be retained
5.	Allowance has been made for the allocation to be overdrawn by up to 100 GL to ensure adequate water is available for forest watering, provided there is sufficient water in storage. This is proposed that sufficient water will be defined by the Commission, to ensure each state can underwrite the overdraw. Possible definitions include: more than 2,000 GL of water stored in Dartmouth, each state having more than 700 GL stored in Dartmouth, or each state having more than 50 GL in excess of the mandatory reserve for the following year.
6.	Each state's share of the Barmah–Millewa environmental allocation can be borrowed for consumptive use by that state, subject to clearly defined borrowing and payback rules to be agreed between the states and endorsed as part of these arrangements. Any water borrowed by either of the states must be paid back Initially, Victorian water users can borrow when their general security allocations would otherwise be less than 30%, only to the extent necessary to get these allocations to 30%. The water must be repaid as soon as borrowing is not needed for this. Both states agree that the above borrow and payback triggers will be adopted as operational guidelines during the interim period. However, each state reserves its position to alter the application of these triggers in special or exceptional circumstances, and in such circumstances to consult on the matter through the Commission. The idea that water paid back can not be spilled until one year after it is paid back is to be further investigated and considered for possible adoption.
7.	In principle, credits may be allowed to the environmental allocation for water returning from the forest to the river, where this returning water is not surplus to requirements—the operational details to be agreed between the States.
8.	Releases for the Barmah–Millewa forest will be made to top up the Yarrawonga flow using target flows similar to the following: • If there is a flood ≥ 500 GL/m from September through to November, then maintain at 400 GL in December (if sufficient volume in the allocation); • If there is a flood ≥ 500 GL/m in September or October and kitty is ≥ 400 GL (including overdraw), keep at 500 GL/m till November and 400 GL in December; • If 4 years pass with no release, and no flood of ≥ 500 GL/m in September to November and 400 in December, try for 500 GL/m in October and November and 400 GL in December; • If 3 years pass with no month from August to November with ≥ 660 GL, then if a release starts in October or November, the target flow increases to 660 GL at Yarrawonga.
9.	The above operating practices for releases can be varied and refined from time to time, by agreement between the managers of the forest water in consultation with water managers in the two states, and with the agreement of the Murray-Darling Basin Commission.

Source: MDBC (2005b).

Richardsons Lagoon.

There are four key significant ecological asset sites identified under The Living Murray First Steps Decision within the study area: Barmah-Millewa Forest; Gunbower and Koondrook-Perricoota Forest; Hattah Lakes; and Lindsay-Wallpolla and Chowilla Floodplain. The Murray Channel is also a significant ecological site with significant influences on the River Red Gum Forests associated with the study area but because it is formally in NSW, it is not considered here.

The following briefly describes each of these sites, the consequences of river regulation on these sites and current environmental flow practices within the sites.

Significant Ecological Asset Site 1: Barmah-Millewa Forest

The Barmah–Millewa Forest covers a total area of 66,615 hectares, with the Barmah Forest area in Victoria covering 28,500 ha. It is the largest area of river red gum forests in the River Murray system and largest in Australia. It includes the floodplains of both the Murray and Edward Rivers. The site is Ramsar listed and of international significance and in 1992 was included on the Register of the National Estate. Map D shows the location of Barmah–Millewa Forest in relation to the length of the River Murray and other Significant Ecological Assets.

The Barmah–Millewa system is dominated by the Barmah Choke, which has been the dominant factor in the creation of the unique forest and wetland ecology and river flow and flood patterns we see today (see chapters 2 and 3 for details of its formation). Today there is increasing evidence that the maintenance and

health of the wider River Murray system is directly linked to the health of Barmah–Millewa (see chapters 4 and 5).

Chapter 5 provides a detailed description of vegetation communities associated with Barmah–Millewa Forest. Suffice to say that there is a wide range of vegetation communities existing within Barmah, all of which have evolved in association with the unique natural flow and flood regimes of the River Murray. Table 15.6 describes the importance of different flood frequencies, duration and seasonality for specific vegetation communities prior to regulation.

Table 15.8 Flood frequencies of the major Gunbower forest floodplain vegetation communities before regulation.

Vegetation community	Flood frequency (% of years with inundation)	Duration (months)	Season (ideal)
Watercourses	Varies	Varies	Varies
Permanent wetlands	Some always wet	Some always wet	–
Semi-permanent wetlands	1:1 (100%)	Dries out only after 2 dry years	Spring
Temporary wetlands	1:1.4 to 1:5 (20% to 70%)	Range from 5 months to 4–6 weeks depending on community	Late winter to spring
River red gum forest with flood dependent understorey	1:1 to 1:1.14 (70% to 90%)	5 months	Spring
River red gum forest with flood-tolerant understorey	1:2.2 (45%)	1 to 2 months	–
Black box	1:10 (10%)	1 month	–
Grey box	1:20 (5%)	1 month	–

Source: MDBC (2005b).

Flow and Flood Regime Changes due to River Regulation

River regulation has significantly changed the river flow regimes for Barmah–Millewa Forest. These changes are described in the Box 15.4. Note: these changes while having similarities with other sites along the River Murray have characteristics that are specific to Barmah–Millewa Forest.

Ecological Impacts of Regulation

The most visible sign of environmental degradation resulting from river regulation are changes in vegetation type and spatial distribution. Table 15.7 outlines the main changes to vegetation communities for Barmah Forest, resulting from changed flood regimes. Of particular note is the decline in distribution of Moira grass. This grass is dependent on inundation for short periods of time followed by lengthy dry periods. In contrast, giant rush prefers wetter conditions over longer periods of time. Summer irrigation flows that provide constant low levels of inundation favour giant rush. As a result moira grass is declining in distribution at Barmah Forest. It is estimated that since 1930, 1200 hectares or 30 percent of area of Moira grass has been lost to river red gum spread and a further 1200 hectares lost to giant rush encroachment.

River regulation (as well as some past and current land-use activities within the study area) have impacted on the fauna of Barmah–Millewa Forest, particularly in relation to wetlands. Chapter 5 provides details of the biodiversity of the Barmah area. Suffice to say that Barmah–Millewa is a significant area for colonial nesting waterbirds, fish and macroinvertebrates and a number of threatened species. All of which are dependent on flood regimes consistent with natural conditions for breeding.

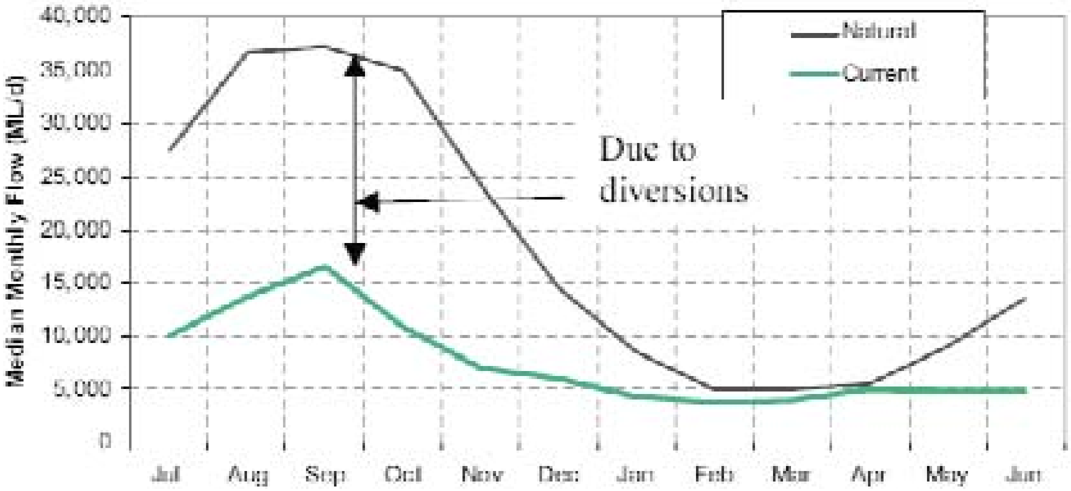
Ways of Addressing Changes Resulting from River

Table 15.9 Impact of environmental changes on vegetation communities of Gunbower Forest.

Vegetation community	Known or expected stresses
Watercourses	• Reduced connectivity between wetlands and river. • Reduced fish breeding. • Loss of diversity of habitats within forest.
Permanent wetlands	• Loss of wetland type - flooded less and therefore those which remain would be now shallower and smaller.
Semi-permanent wetlands	• Extent of wetlands has declined. • Number of sites has declined. • Reduction in permanence. • Red gums encroaching. • Loss of grebes, terns, herons and egrets. • Alterations to littoral fringe.
Temporary wetlands	• Colonisation by red gum and weeds such as Noogoora burr and thistles. • Wet period too short to promote aquatic plants. • Wetland-adapted plants and animals out-competed by those with short-life cycles, rapid growth and maturity.
River red gum forest with flood-dependent understorey	• Extent has declined to a narrower zone around wetlands. • There has been an increase in weed species (thistle, fleabane, aster, Noogoora burr). • Decline in population of flood-dependent species.
River red gum forest with flood-tolerant understorey	• There has been an increase in weed species (such as horehound). • Probable increase in abundance of true terrestrial plants. • Reduction in red gum productivity and associated benefits to herbivores and insectivores.
Black box	• Box is tolerant of long dry spells, so possibly no significant changes. • Possibly has encroached on red gum with flood-tolerant understorey in response to declining flood frequencies.
Grey box	• Probably no change in water regime.

Source: MDBC (2005b).

Figure 15.12 Changes in median monthly flow patterns between natural and current flows at Torrumbarry Weir.



Source: MDBC (2005b).

Regulation

A set of operating rules have been jointly developed by NSW, Victoria and the Murray-Darling Basin Commission to administer the allocation of water to Barmah–Millewa Forest. These are outlined in Box 15.5. These rules and triggers underpin all actions and decisions associated with environmental flows for Barmah–Millewa Forest.

As well as the highly prescriptive operating rules and triggers, various delivery techniques are used or being considered to address the adverse effects of river regulation on the biodiversity of Barmah–Millewa Forest. Most of these involve using the existing regulating structures such as the eight primary regulators, two secondary regulators and at least twenty-seven tertiary regulators. All these structures are operated by DSE with funding assistance from River Murray Water. Goulburn-Murray Water maintains the regulating structures on behalf of River Murray Water.

One proposal being investigated to achieve environmental outcomes for Barmah–Millewa Forest is by-passing Lake Mulwala (diverting flows coming down the River Murray via the Edward River system) to prevent unseasonal flooding of Barmah–Millewa wetland system by rain rejection flows (see first section of this chapter). Such a proposal focuses on engineering solutions to the problem and requires considerable capital investment. This proposal is referred to in the Living Murray Environmental Watering Plan, 2005.

A second proposal involves the possibility of acquiring land for a Hume–Yarrawonga Easement to improve the flooding regime of the River Murray system downstream of Hume Dam. This involves the acquisition of flow rights over private land, thereby enabling temporary unregulated flows at rates of up to 45 GL per day to flow downstream from the Hume Dam. This would provide increased operational flexibility for control of flooding of the Barmah–Millewa system and increase the volume of water available downstream of Barmah forest.

A third is the Lower Goulburn proposal. This involves rehabilitation of the floodplain of the lower Goulburn River as it enters the River Murray to a more natural flow regime through the development of a levied floodway of approximately 10,500 ha. Implementation of this proposal would involve purchasing approximately 9700 ha of land from landholders. It would also achieve increased flows into the River Murray system and back flow into the Barmah Lakes (similar to natural flood regimes). An added benefit would also be the enhanced flooding of Gunbower forest.

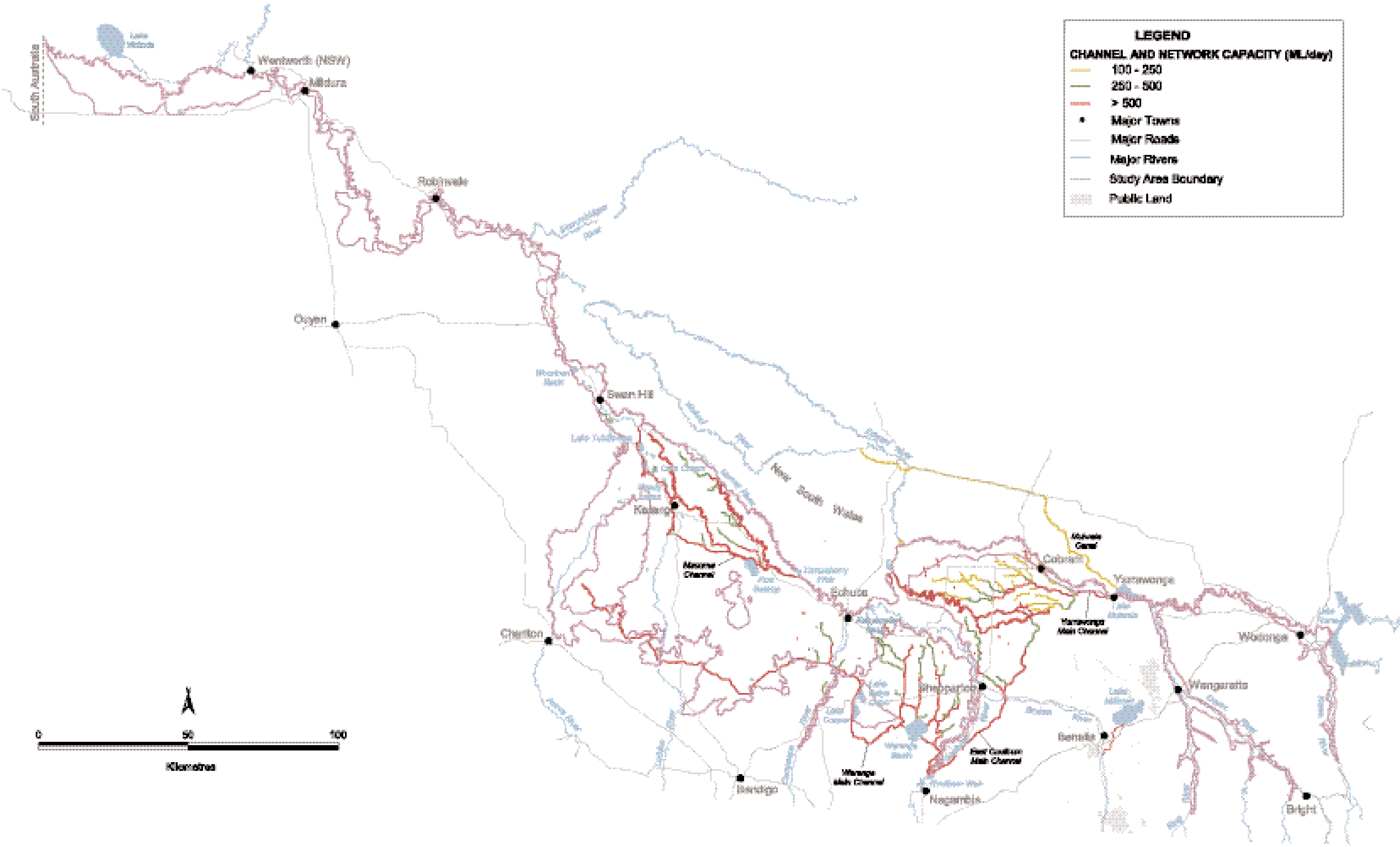
Figure 15.11 Environmental flows in Barmah Millewa Forest.

Ecological Asset Site 2: Gunbower and Koondrook–Perricoota Forests

Gunbower and Koondrook–Perricoota Forests lie west of Echuca and Torrumbarry Weir (see Map D). Like Barmah–Millewa Forest, the Gunbower and Koondrook–Perricoota Forests straddle the River Murray with Koondrook–Pericoota in NSW and Gunbower forest located in Victoria. Some irrigation occurs on Gunbower Island, although the majority of the Island is state forest covering an area of 19,931 ha. The forest is managed by DSE Forests while the eastern end of the forest (9712 ha) is a proclaimed Wildlife Sanctuary and land between the River Murray and the River Track is part of the River Murray Reserve, managed by Parks Victoria (see chapter 9).

Over thousands of years, Gunbower forest has been influenced by the impact of the Cadell Fault and Barmah Choke which limits river flow downstream of Barmah forest. The maximum flow from the River Murray into the forest is only 30 GL per day. Major flooding of Gunbower forest is dependent on the inflows from the Goulburn Broken river systems and to a lesser extent the Campaspe River system. Maximum flooding of Gunbower forest is only achieved when flooding of the

Map 15.2 Irrigation channel network.



River Murray is synchronised with floods coming down these two tributaries.

The Gunbower and Koondrook–Pericoota Forests are the second largest river red gum forests in Victoria and were Ramsar listed in 1982 and are also internationally significant for their biodiversity values. Details of the conservation and biodiversity of the forests are described in chapter 5. Vegetation communities throughout the forests have adapted to the cycles of wet and dry associated with the natural flow regimes of the River Murray. This relationship of the water flow across seasons and the types of vegetation communities is summarised in Table 15.8.

Flow and Flood Regime Changes due to River Regulation

The major river flow and flood characteristic altered by river regulation in Gunbower forest is the reduction in frequency of medium sized spring floods (see chapter 4). A comparison of the natural and current monthly flows in the river is shown in Figure 15.12. In particular note flows have declined in frequency downstream of Torrumbarry Weir by over 25 GL per day.

Gunbower and Koondrook–Perricoota Forests are downstream of some of the River Murray's major water storages and three of the major diversion points on the River (located at Yarrawonga–Mulwala Canal and Yarrawonga Main Channel and the Torrumbarry Weir–National Channel, see Map 15.2 Channel network). This area is also downstream of the Edwards River off-take and inflows from the Broken, Goulburn and Campaspe Rivers. Gunbower Creek is maintained at top of bank level during the irrigation season—August to May by the weirs at Gunbower, Cohuna and Koondrook which result in extended high flow periods in the forest, particularly during summer and early autumn.

Torrumbarry Weir is the major physical structure directly influencing the flow and flood regimes of Gunbower forest. The weir creates a head of water (increases the water height) to increase the flow of water into the main channels of Gunbower forest. Levees are used on the outside areas of the forest to protect adjacent farmland from these small and medium sized floods. Prior to their construction water flows would have entered the lower areas of the floodplains and returned to the River Murray near Koondrook. Today, irrigation supply offtakes associated with Torrumbarry Weir limit the maximum flow at the downstream end of the forest system to around 32 GL per day. Flows into Gunbower Forest commence when the flow in the River Murray is approximately 13.7 GL per day and as the river rises, flows enter other parts of the forest.

Unseasonal rain rejection flows are delivered to the forest via three outlet structures on Gunbower Creek: Shillinglaws Regulator and two smaller structures at Reedy Lagoon and Black Swamp. Gunbower Creek has varying channel capacity, from 900–1000 ML per day to 4000 ML per day depending on the location along the creek.

Ecological Impacts of Regulation

Table 15.9 summarises the major ecological consequences of changed water regimes for Gunbower forest for which the Gunbower and Koondrook–Perricoota Asset Plan is designed to address—see chapter 5 for further details of the biodiversity of this area.

Ways of Addressing Changes Resulting from River Regulation

There are two environmental watering strategies currently employed at Gunbower forest to address changed flow regimes. The first includes limiting the extent of rain rejection flows into the forest during summer and the second increases the occurrence of medium sized flows through the use of flow regulating structures. These operate within the context of Gunbower's unique hydrology and geomorphology characteristics.

A current delivery method for Gunbower forest is enhancing naturally occurring floods. This involves supplying additional water on top of a naturally occurring flood. This has the advantage of temporarily restoring the connection between the river and floodplain.

In Gunbower forest the preferred delivery method is managed environmental flows, which have logistical advantages. For example, managed floods provide greater scope to monitor the flood event and allow for monitoring systems to be in place several months before inundation. It also enables several months notification to forest and water users of the likely change in conditions of the forest and provides flexibility for transferring Environmental Water Allocations between storages. A further benefit of managed floods is that they require less water than enhanced flooding practices.

Within Gunbower forest specific environmental flow management options include:

- using existing regulator network;
- managing water flows in the upper end of the forest to overcome the higher elevation constraint of this area—this involves the use of greater volumes of water which are often sourced by piggy backing on floods down the Goulburn River system;
- physically deepening and widening the channels between the river and the river track—river reserve;
- raising Torrumbarry Weir pool—although the benefits of this approach do not go to areas with a high priority for water management.

Ecological Asset Site 3: Hattah Lakes

The Hattah Lakes system lies within the adjacent Hattah–Kulkyne National Park and the Murray–Kulkyne Park. Unlike Gunbower and Barmah, Hattah does not have any association with NSW. Combined the parks have an area of 49,500 ha.

The Hattah Lakes system is an extensive floodplain consisting of at least 18 shallow lakes, streams and temporary swamps and bordered by riverine forests. These systems are located approximately 15 km from the River Murray and are mostly fed by Chalka Creek, connected to the River Murray—see Map D.

Under natural conditions, the majority of the lakes in this system were semi-permanent. The Hattah Lakes consist of a wetland system linked by interconnecting anabranch creeks to the River Murray. Today, these

Box 15.6 Summary of the Changes in Flow Regimes of the Hattah Lakes

Reduced duration of flooding	The flooding behaviour of the lakes system has been altered, both in terms of volume of water delivered to the lakes and the timing of its delivery. A reduction in the duration of flooding and inundation has occurred since regulation. For Lake Hattah, the depth of water retained in the lake has been reduced from 2.8 m to 1.8 m. This means that the average time taken for the lake to dry out after filling has reduced from 26 months to 17 months. Other lakes in the system have experienced a similar shift, with the depth of water retained in Lake Lockie being reduced from 1.2 m to 0.4 m. This has resulted in the average time to dry out being reduced from 12 months to two months.
Reduced frequency of flooding	The frequency, duration and volume of water delivered to the Lakes system has been significantly reduced through time. Modelling of natural and current conditions indicates that under current conditions, the number of floods in 100 years is 57 for Lake Hattah and 11 for Lake Kramen. Under natural conditions, the number of filling events in 100 years is 86 for Lake Hattah and 23 for Lake Kramen. It is important to note that Lake Hattah is one of the first lakes to flood, while Lake Kramen is one of the last (when a large flow event occurs).
Reduced annual volume	The annual volume of water in the lakes is inversely proportional to the percentage of time that the lakes are dry. Modelling of natural and current conditions of the Hattah Lakes system indicates that for Lake Lockie, the proportion of the time that the lake is dry is 72% of the time under current conditions, compared to 9% of the time under natural conditions. Even though Lake Lockie is one of the first lakes to receive water, it has a low capacity and is relatively shallow. Other lakes in the system indicate a similar comparison between natural and current conditions. For example, under natural conditions, Lake Hattah is estimated to be dry 2% of the time compared to 25% under current conditions. As a result of modifications to the Chalka Creek channel, including the installation of regulators, the critical flow volume to achieve flooding between lakes has been reduced in most cases. For example, the critical flow between Lake Lockie and Lake Hattah has been reduced from 48.9 GL/d to 36.7 GL/d.

Source: MDBC (2005b).

Table 15.10 Preferred flood requirements for vegetation species, Hattah Lakes.

Species	Ideal flood requirements
River red gum	Winter–spring flooding every 1 to 2 years for a duration of 4 to 7 months (no more than 24 months)
Tall flat sedge	Flooding for 135 to 200 days per year, at depths less than 60 cm
Spiny flat sedge	Flooding for 2 to 6 months (optimal 3 mths) to a depth less than 10 cm
Cane grass	Frequency 1:2 to 1:5 for a duration of up to 6 months
Spiny mudgrass	Annual–biannual flooding, 3 to 10 months duration
Water couch	Summer flooding for 4 to 8 weeks at a depth not less than 10 cm
Submerged macrophites	Annual flooding, variable duration
Fish	Flood frequency every 1 to 2 years for short lived species; some permanent water for permanent residents
Colonial nesting water birds	Inundation for 5 to 8 months following winter–spring flooding and inundation of 7 to 10 months following autumn flooding
Ducks	Flooding for between 3 to 7 months (optimal)–up to 5 months to reach peak breeding and 2 months fledging time

Source: MDBC (2005b).

lakes are Ramsar listed. Details of the fauna and flora of the Hattah Lakes system are provided in chapter 5. Under natural conditions flooding of Hattah Lakes occurred through direct overflow from the River Murray as well as backflow from the creek systems scattered through the lake system. Ideal flood conditions for Hattah Lakes occur when floods inundate the lakes for several months of the year before periodic drying. Water requirements for the major vegetation communities in Hattah Lakes vary. For flood dependent species, flood depth, flood duration, flood frequency and seasonality are all important.

Flow and Flood Regime Changes due to River Regulation

The *Mallee Catchment Management Authority Draft Integrated Water Management Plan* identifies primary and secondary flows paths. Primary flows are flows to lakes that occur as an off take from the Chalka and Cantala distributaries. Approximately 12 of the 18 lakes in Hattah Lakes receive these primary flows. Secondary flows are those that occur as a result of `spillover' from other lakes or tributaries within the system onto the floodplain of the wetland system. However, one of these lakes (Lake Kramen) receives primary flows from the River Murray and Chalka Creek and secondary flows from Lake Nip Nip and Lake Tullamook (through sheet flooding as a result of exceptional flood events).

The overall sequence of flood events is complex and involves a complicated inter-dependency between lakes and flows, filling and emptying of each lake depending

on its position in the system, its area, and its depth. Lake Lockie is the first lake to receive floodwaters, several days after they first enter Chalka Creek. All the southern lakes are then filled from Lake Lockie, typically taking another three weeks for water to reach the furthest lakes. After Lake Lockie, water flows into Lakes Hattah and Little Hattah, followed by Lake Bulla, and then, in order, Lake Arawak, Lake Marramook, Lake

Brockie, Lake Boich, Lake Tullamook, Lake Nip Nip and finally, Lake Kramen. Lake Lockie is believed to deliver flow to Lake Roonki—see chapter 2 and 3.

The northern part of the system, Lakes Mournpall, Yerang, Yelwell and Konardin, receive water both directly from Chalka Creek, and via Lake Lockie. Lake Bitterang is the last of the lakes to fill, with floodwaters only reaching it over a month after the beginning of flooding, and then only if the flood level is sufficiently high. When the lakes are full, floodwaters also spread over surrounding floodplains, including an area of black box flats to the west and south-west of Lake Lockie. Lake Kramen fills by overland flow from the Murray in a very high river. Lake Cantala is fed by a minor anabranch of the Murray River.

The lakes only fill during high flow events in the River Murray, with a flood of at least 152 GL per day required for all of the lakes to fill. Water retained in lake basins after floodwaters recede is gradually lost through evaporation. Most lakes are shallow, and dry up within two years if not refilled, but Lake Hattah may retain water for three years, and Lake Mournpall for up to seven years.

The hydrology of the Hattah Lakes system has altered in response to the construction of locks and weirs along the River Murray, and the inlet channel, at Chalka Creek, has undergone deepening and widening. A regulator on Chalka Creek at Messengers Crossing is used to delay flow recession from the lakes, helping to increase the duration of inundation. Channels (with regulators) have been constructed between Lake Lockie and Lake Hattah and between Lake Hattah and Lake Little Hattah.

The River Murray headworks storage and diversions have resulted in an overall reduction of mean annual flow at Euston Weir to 50 percent of pre-regulation volumes. River regulation has also reduced the frequency and magnitude of small-to medium-sized floods to the lakes. Flows in spring are considerably less than under natural conditions. Under natural flow regimes the lakes usually contained water for most of the time albeit extremely shallow for most of the time. The Hattah Lakes system under current conditions presents a trade-off between the frequency of wetting and the duration of wetting. While the frequency of events may have increased, the reduced `commence to flow' threshold allows water to drain from the lakes faster than under natural conditions. The regulator at Messengers Crossing on Chalka Creek reduces this problem. The changes in flow regimes at Hattah Lakes are summarised in Box 15.6.

Ways of Addressing Changes Resulting from River Regulation

Chapter 5 provides details of the fauna and flora for this area. It also describes the ecological changes resulting from river regulation. Table 15.10 provides an outline of the preferred flood regimes for the various species in Hattah Lakes. The purpose of environmental flow watering events is therefore to attempt to achieve these flood requirements or if not, minimise the effects of river regulation of flow regimes.

At Hattah Lakes the environmental managers face a major physical constraint—the problem of initiating flows into the Hattah Lakes system through the higher

Chalka Creek relative to the River Murray channel. This requires high flows and volumes before flows commence. Only very large floods result in all the Hattah Lakes being flooded. Smaller floods that have a recurrence interval of every several years result in 30 percent to 50 percent of the Lakes being flooded. Utilising these smaller flood events that occur relatively frequently is just as important as managing the less frequent larger flood in Hattah Lakes.

There are four major delivery methods for watering Hattah Lakes:

- manipulating Euston Weir and upstream storages such as Torrumbarry Weir and Hume Dam;
- pumping additional water into the lakes from the River Murray—see Figures 15.9 and 10 for examples of pumping for environmental flows and flooding resulting from pumping. Currently, this method is still in its infancy but was used in the 2005–06 with a high degree of success;
- improving water management within the Lakes system through the use of regulators to manipulate flows to specific sites at specific times and for retention of water once an area is flooded; and
- topping up or enhanced flows. These involve piggy backing off inflows to the River Murray from its tributaries such as the Murrumbidgee and Goulburn rivers to increase the overall volume of water in the system.

Figures 15.13 and 14: Pumping and Flooding.

Another specific action that could be implemented at Hattah Lakes is the deepening of Chalka Creek in order to provide flows to the Hattah Lakes at lower river discharge levels. Installing a pump station at Chalka Creek to pump water into Chalka Creek and the Hattah Lakes is also an option. This allows an increase in flood frequency as well as duration and magnitude of floods.

Table 15.11 Flow thresholds for landscape feature inundation for Lindsay and Wallpolla Islands

Stage	Lindsay Island	Wallpolla Island
Stage I Very Low <20 GL/d	Creeks are extensively ponded. Water levels and creeks in backwater controlled by Lock 6.	Creeks are ponded. Water levels in Wallpolla Ck and creeks to the west are controlled by Lock 9. Virtually no through flow.
Stage II Low 20-35 GL/d	Major creeks begin to flow as inactive anabranches become connected to the River Murray upstream resulting in a change from ponded to flowing.	Creeks become connected to the River Murray weir pool and flowing. If sufficient head occurs, Finnigans, Sandy, Moorna and Dedmans creeks will flow. Very few inundated areas occur west of Moorna Ck. Anabranches become connected at Thompsons Ck to the River Murray in the north, and Wallpolla Ck to the River Murray in the south.
Stage III Small 35-60 GL/d	A few anabranches begin to form, e.g. along Mullaroo Ck and River Murray at Toupnein Island, and some backwaters begin to expand. A network of small channels associated with or near River red gum forests forms.	The number and complexity of flow paths is increased as small, unnamed creeks begin to flow and may connect to other small creeks—Sandy Ck to Finnigans Ck, Moorna Ck to Wallpolla Ck, Dedmans Ck to Wallpolla Ck. Occasional filling of backwater creeks.
Stage IV Medium 60-115 GL/d	Backwaters continue to expand (e.g. Oscars Ck) off Pollards Island, south of Toupnein Ck and centre of Lindsay Island. The terraces of the Lindsay River become flooded. Additional flow paths begin to form and existing filled creeks join up.	Backwaters that are expanding are off the main eastern creeks e.g. Sandy, Finnigans, Thompson and Wallpolla Creeks. Wallpolla Ck connects to Willipenance Ck. Anabranches become active off Wallpolla Ck. Floodplain inundation begins to occur north of Wallpolla Ck and west of Moorna Ck.
Stage V Large >115 GL/d	Flow paths continue to spread out and coalesce, more overbank flows from the River Murray, landscape features begin to be submerged and individual flow paths or landscape features (e.g. creeks and terraces) are difficult to distinguish.	Flow changes occur as expanding backwaters begin to coalesce with the area between Moorna Ck and Dedmans Ck becoming inundated (anabranches merge with the River Murray to return flows to the river).

Source: MDBC (2005b).

Box 15.7 Changes in flow regimes of Lindsay–Wallpolla Islands based on an analysis of the 109 year flow record

Reduced flood frequency	Downstream of Wentworth Weir, under current conditions, the frequency of flood events with peaks greater than 10 GL/d has been reduced. Small flood events that are above regulated flow (peaks between 20 GL/d to 40 GL/d) now occur approximately 56 – 86 times per year rather than approximately 106 – 117 times per year. However, it is the frequency of events larger than this (classed as 'medium-sized' events) that have suffered the greatest impact under current conditions. This is due to the dampening effect of lock and weir operation. For these events (peaks between 50 GL/day to 100 GL/d) frequency has been at least halved under current conditions. For floods with peaks >100 GL/d the frequency is less than one third of the natural frequency. In contrast to the reduced frequency of floods with peaks >10 GL/d, it should be noted that the frequency of small in-channel events with a peak of <10 GL/d has doubled.
Reduced flood duration	For the Lindsay–Wallpolla Islands, the greatest change in event duration has been for flows up to 10 GL/d. The median duration of events below 10 GL/d has been reduced from 258 days to 46 days. Flows above 20 GL/d and below 115 GL/d suffered the greatest decrease in the duration of events as a result of river regulation. Larger flood events (greater than approximately 115 GL/d) have been relatively unaltered.
Reduced annual volume and changes to seasonality	For flows up to approximately 20 GL/d, the seasonal pattern has largely been retained, with the exception that more low flows occur in winter than could be expected under natural seasonal conditions. For higher events, up to 60 GL/d, seasonality has shifted, now occurring one to two months later in the season. For larger events (> 60 GL/d) the onset of flooding has been slightly delayed. At the South Australian border, current median flow is 39% of natural (Gippel & Blackham 2002). Mean flow is 46% of the natural volume.

Source: MDBC (2005b).

Table 15.12 Table Water Management Unit Flow Requirements.

<table>
<tr><th>Water Management Unit</th><th>Duration</th><th>Frequency</th><th>Timing</th></tr>
<tr><td>River red gum</td><td>3 to 8 months</td><td>1 in 2 years</td><td>Spring to early summer</td></tr>
<tr><td>Black box woodland</td><td>2 to 6 months</td><td>1 in 5 years</td><td>Spring to early summer</td></tr>
<tr><td>Lignum shrubland</td><td>3 to 12 months</td><td>1 in 8 years</td><td>Spring to autumn</td></tr>
<tr><td>Open areas</td><td>Increase</td><td>Increase</td><td></td></tr>
<tr><td>Permanent wetlands</td><td colspan="3">Increase water level variability, provide a low water phase
Assess individual wetlands for requirements</td></tr>
<tr><td>Wetlands connected by 60 GL/day (individual medium sized wetlands)</td><td colspan="3">Evaluate water regime needs</td></tr>
<tr><td rowspan="2">Wetlands connected by 60-115 GL/day</td><td>Decrease</td><td>Increase</td><td>–</td></tr>
<tr><td colspan="3">Maintain flood duration</td></tr>
<tr><td>Connected by >15 GL/day</td><td>Increase</td><td>Maintain</td><td>–</td></tr>
<tr><td>Lake Wallawalla</td><td colspan="3"></td></tr>
<tr><td>Herbfield zone</td><td>2 to 4 months</td><td>1 in 3 years</td><td>Spring</td></tr>
<tr><td>Red gum zone</td><td>Minimum of 6 months</td><td>1 in 2 to 5 years</td><td>Late Winter/Spring/ early Summer</td></tr>
<tr><td>Black box zone</td><td>2 to 4 months</td><td>1 in 3 to 5 years</td><td>Not critical</td></tr>
<tr><td>Active channels connected to weir pools</td><td>Reduce</td><td>Reduce</td><td></td></tr>
<tr><td>Active channels drier than natural</td><td>–</td><td>Increase</td><td>–</td></tr>
</table>

Source: MDBC (2005b).

Ecological Asset Site 4: Lindsay–Wallpolla and Chowilla Floodplain

Features of Lindsay–Wallpolla and Chowilla Floodplain

The Chowilla Floodplain and Lindsay–Wallpolla Islands Significant Ecological Asset (SEA) comprises three separate locations: Lindsay Island in Victoria; Wallpolla Island in Victoria; and the Chowilla Floodplain, which spans South Australia and New South Wales and the NSW section of the Chowilla Floodplain. Under the SEA arrangements Lindsay Island and Wallpolla Island systems are a single group—in reality however, they are separated by approximately 40 river kilometres.

Lindsay and Wallpolla Islands are formed on the southern side of the River Murray (Victoria) by a series of anabranches that leave and then rejoin the river, leaving the islands situated between the anabranch channels and the main stem. Wallpolla Island covers an area of 9,200 ha and Lindsay Island has an area of 15,000 ha. The main anabranch forming Wallpolla Island is Wallpolla Creek and the main anabranch forming Lindsay Island is Lindsay River. Lake Wallawalla is a shallow, permanent riverine lake located off the lower Lindsay River and is part of Lindsay Island. Potterwalkagee Creek is another anabranching channel that is located between Lindsay and Wallpolla Islands, and it forms Mulcra Island (2156 ha). Thus, Lindsay Island and Wallpolla Island are linked by Mulcra Island, and although it has ecological values, Mulcra Island is not part of the Significant Ecological Asset.

Wallpolla Island is a state forest while Lindsay Island is part of the Murray-Sunset National Park. The Victorian Government and the Mallee Catchment Management Authority have identified both the Lindsay and Wallpolla Islands as high ecological value areas. Lindsay Island, Wallpolla Island and Lake Wallawalla are listed under the Directory of Important Wetlands and are nationally significant. The anabranches of the islands are also important native fish breeding habitats. Although the areas of permanent and semi-permanent wetland in each site are small, they support species that are of national, state and local importance. Lake Wallawalla is considered to be a `high value' wetland system.

Flood flows from the River Murray are crucial to the environmental condition of the Lindsay–Wallpolla system. The health of this system is threatened by river regulation. Due mainly to reduced frequency of medium-sized floods. The seasonal pattern of river flow remains largely unchanged.

The islands are located in the far northwest of Victoria just downstream of Mildura–Wentworth. Wallpolla Island is located downstream of Wentworth Weir (Lock 10) and upstream of Lock 9. Lindsay Island is located just downstream of Lake Victoria and between Lock 6 and Lock 7 (approximately 700 km from the River Murray Mouth). Frenchmans Creek flows from the River Murray to Lake Victoria, diverting some water from Wallpolla Island, while the Rufus River runs from Lake Victoria into the Lindsay Island system. One of the largest channels within this system is Mullaroo Creek, which diverges from the River Murray just upstream of Rufus River, crosses the island from east to west, and then joins the Lindsay River.

Lake Wallawalla is a quasi-circular deflation basin located on the southern point of the system with a surface area of 828 ha. It is a significant source of groundwater recharge to the Lindsay Island system. It is separated from the main floodplain area of Lindsay River by a levee

Figure 15.15 Pumping structures for environmental flows directly from river.

Figures 15.16 and 17 Environmental flow achievements.

that impedes the natural flood path (the Mail Route Road). The Mail Route Road acts as an impediment to medium-sized floods, with several small culverts allowing limited flow. Under natural conditions, this would have made a continuous connection with the floodplain. Black box communities surround the lake, with extensive sand dune deposits to the south-east. During flood inundation, Lake Wallawalla becomes a wetland and is a significant site for bird breeding.

Table 15.11 below describes the water volumes required before water will commence to flow into Lindsay-Wallpolla Islands systems and hence is a major determinant of when and how environmental flows are implemented.

Flow and Flood Regime Changes due to River Regulation

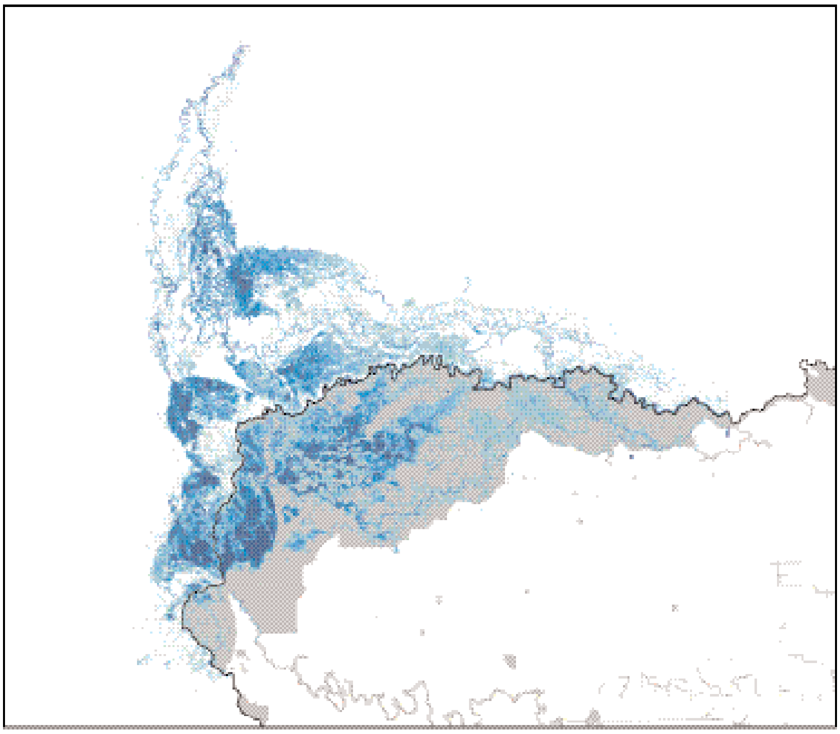
The major changes from river regulation for Lindsay–Wallpolla flow regimes are: reduced flood frequency; reduced flood duration; and reduced annual volume and changes to seasonality (see Box 15.7). Of the water that flows from the River Murray into the Lindsay–Wallpolla Island systems, some is lost to groundwater recharge and evaporation, but the majority is returned to the River Murray downstream.

As described above the Lindsay-Wallpolla Island system has an extensive range of vegetation communities and hence habitat types. Each of these require their own unique flooding regime. Table 15.12 describes the water flow requirements for different vegetation groups within Lindsay–Wallpolla Islands.

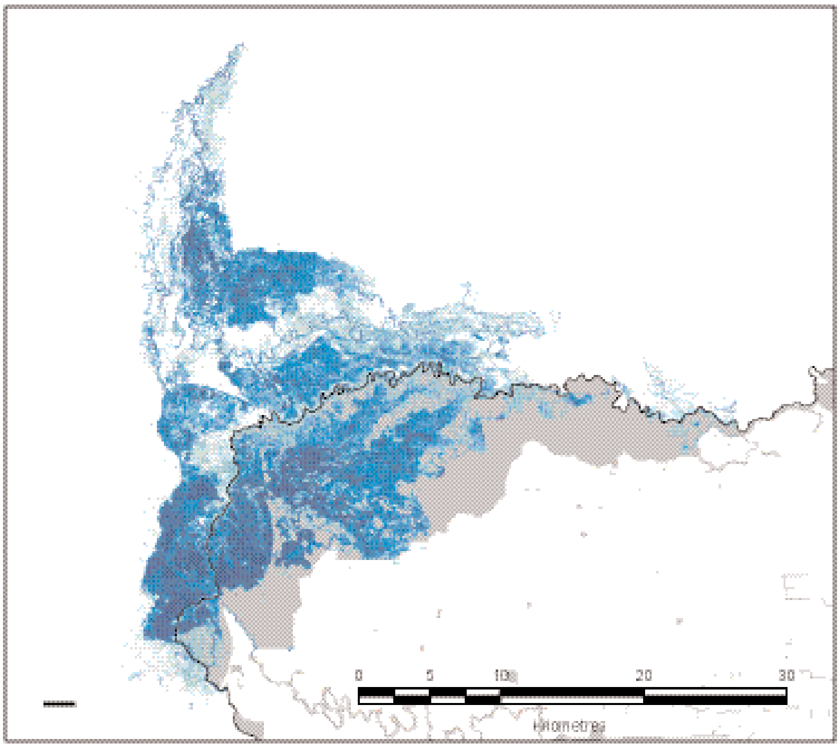
Maps 15.3 Distribution of Environmental Flows at Barmah-Millewa 2005-06.

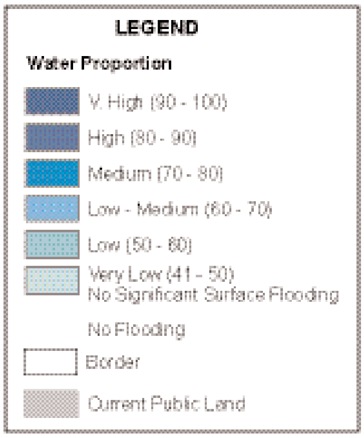
Flood Mapping in the Barmah-Millewa Forests October - November 2005
(period of high released flows) Spot -4 satellite imagery

14th October 2005 (peaked Yarrawonga 3-4 October 17,000 ML/day)



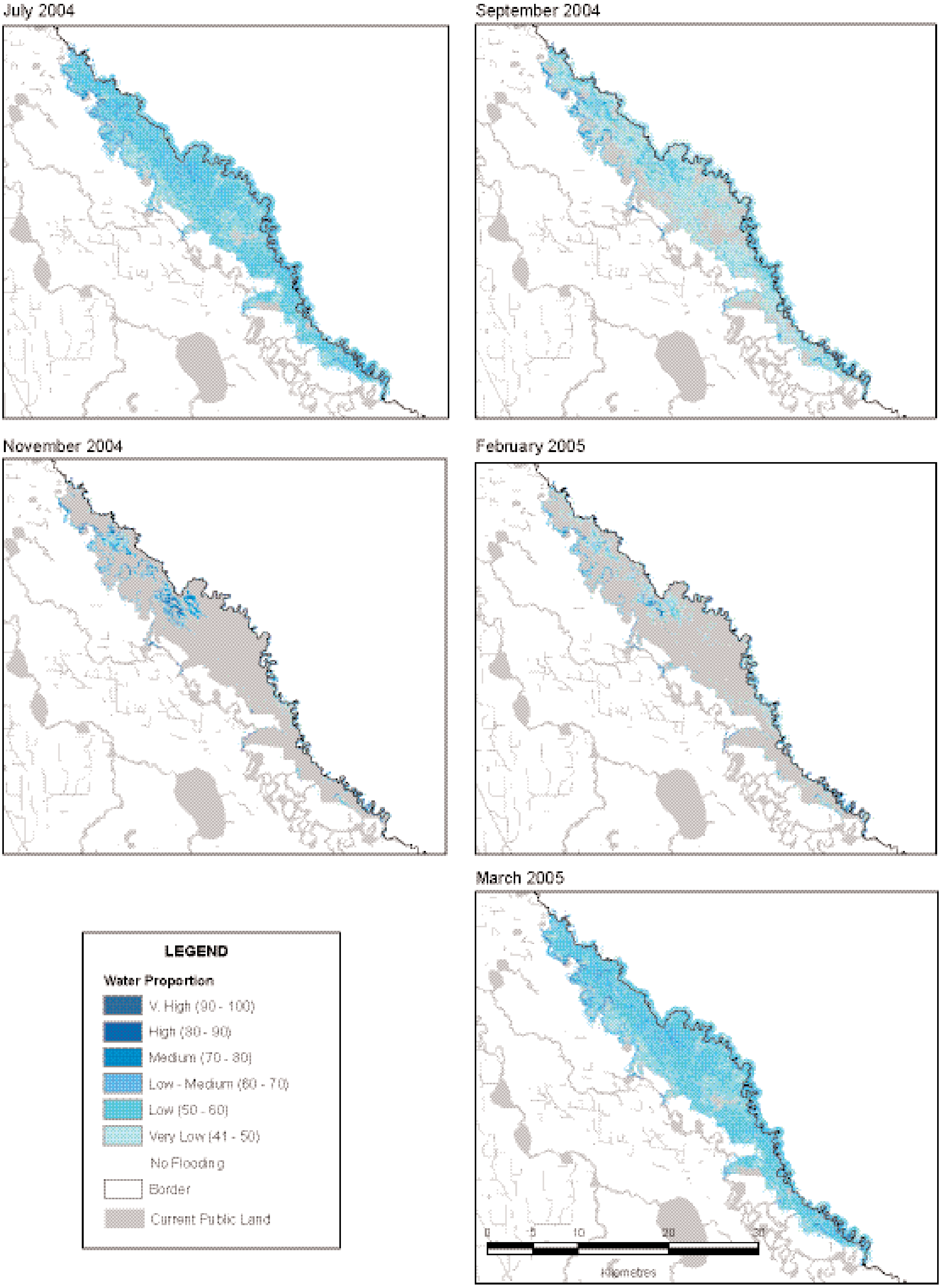
25th November 2005 (peaked Yarrawonga 12-13 November 28,000 ML/day)





Maps 15.4 Distribution of Environmental Flows at Gunbower and Koondrook–Perricoota Sites 2005-06.

Flood mapping in the Gunbower State Forest July 2004 - March 2005
(period of high release flows) Landsat 5 Satellite imagery



Ways of Addressing Changes Resulting from River Regulation

Flows in this section of the River Murray follow a seasonal pattern similar to that prior to river regulation, with maximum flows in winter and spring, and minimum flows in autumn. However, the actual volume for the seasonal pattern is lower with regulation. A range of methods deliver environmental flows to Lindsay–Wallpolla Islands, all of which are linked to the specific geomorphology of the area (see chapters 2 and 3). These can be grouped as either the use of weirs and structures such as regulators and or the use of pumping.

In some situations, water from Lake Victoria could be used to achieve water spills onto the floodplain, for floods less than 50 GL per day because of the outlet constraint of Lake Victoria. Water could be supplied from Lake Victoria through Rufus Creek to `top up' smaller floods for the western end of Lindsay Island system (Wallpolla Island is just upstream of Lake Victoria). This method has the potential to increase flood frequency or duration of medium-sized events that allow connectivity of the anabranches.

Existing weirs and regulators on channels could be further enhanced to manage flows through a range of active channel habitats. These structures provide operational flexibility in that they can be used to facilitate flooding and prevent flooding combined with extending the time for flood inundation and the timing of the flood. Levees could be used in conjunction with weirs to pond water, but the negative effect of interfering with the distribution of waters from natural floods was considered to be sufficient reason to reject this method. The construction of fish passages also falls under this category.

Pumping is carried out in the Chowilla and Lindsay–Wallpolla as an emergency measure for isolated wetlands that have not been watered for a long time. Pumping also has the potential to water areas of floodplain, such as Black Box, which are located on high elevation areas. It can also be used for filling wetland systems to simulate flooding. There are, however, arguments against pumping because of the high ongoing cost and intensive management required and the need for the construction of levees to pool the water and prevent run-off.

Figures 15.18 Australian white ibis nesting in a river red gum forest.

16 Earth Resources

Currently earth resources such as road and building construction materials are accessed throughout the study area. New research and technology developments suggest that the area may also contain minerals including gold and heavy mineral sands.

A detailed description of the geology and geomorphology of the River Red Gum Forests study area is provided in chapters 2 and 3. This chapter describes the earth resources and highlights the active exploration and mining tenements within the study area particularly industrial minerals such as mineral sands and gypsum (McHaffie & Buckley 1995; Campbell et al. 2003) (Map 16.1). More generally, sand and gravel deposits in the vicinity of the major river systems may be significant sources of construction materials for local communities. There are also areas of brown coal near the surface in the Kerang-Torrumbarry area that are currently not economic to extract. The central part of the study area has Bendigo-style gold deposits buried under a cover of more recent sediments (Phillips & Hughes 2003). Copper, gold, molybdenum, tin, nickel, iron, bentonite, platinum group elements and base metals (e.g. lead, copper and zinc) may also be present in economic quantities.

Currently, the earth resources tenements on Crown land within the study area are:

- Two petroleum exploration permits;
- 17 mining exploration licences comprising:
  - > three for mineral sands;
  - > two for gypsum;
  - > 12 for gold/silver/platinum;
- Four mining licences for extraction of gypsum;
- Four work authorities - three for sand or gravel, and one for granite extraction; and
- 8 pipeline licences associated with mining and resource extraction activities.

In addition to existing tenements, the study area may contain more extensive areas of extractive materials, mineral sands, base metals and potential for economic gold deposits (Map 16.2).

MINERAL POTENTIAL

Gold

Gold-bearing bedrock is well exposed in the central portion of what is known as the Bendigo Zone (see chapter 2). The Bendigo Zone is a distinct geological strip running north-south through central Victoria. Within the study area, this zone is covered by younger sediments from near Swan Hill to Echuca, and outside the study area south to Werribee and a point about 20 km south of Colac. More recent Cainozoic rocks cover the northern third of the zone (see Map 2.1).

Most of the viable gold has been extracted from the exposed portion of the Bendigo Zone although this is currently being re-evaluated (e.g. Bush et al. 1995).

Preliminary estimates of gold potential within the Bendigo Zone of the study area suggest that up to 300,000 kg of gold resource may be present (GeoScience Victoria DPI in-house estimate) worth an estimated $6 billion to $8+ billion at current gold prices ($830 AUD per oz).

The main gold-prospective area within the study area lie under surface sediments and are not exposed on the surface. About 60 percent of this Bendigo Zone ‘under cover’ area is lies within the River Red Gum Forests study area, although a considerably lower percentage of this area is public land.

The Victorian Government recently commenced the three year *Delivering Gold Undercover* project to attract exploration and development and invest in data and technologies for identifying gold north of the golden triangle in central Victoria, in the ‘under cover’ area (DIIRD 2005). This initiative is aimed at encouraging new areas of gold exploration, where an additional 2,270,000 kg gold resource has been estimated (GeoScience Victoria DPI in-house estimate).

The likelihood of finding economically viable gold deposits in the study area outside the Bendigo Zone is low (Phillips & Hughes 2003). However, gold has been found in some areas in east in the past; notably the Ovens River, which yielded around 15,000 kg (current value over $300 million). The Kiewa valley has also been worked in the past and may still contain gold deposits. It is likely that not all the gold was extracted and developments in mining technology may make this area (and similar alluvial systems) of economic interest in the future.

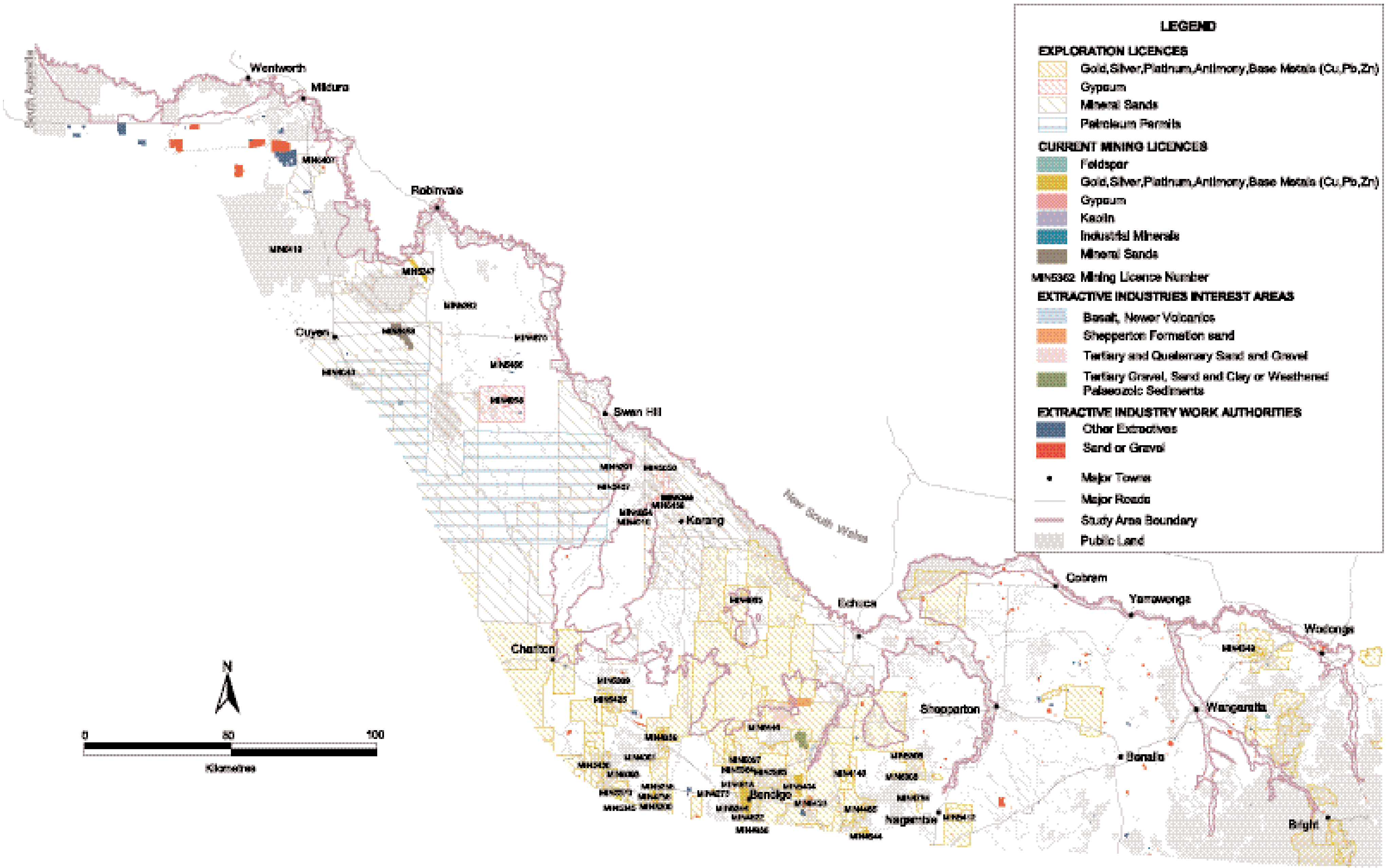
Mineral Sands

Mineral sands contain a group of minerals which are rich in the elements titanium and zirconium (the main elements of economic interest at present). In places these deposits contain economic concentrations of heavy minerals such as ilmenite, rutile and zircon. The titanium-bearing minerals are primarily used for producing paint, but could also be used to produce titanium metal. The zirconium-containing mineral (zircon) is mostly used as a high-temperature refractory in lining furnaces for smelting and casting metals, but also has other uses.

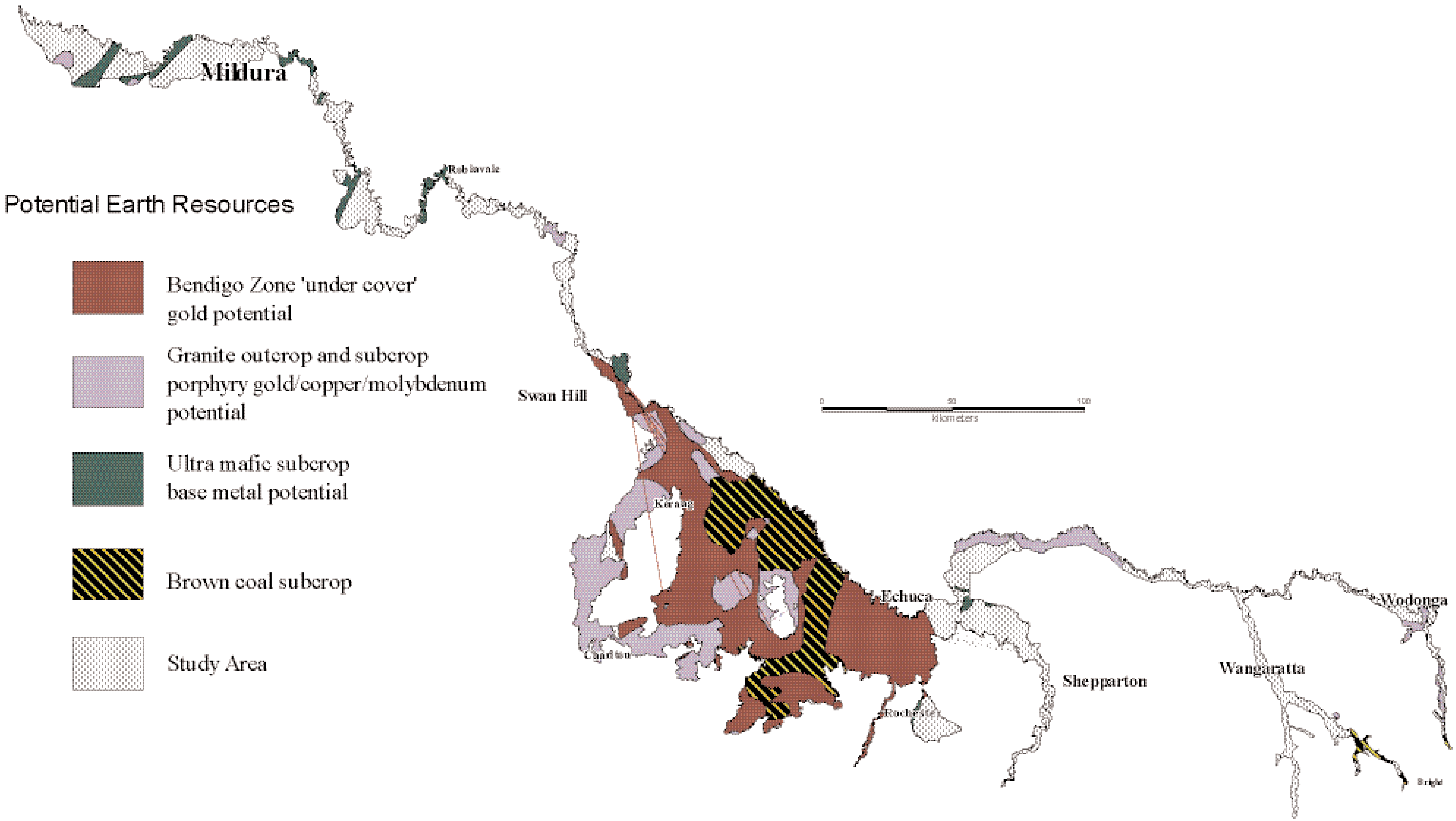
Past drilling found deposits close to the Murray Basin margin near Kerang, Boort and in an area through to Edenhope and Casterton. The Wemen deposit near Robinvale was discovered in 1995 and was the first to be mined with operations commencing in 2001 (Campbell et al. 2003). Economic deposits have been identified near Ouyen (KWR deposit) and exploration indicates that the Murray Basin may contain other world-scale heavy mineral sand deposits (Campbell et al. 2003).

There are currently three exploration licences for mineral sands within the study area. These are primarily in the western portion of the study area where the late Miocene-early Pliocene shallow sea deposited sand dunes and strandlines—the Parilla Sand—containing heavy minerals (Brown & Stephenson 1991; Campbell et al. 2003).

Map 16.1 Existing work authorities, exploration permits and extractive mineral licences within the study area.



Map 16.2 Potential mineral resources within the study area.



Source: DPI, January (2006).

Gypsum

Victorian gypsum deposits occur typically in Quaternary lakes and aeolian dunes located in northwest Victoria. Major deposits are located between Kerang and Swan Hill, within the River Red Gum Forests study area, and the Raak Plains to the west of Hattah (Olshina 1999; Buckley 2003; Campbell et al. 2003). Gypsum mined in Victoria is mostly used as soil conditioner, for plaster and plasterboard and in the construction industry. Currently there are two exploration licences and four mining licences to extract gypsum in the study area.

Other Minerals

Porphyry—a variety of granite—can sometimes contain copper, gold and molybdenum. Two such deposits are known in east Gippsland (both currently sub-economic). Granitic rocks within the study area may be found to contain porphyry systems in the future.

Ultra-mafic rocks (i.e. rocks with a volcanic origin that are often rich in certain minerals) are known to host base metal deposits, for example those in the West Coast Mine District of Tasmania. The Tasmanian terrain hosts many major mines, and has produced between 700 and 1000 million tonnes of ore-grade rock. It is unlikely that deposits of this magnitude would remain in Victoria, however there may be smaller base metal deposits within the study area. A reasonable estimate of the potential value of base metal resources within the study area is between $150 and $300 million (GeoScience Victoria DPI in-house estimate).

A large bentonite clay deposit is currently being worked at Arumpo, in NSW, north of Robinvale and 70 km east of Mildura (McHaffie & Buckley 1995). This deposit has reserves of up to 70 million tonnes with a current value in the range of $10 to $40 per tonne, depending on quality. Its proximity to the River Red Gum Forests study area, in an area of similar geology, implies a significant potential for such deposits in this region.

Petroleum

Hydrocarbons have been detected in most Mesozoic age sedimentary basins within Victoria. The largest economic accumulations of oil and gas in Victoria are found within sections of the southern rift Gippsland and Otway Basins, which have produced commercial quantities for over 30 years.

The River Red Gum Forests study area contains at depth, Mesozoic sediments of the Murray Basin (see chapter 2). To date exploration for petroleum has been limited despite new data acquisitions by the Minerals and Petroleum Division of DPI. Generally the amount is small and only detected by sophisticated equipment. Two petroleum exploration permits are currently held. Lack of appropriate rock structures and poor petroleum generation conditions, combined with the expensive nature of petroleum investigations, have limited exploration in the Murray Basin and favoured continued exploration in the southern rift basins (Bernecker et al. 2003).

Energy Resources

A large area of brown coal—equivalent to about 2,000 km^2 and one third the size of the Latrobe Valley coalfields—occurs in seams up to 40 metres in the centre of the River Red Gum Forests study area near Kerang, Torrumbarry and Echuca (Holdgate 2003). This resource is buried up to 100 metres deep and is not regarded as economic to extract at the moment. Future changes in energy costs or advances in technology (e.g. coal-to-liquid fuels and 'clean coal' technology) may enhance the economic viability of this deposit.

Very little is known about other resources such as geothermal energy potential within the study area.

ECONOMIC VALUE OF CURRENT INDUSTRY

Extractive Industry

Extractive industries produce crushed rock, sand, gravel and clay, mostly for building, construction and road-making, as well as stone blocks and slabs for decorative use in buildings, paving and monuments. Crushed rock is used as aggregate for road surfacing and road base construction, bedding materials for dam construction and pipe laying, and armour stone for embankments. Each such application requires stone of defined size and properties, with basaltic rocks the most widely used material in Victoria (i.e. bluemetal is used extensively in construction industries). Stone can be cut to specific proportions for use in building (especially for cladding), construction (paving) and monuments (dimension stone). Decorative stone is increasingly used for the manufacture of bench-tops and other furniture.

The industry is of significant economic importance as a provider of essential materials for housing and infrastructure. In general, stone resources are sought close to where they will be used to reduce transport costs. The value of extractive materials produced within the study area, as reported by licensees, is shown in Table 16.1.

Mining of Minerals and Petroleum

Within Victoria the production of gold, brown coal and petroleum has long been a significant producer of wealth, with mineral sands production of increasing importance. The economic value of products extracted from mining licences within the River Red Gum Forests study area is shown in Table 16.2.

Value to the Community

Earth resources operations vary greatly in their economic, environmental and social impacts. There are over 800 extractive industry operations registered in Victoria producing almost 40 million tonnes of material per annum. The industry occupies sites in metropolitan, regional and rural areas with more than 75 percent of quarries located outside the greater Melbourne region. The industry is characterised by a mix of some large operators and many medium and small operators, some employing only one or two people. Many of the smaller operators are based in remote localities.

The industry directly employs over 2200 people, with a flow-on effect of an additional 2–3 people indirectly employed for every direct job. The extractive industry is widely distributed across the region and has provided employment over many decades making it an important employer in many rural and regional communities.

Table 16.1 Value of extractive production from licences within the study area.

Date	Tonnes Produced	Dollar Value ($)
11 years (94/95 to 04/05)	11,221,760	90,598,980
Average over 11 years	1,010,160	8,236,270
2004/2005 total	1,289,260	12,547,850

Source: DPI, January (2006).

Table 16.2 Value of mining production from licences within the study area.

Date	Cubic Metres Produced	Dollar Value ($)*
9 years (total) (96/97 to 04/05)	414,930	-
Average over 9 years	46,100	-
2003/04-2004/05 data	71,140	236,910

Source: DPI, January (2006).

* Dollar value: the dash indicates there are no data for this period.

Transport costs typically make up most (up to 25 percent) of the price of materials and so proximity to market is important. Minimising transport distance also reduces the environmental impact and energy consumption associated with the movement of large quantities of construction materials.

MINING METHODS AND ADMINISTRATIVE FRAMEWORK

Open-cut and underground mining are the two major mining operations likely to be used within the study area:

Economically viable deposits of mineral sands, coal, extractive industry material (sand, gravel, etc) and some industrial minerals (e.g. gypsum or clay minerals such as bentonite and kaolinite) are most likely be extracted using open-cut methods. Open-cut mines vary from modest pits for small sand quarries or gypsum mines to large pits for mineral sands or extensive clay deposits.

Gold and base metals are likely to be accessed underground through shafts or declines unless there is a major deposit overlain by relatively thin cover, in which case open-cut methods are more economic.

Research on remote mining could significantly enlarge the window of economically viable resources at depth. Remote mining extracts resources with robotic devices and modified drilling equipment operated from the surface and does not require the mine to be free of water or ventilated (or made safe for people). When and if such techniques become commercially available, they may be able to access ore deposits which are currently out of reach for intractable geotechnical or other reasons.

The Department of Primary Industries (DPI) regulates a number of primary industries to achieve agreed social, economic and environmental outcomes. For example, the Minerals and Petroleum Division (MPD) within DPI ensures that mining, petroleum, extractives, pipeline and geothermal operations meet health, safety and environmental requirements. This responsibility is carried out with the support of other government agencies which administer associated legislation, including the Department of Sustainability and Environment, the Department of Infrastructure, the Environment Protection Authority, WorkCover and local government.

The principal Acts administered by MPD as a regulator for earth resources activities are the *Mineral Resources Development Act 1990, Extractive Industries Development Act 1995, Geothermal Energy Resources Act 2005, Petroleum Act 1998,* and the *Pipelines Act 1967*. The *Pipelines Act 1967* regulates the construction and operation of major transmission pipelines such as those used for oil and gas which, as infrastructure, would be distinguished from regulations for extractive and mining activities.

The *Mineral Resources Development Act 1990* provides the legislative framework to develop and regulate the mineral exploration and mining industry. This Act applies to all minerals, including gold, coal, and mineral sands. The Act establishes the system for resource allocation and approval of mineral exploration and development, including compensation, rehabilitation and royalty requirements. Additionally, it defines the term 'restricted Crown land' that is used under various acts, to control exploration or production of earth resources (see land use arrangements discussion below).

Earth resources legislation contains a number of specific measures that seek to minimise the impacts of earth resources activities on the environment. The key tools are summarised below.

Regulated Activities

Before any activities (such as exploration, mining or actual extraction of material or energy) can be undertaken, companies must have an exploration or mining licence, or permit for extraction of the resource in accordance with the relevant legislation, and also have obtained a 'work authority' or permit. In order to gain a work authority a company must demonstrate that it has:

- an approved work plan (addressing safety and environmental matters)
- entered into a rehabilitation bond
- met any planning requirements
- obtained any other consents and authorities required, and
- obtained the landowner's consent with regards to an appropriate site and an agreement with the landowner for compensation for extraction activity.

Work Plans

Resource companies must submit work plans for approval prior to the granting of consent to undertake activity within a licensed area. DPI is responsible for assessing and approving these work plans. Work plans provide detailed regulatory information about the proposed operation—particularly its health, safety and environmental management (including rehabilitation). A typical draft work plan covers the following areas:

- description of proposal
- site location, infrastructure and resource assessment
- site details (location of crushing plants, on-site offices and transport 'haulage' routes, sludge ponds, and geographical features like water courses, vegetation and topography)
- details of operation
- environmental, and occupational health and safety controls
- rehabilitation plan
- dust and noise emission control
- drainage and discharge control (including storm water management)
- erosion control and ground water protection
- removal or restoration of native vegetation
- noxious weeds and pests control
- internal buffers, screening and roads
- progressive and final rehabilitation
- fencing and security.

Rehabilitation

The above Acts prevent a licence holder from operating unless they have an approved rehabilitation plan and have provided an approved rehabilitation bond. The *Mineral Resources Development Act 1990* also requires any potential long term degradation of the environment to be taken into account while the *Extractive Industries Development Act 1995* requires the rehabilitation plan to take into account the need to protect or conserve native vegetation and protected flora and fauna.

Rehabilitation bonds are financial securities provided prior to the commencement of works. The bond guarantees that rehabilitation will be undertaken. Bonds must be high enough to fund any rehabilitation work necessary as a result of approved works. This ensures that any costs of rehabilitation are borne by the licensee and not the community.

Native Vegetation

All resources industries are subject to Victoria's Native Vegetation Framework *Native Vegetation Management—A Framework for Action* (DNRE 2002) and DPI administers this through licences and work plan conditions in consultation with the Department of Sustainability and Environment. A proponent must have the significance of any native vegetation to be removed assessed, and ensure that the proposal is consistent with Victoria's Native Vegetation Framework e.g. through rehabilitation and offsets.

Planning Requirements and Environment Effects Statements

All resources industries are subject to planning requirements under the *Planning and Environment Act 1987* although some activities such as exploration do not require planning approval. Planning approval focuses on land use issues, including the appropriate location of operations. If significant risks to the environment are anticipated, or there are significant levels of public concern, proposed projects under all Acts may be subject to rigorous public assessment and review under the *Environment Effects Act 1978*. Normally this would only be done for major projects with significant risks.

Native Title

Mining and extractive activities on Crown Land, including the grant of occupancies, may be considered 'future acts' under the *Native Title Act 1993* which triggers consultation processes with Native Title claimant groups. Proposed activities require assessment for implications under this Act prior to work commencing. DPI will not grant an exploration or mining licence on Crown land that may be subject to or has an existing native title claim until the future act provisions under the *Native Title Act 1993* have been satisfied. Guidelines by DPI for industry and native title claimants assist with this process.

LAND USE UNDER EARTH RESOURCES LEGISLATION

Specific extractive industry operations are governed by the legislation described above. The implications for these activities on Crown land are explored in more detail below.

Mining

Exempted Land

Section 6 of the *Mineral Resources Development Act 1990* exempts certain areas of land from exploration, minining and searching licences or other authorities under the Act. Licences would not be issued for these areas except under special and limited circumstances (examples of which are given below). These exempted areas include:

- and in a reference area under the *Reference Areas Act 1978;*

- land in a national park, marine national park or sanctuary, wilderness park or state park under the *National Parks Act 1975*, with the exception of pre-existing (i.e. at the time of park establishment) tenements (mining or exploration licences), and miner's rights and tourist fossicking authorities which apply in certain park areas that are subject to notices under section 32D(1) of the *National Parks Act 1975*;
- land that is an Aboriginal area or place to the extent of the terms of a permanent declaration under Section 10 or 21E of the *Commonwealth Aboriginal and Torres Strait Islander Heritage Protection Act 1984*; and
- land that is a permanent archaeological area under Section 15 of the *Archaeological and Aboriginal Relics Preservation Act 1972*.

In addition to the permanent exemptions under Section 6, the Minister responsible for the *Mineral Resources Development Act 1990* has the ability under Section 7 to exempt other land from exploration or mining licences. The Minister can grant an exemption for any reason considered appropriate including (but not limited to):

- to protect land that is of significant environmental importance;
- to implement a recommendation from the Land Conservation Council; and
- to enable the orderly and optimal development of mineral resources in Victoria.

These exemptions can by revoked by the Minister at any time under Section 7(5) by notice in the Government Gazette and recorded in the mining register.

The Act establishes two further categories of Crown land—'restricted' and 'unrestricted'—with different requirements flowing as a result.

Restricted Crown Land

Under Section 44, a licensee who proposes to do work on restricted Crown land must obtain the consent of the Ministers administering the land under the *Crown Land (Reserves) Act 1978* and the *Forests Act 1958*. Schedule 3 to the *Mineral Resources Development Act 1990* states that restricted Crown land comprises:

- any land that is the subject of relevant recommendations proposing that the land be reserved under the *Crown Land (Reserves) Act 1978* for regional parks, coastal parks, marine parks, flora and fauna reserves, wildlife reserves, natural features and scenic reserves (including caves and geological reserves), bushland reserves, historic areas, public land water frontage reserves, streamside reserves, coastal reserves, national heritage parks, nature conservation reserves, and historic and cultural features reserves;
- any land subject to Government accepted relevant recommendations of the Victorian Environmental Assessment Council, or that is subject to relevant recommendations of the Land Conservation Council for which notice has been given by the Governor in Council (prior to the repeal of the *Land Conservation Act 1970*);
- any land that is an alpine resort within the meaning of the *Alpine Resorts Act 1983*;
- any land that is a heritage river area under Section 5 of the *Heritage Rivers Act 1992* or a natural catchment area under Section 6 of the *Heritage Rivers Act 1992*, other than land which is already exempted from exploration and mining activity under Section 6 of the *Mineral Resources Development Act 1990*; and
- any other Crown land (other than land exempted from exploration and mining activity under Section 6 of the *Mineral Resources Development Act 1990*) that the Minister for Resources and the Minister administering the *Crown Land (Reserves) Act 1978* and the *Forests Act 1958,* declare to be restricted Crown land for the purposes of the *Mineral Resources Development Act 1990.*

Unrestricted Crown Land

No additional consent requirements apply to unrestricted Crown land, although the Minister for Resources is required to consult with the Ministers administering the land under the *Crown Land (Reserves) Act 1978* and the *Forests Act 1958* when considering an application for a licence. Those Ministers may recommend conditions to which the licence should be made subject.

Additionally, land purchased or donated to the Crown may be unrestricted because it may not be subject to a recommendation by LCC, ECC or VEAC, or been nominated as restricted or exempted. However, other obligations and contractual arrangements may technically restrict mining activities, even on unrestricted Crown Land.

Extractives

Stone resources are owned by the landowner and extraction requires a work authority under the *Extractive Industries Development Act 1995*. The owner of Crown land is the Minister responsible for the Act under which the land is controlled or managed. The *Extractive Industries Development Act 1995* applies to the extraction or removal of stone from land for sale or commercial use in construction, building, road or manufacturing works. Under the Act, stone includes gravel, sand, soil, building stone and clay (but does not include fine clay, kaolin or salt).

Under the *Extractive Industries Development Act 1995*, the following areas are not available for production of stone:

- land in a reference area under the *Reference Areas Act 1978;*
- land in a national park, wilderness park, state park, marine national park or marine sanctuary under the *National Parks Act 1975*;
- land that is an Aboriginal place, to the extent of any terms of a declaration of preservation in force under Section 21C, 21D or 21E of the Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*; and
- land that is an archaeological area or contains relics registered under Section 10(a) of the *Archaeological and Aboriginal Relics Preservation Act 1972*.

References to restricted Crown land or exempt Crown land as defined in the Schedule 3 to the *Mineral Resources Development Act 1990* (see description above) have been recently removed from the *Extractive Industries Development Act 1995*. New provisions under

Section 11 of the *Extractive Industries Development Act 1995* provide for applications to consent to search for stone on any Crown land. The Minister responsible for the Act under which the Crown land in controlled or managed may agree, agree subject to conditions, or refuse consent but not without valid reason.

Petroleum

The Petroleum Act 1998 governs onshore exploration and development of petroleum resources in Victoria. The maximum holding permitted under a Petroleum Exploration Permit (PEP) is 12,500 square km for a period of five years. The permit can be renewed once for another five year period with a reduction in area of at least 50 percent. The Act also provides for the issue of Petroleum Production Leases (PPL) and general administrative procedures supported by the Petroleum Regulations 2000.

Petroleum exploration and production activities must not be carried out in reference areas defined under the *Reference Areas Act 1978*, or wilderness zones or wilderness parks as defined under the *National Parks Act 1975*. Written consent to undertake petroleum operations on restricted Crown land (defined under the *Mineral Resources Development Act 1990*) may be obtained from the responsible Minister. In general, written permission or consultation with the land manager or Minister responsible for the land must be undertaken prior to any significant petroleum operations carried out on Crown land, whether it is restricted or unrestricted. Other exemptions may be applied by the Minister for land that requires protection for significant environmental, commercial, economic or any other reason considered appropriate. The Minister may also revoke any exemptions issued in this way.

While the *Petroleum Act 1998* permits construction of pipelines of limited length within the permit area, the *Pipelines Act 1967* governs the control, ownership, location, construction and operation of pipelines more generally. Following a major review, the new *Pipelines Act 2005* was passed by Parliament in September 2005 and will come into effect when supporting Regulations are developed by MPD in consultation with interested stakeholders.

Geothermal Energy Resources

The *Geothermal Energy Resources Act 2005* provides the legislative framework for the development and regulation of the large-scale commercial geothermal exploration and extraction industry. This Act establishes that the heat energy within the Earth belongs to all Victorians, and is therefore vested in the Crown. Based on the *Petroleum Act 1998* model, the *Geothermal Energy Resources Act 2005* establishes the system for resource allocations and approvals required for geothermal exploration and extraction, including compensation and rehabilitation requirements.

The Act sets out permanent exemptions where a person must not carry out any geothermal energy operation on land that is a reference area, a marine national park or sanctuary, a national park, wilderness zone or park in a similar manner to the *Mineral Resources Development Act 1990*. Consent is required to carry out any geothermal energy operation on restricted Crown land (as defined above) but this is dependent on first obtaining consent of the Minister responsible for that land. Consent is also required for any land owned, vested in or managed or controlled by a water authority as defined under the Act.

In addition, the Minister can exempt land from geothermal energy operations for significant environmental reasons, to protect significant commercial or economic operations, to protect the land; or for any other reason considered appropriate. The Minister can also revoke these exemptions.

FUTURE REQUIREMENTS FOR RESOURCES

Obtaining general community consent to operate is vital for securing future access to resources. It also ensures development in accordance with principles of sustainability. Increasingly, the community expects better environmental and safety management and continues to push to minimize environmental disturbance during resource extraction. Consequently, these pressures demand that industry's performance needs to improve continually.

Earth resource operations are commonly regarded as producing large and undesired environmental impacts. Yet only a small number of operations fit this description. Extractive operations can have low environmental impacts and a small environmental footprint. In addition, extractive operations are obliged to progressively rehabilitate the land they occupy. Exploration can have little impact on the environment, particularly aerial surveys and geological mapping, for example.

Some production activities also have a relatively small ecological footprint. For example, underground mining involves tunnelling from a surface portal to extract resources (such as reef or deep lead gold), frequently hundreds of metres below the surface. An important advantage of underground mining is the high value of production relative to the generally small area of surface disturbance.

Increasingly, earth resources operations have focussed not only on economic and social gains, but also on the ability to offset any environmental impacts. For example, using reclaimed water for processing plants does not providing an environmental 'gain' but does reduce consumption of fresh water reserves.

Society's ever increasing demand for minerals and energy requires ongoing exploration and technological developments. Continued access to highly prospective areas is an important consideration in any land use planning decision-making process.

SUMMARY

Exploration, mining and extractive industry activity are currently limited on public land in the study area, but there is the potential for future expansion. 'Under cover' gold and near surface mineral sands resources offer the greatest potential. Current relatively minor uses of construction materials and dimension stones are of value, particularly for local communities.

17 Community Uses and Services

Small areas of public land throughout the study area are used for community uses and the provision of services by public utilities. Many of these areas are within townships or along major service routes, while others are located in more isolated areas.

This chapter focuses on only two public land use categories: community use areas, and services and utilities. These land use categories occupy a small proportion of public land across the study area, but how they provide community services and how they are managed are important issues for VEAC to consider. An extensive description of all other pubic land use categories can be found in chapter 9.

COMMUNITY USE AREAS

Many blocks of public land have been set aside for community uses in townships and small communities. Activities associated with these areas include education, recreation or other specific community purposes. Locally based Committees of Management are responsible for management of many of these reserves. Falling within the community use category are:

- Recreation Areas
- Parklands and Gardens
- Buildings in Public Use
- Education Areas.

Recreation Areas

Recreation relates to the various activities that people undertake during their leisure time. For a discussion of recreational and tourism use of public land more generally and in larger public blocks, refer to chapter 11.

Recreation areas are generally small reserves close to townships with facilities for organised sports with an emphasis on outdoor activities—cricket ovals and netball courts, for example. There are many recreation areas located across the study area. These networks of recreation areas are important for people's health and well-being as well as for the social vitality of local communities.

Parklands and Gardens

The parklands and gardens include small intensively used community parklands, playgrounds and ornamental gardens. Examples are municipal parks and playgrounds, public barbecue facilities, and botanic or ornamental gardens that are used for informal recreation. Parklands and gardens are located within town areas in easy reach of shops and town facilities. They are found in nearly all towns and regional cities within the study area, and are predominantly managed by local government. Most are small and highly modified, but some retain natural habitat. Some also have historical values.

Buildings in Public Use

Many public buildings such as halls, schools, libraries, museums and their associated facilities which have been principally established for community use are located on public land. These facilities are used for a range of community activities including education, recreation, meetings, community information dissemination and tourist advice. Some buildings, such as schools, are use-specific but also double as multi-purpose buildings for a range of activities. Community halls also serve a range of purposes including entertainment, indoor sports activities and meeting forums. Older buildings such as education buildings may also have historical values. These buildings may be managed by the Department of Education and Training, local government, appointed Committees of Management or community organisations (not for profit groups).

Education Areas

Environmental education is a key strategy for ensuring the long-term sustainability of natural systems across Victoria and has been an important element of government environmental policy over recent decades. Under legislation, the Victorian Commissioner for Environmental Sustainability is required to evaluate and audit all public environmental education programs in the state. Environmental education is now also a key aspect of the formal school education system as well as being a high profile area in the vocational and tertiary education sectors.

Because of its biophysical focus, environmental education frequently involves field studies and investigations, which require access to specifically allocated areas of public land. These education areas are set aside as reserves of modest size where people, usually students can study natural ecosystems, observe and practice methods of environmental analysis and field techniques associated with the natural sciences and conduct long-term experiments. Such areas are usually selected on the basis of whether the area has relatively undisturbed natural vegetation. They may have a range of facilities on site, including buildings for accommodation purposes which greatly affects how much they are used. A further description of education areas, particularly those in the study area, can be found in chapter 9.

SERVICES AND UTILITIES

There are numerous, generally small, service and utility areas in the study area. These are used for transport networks, electricity and gas distribution, communications, survey and navigation, municipal buildings and services, hospitals, public offices and justice, water and sewerage services, cemeteries and other utilities.

Transport

Roads

Victoria has an extensive and complex road network. Statewide there is approximately 196,000 km of roads (from major arterial roads to minor local roads, to forest tracks). The *Road Management Act 2004* categorises and establishes the management responsibility for all public roads in Victoria as follows:

- freeways including tollway freeways (VicRoads)
- arterial roads
- urban (local municipal council)

- non-urban (VicRoads)
- non-arterial state roads such as forest roads (relevant state agency, e.g. the Department of Sustainability and Environment)
- municipal or local roads (local municipal council).

With the exception of freeway tollways, all types of roads are found in the River Red Gum Forests study area located on public land either retained as Crown land at the time of land survey and settlement or since purchased for roads.

The primary purpose of roadside reserve management is to maintain road functionality.   This frequently involves vegetation removal or trimming both of native and introduced plant species. It may also involve more extensive disturbance to land and drainage systems to maintain an existing road or for the construction of structures such as bridges (see chapter 9 for more detail). As well as these functional aspects road reserves may also protect natural, historical and community values such as biodiversity, visual amenity and recreational opportunities. VEAC is particularly interested in these reserves from a nature conservation perspective as they often provide for biodiversity values as habitat corridors linking vegetated reserves. Many unused road reserves retain native vegetation, some with rare plant species.

As part of its commitment to biodiversity conservation on major arterial roads and freeways VicRoads has a number of strategies and plans in place to guide its operations that may impact on biodiversity values. These include the:

- Roadside Habitat Values Plan
- Roadside Management Strategy
- Roadside Management Plans
- Roadsides and the Environment Strategy.

At an operational level, these plans and strategies involve detailed biological surveys on road reserves. They also involve VicRoads working with local government, particularly around the issue of native vegetation removal under the *Planning and Environment Act 1987*. Ongoing monitoring and evaluation of these plans and strategies is conducted to establish whether or not on-ground actions are achieving the strategic and management objectives, as well as VicRoads' statutory responsibilities.

Railways

Historically, rail transport has played a critical role in the expansion of Victoria's economy but today, rail's significance relative to road transport has decreased in recent decades as the road network has improved. Several rail lines were closed during the 1980s and 1990s. Some of these decommissioned lines have remained as public land and have 'rail trails' for recreational use or bushland reserves where natural values have been identified. In other places, rail reserves have been sold, usually to adjoining landowners. A systematic review of rail reserves was undertaken in the 1980s by the Victorian government. This resulted in the outstanding natural or recreational values along certain lines being identified and this land being retained as public land to protect these values (see also chapter 9). For example, the Bonegilla Station Bushland Reserve, east of Wodonga, was established partly to protect a stand of the threatened purple diuris orchid.

Railways located on the northern plains are in a highly modified biophysical environment. Plants that were once common have been removed through large-scale agricultural development and human settlement. Some threatened species and communities persist on rail reserves. In part, this is due to the management history of many rail reserves, including the exclusion of grazing, ploughing, grading, herbicide and fertiliser application and the use of fire as a management tool. Regular burning for fuel reduction was an essential part of rail reserve management for over a century. Timing of this management regime fortuitously replicated the ecological conditions necessary for some plant communities, but had negative effects on others.

Species persisting in rail reserves include the nationally endangered turnip copperburr and mountain swainson-pea, and the nationally critically endangered spiny rice-flower. Some of the best examples of Northern Plains Grassland community, listed under the Victorian *Flora and Fauna Guarantee Act 1988*, occur on rail reserves within the study area.

Informal management of these sites is important for the conservation and protection of certain threatened species and communities. The Victorian Rail Industry Environment Forum (consisting of DSE, DPI, Country Fire Authority, VicTrack, Pacific National, Australian Rail Track Corporation, Connex, and Municipal Association of Victoria) is currently developing Vegetation Management Guidelines for Rail Corridors (due to be released later in 2006). These guidelines will provide a framework for land managers and rail lessees to encourage changes to works practices, to address the interlinked issues of biodiversity conservation, prevention of weed invasion and reduction of weed impacts, management of the risk of wildfire and efficient operation of the rail network.

Gas and Electricity

In previous LCC, ECC and to a lesser extent VEAC investigations, gas and electricity utilities were important considerations for the services and utilities land use category. During these times Victoria's gas and electricity industries were managed by integrated, government-owned entities such as the State Electricity Commission and the Gas and Fuel Corporation of Victoria. Private land purchased by these entities for their systems and infrastructure was "public land" for the purposes of LCC and ECC investigations. The supply of petroleum products, including the production of natural gas was controlled by the private sector.

In the 1990s, government changes led to the privatisation of these entities and divisions into three discrete business activities: supply, distribution and retail. Under these business arrangements the government's role changed from directly owning and managing energy businesses on behalf of the community to one of setting policy objectives and managing the statutory framework governing the energy market. Today, Victoria's energy industry is largely privately owned and operated.

Gas

Victoria's 1900 km gas distribution pipeline is owned by GasNet, a privately owned company whose core business activities are pipeline ownership, construction and operations. GasNet supplies approximately 1.4 million residential consumers and approximately 43,000 industrial and commercial users throughout Victoria. The primary function of GasNet's infrastructure is to transport gas from Esso's Longford treatment plant in southeast Victoria (which processes gas from offshore Bass Strait gas fields) and from the onshore Otway Basin to areas across Victoria as well as into parts of NSW.

The GasNet distribution network is relatively limited in its coverage within the River Red Gum Forests study area. Only minimal amounts of the pipeline network run under public land in the study area. Map 17.1 illustrates the gas distribution network across Victoria. It highlights that natural gas is mostly distributed around the eastern part of the study area. Where gas pipelines cross public land, the land remains public land.

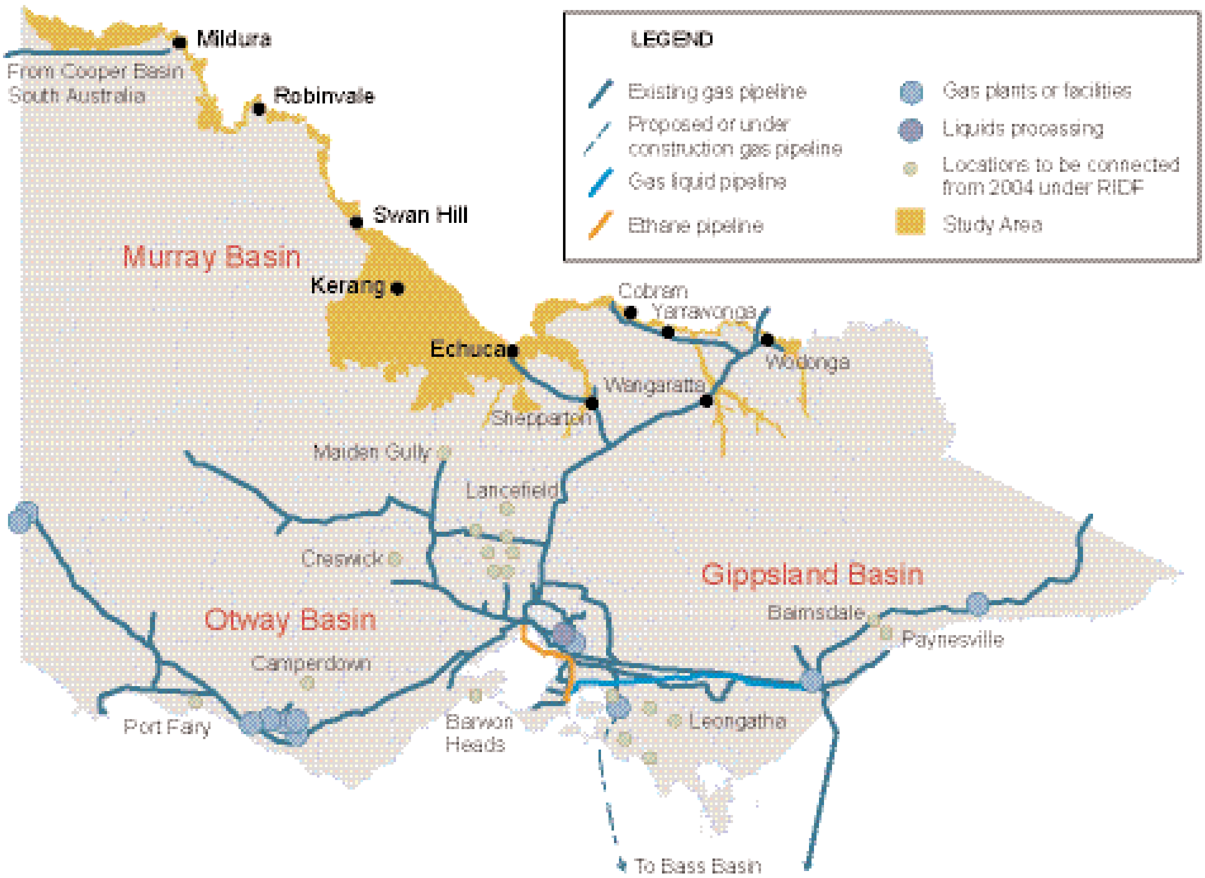
GasNet's provides high pressure transmission pipelines and associated assets, maintains services and connects the gas network to gas suppliers, distributors and directly to customers.

As part of the changes in the 1990s, the Victorian Government established the Victorian Energy Networks Corporation (VENCorp). This statutory authority has overall responsibility for the operation of the gas transmission system including:

- analysing the system capacity and security standards and controlling the flow of gas through the system on a day to day basis;
- administering the gas spot market, including all settlement functions;
- providing connection and other services to gas suppliers, distributors and directly to the connected customer; and
- administering the Market and System Operations Rules under which the Victorian gas market functions.

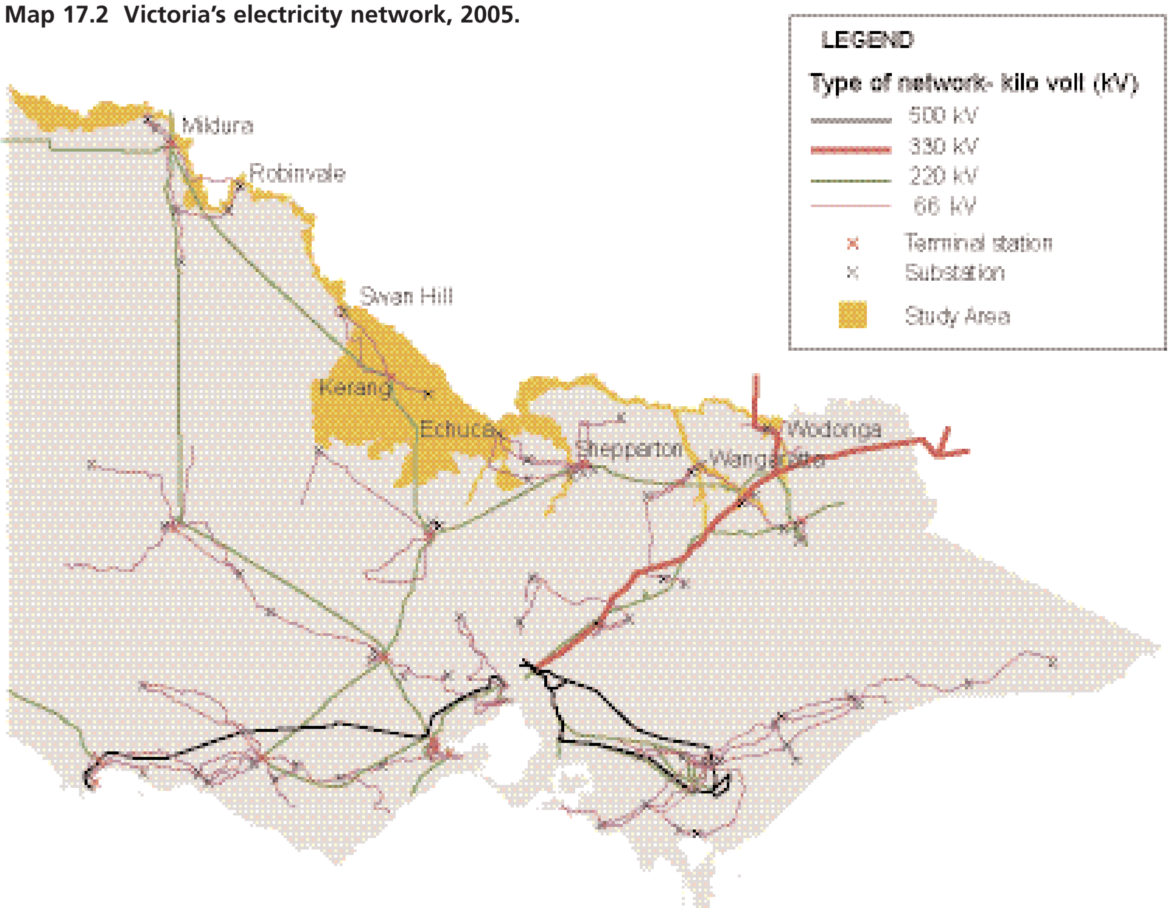
In Victoria natural gas is distributed to local areas by

Map 17.1 Victoria's natural gas networks and processing facilities, 2005.



Source: DPI 2004, Minerals and Petroleum Divisions Statistical Review; Australian Government (2004); BusinessVictoria (2006).

Map 17.2 Victoria's electricity network, 2005.



Source: Modified from DSE (2005g) and data from Sustainable Energy Authority Victoria, 2005

three private distribution companies, Multinet, Envestra (which services the major population areas around Mildura) and TXU/TRU (which the areas around Echuca, Shepparton and Wodonga). Only a minimal amount of public land in the study area is associated with the gas distribution pipelines network. Where compression stations existed on public land held by the former Gas and Fuel Corporation, this land has been transferred to GasNet and is now freehold.

Electricity

Victoria's 6000 km high voltage electricity transmission system is owned and maintained by AusNet, a wholly-owned subsidiary of Singapore Power Limited (SPIPowerNet). AusNet's core business functions are widely known as the 'pipes' and 'wires' of the electricity network. AusNet's electricity distribution network delivers electricity to approximately 575,000 supply points in an area of more than 80,000 square kilometres in Victoria, including the study area (Map 17.2).

The high voltage transmission system is largely a network of transmission conductors (cables) supported on more than 13,000 galvanised steel towers. The conductors carry electricity at extra high voltages from the power stations to 46 terminal stations around Victoria, where the voltage is lowered for distribution for local distribution companies to deliver to homes and businesses.

The corridors of land upon which AusNet's network is built are referred to as 'transmission line easements'. More than 17,500 ha of easements secure a 'right of way' for the safe transmission of power. In most cases AusNet does not own the easement land. Rather, the easement provides the right to use the land space by agreement with the original landowner. Ownership of the land remains with the landowner with the easement also allowing access for field crews to maintain the network. Under the easement right AusNet may limit the type and scope of activities on the easement, including restriction on what is grown or built on it including easements on public land.

With its transmission system, AusNet is subject to the operational control of the National Electricity Market Management Company (NEMMCO), a government based agency, owned by the state and territory governments involved in the National Electricity Market (NEM) which includes Victoria, NSW, SA and ACT. NEMMCO's role is to ensure the integrity of the system and to operate the market. VENCorp is also responsible for planning of the Victorian electricity transmission system to ensure existing and expected demands are met.

Within Victoria there are five electricity distributors. The metropolitan area is serviced by AGL Electricity, CitiPower and United Energy whilst rural areas are serviced by TXU/TRU (formerly Eastern Energy) and Powercor.

COMMUNICATIONS, SURVEY AND NAVIGATION

Communications

Statutory responsibility for communication networks throughout Australia resides with the Australian Government. Sites for these structures are favoured on the basis of their elevation and absence of physical barriers to communication frequencies. Consequently, most communication towers or structures are built on prominent hills or high points. Reliable road access and the availability of power to these sites are also important siting factors. Many communication towers and satellite dishes across Victoria are either located on public land or require access across public land. For example, within the study area, the communication structure located on Huon Hill near Wodonga requires access across public land.

Survey and Navigational Infrastructure

Trigonometrical stations and sites are often located on public land and in some cases access to the sites is through public land. Trigonometrical stations are used for land survey control points. With widespread Global Positioning Systems now in use, they are becoming less central to land surveying operations.

Municipal Buildings and Services

Municipal buildings and services are frequently located on public land. Such buildings include local government offices, depots and outbuildings.

Hospitals and Public Offices

Public building such as hospitals, public offices, police stations, courthouses and prisons are generally located on public land. Some recent prison facilities operated by the private sector are on private land. Within the study area many public buildings such as hospitals at Cobram, Echuca and Mildura are located on public land.

Water and Sewerage Services

Water

Details on land-use categories for water production, particularly the use of declared water supply catchment is presented in chapter 9. Chapters 4 and 15 refer to hydrological systems and water use and environmental flows. This section describes the public land associated with the infrastructure for the distribution of water to townships across the study area for human use and economic production purposes, and systems of channels supplying stock and domestic water to rural areas.

The water production land use category encompasses the actual water storage areas, diversion weirs, pump intakes and associated buffer areas. The Ovens River off-take supplying urban Wangaratta is such a catchment off-take point. Separate land use provisions apply to the harvesting areas—see chapter 9 for an outline of declared water supply catchments. In most cases these water supply catchments include private as well as public land.

In the context of this chapter water production land is firstly, land on which township water, storage and reticulation infrastructure is built, and secondly the stock and domestic channel distribution systems. A large number of water utilisation areas were recognised in the LCC Mallee Study (1977b) and subsequent Mallee Review (1989a), Murray Valley (1985), North-Eastern Study 3, 4 and 5 (1977a), and North-Eastern Area (Benalla-Upper Murray) Review (1986).

In the Mallee, water for urban supply is pumped from the River Murray or from channels and pipes, and stored in elevated reservoirs in townships before being distributed. In the Kerang region, water is drawn for irrigation and stock purposes from Torrumbarry weir on the River Murray, and diverted to the Loddon River, from where it flows through a series of natural lakes connected by channels. These lakes include Reedy Lakes, Racecourse Lake, Lake Charm, Lake Tutchewop, Lake Kelly and Lake William. Drainage areas such as the Kanyapella floodway, are diversions for flood waters and are included in the services and utilities land use category. Some water storages in the Kerang lakes region are linked to areas used for other purposes. Lake Tutchewop services and utilities area which is primarily used for drainage and abuts Lake Tutchewop Wildlife Reserve.

From time to time, new facilities are required and old facilities decommissioned. Consequently areas allocated to water production will occasionally require amendment. There have been many changes in the administration of water services since the 1980s, particularly the amalgamations of water authorities in the 1990s and the results of the Water White Paper, *Our Water Our Future* (DSE 2004i). All former water authorities have been restructured and the total number significantly reduced. There are two rural water authorities in the study area, First Mildura Irrigation Trust and Goulburn-Murray Rural Water (trading as Goulburn Murray Water) and two urban rural water authorities, Lower Murray Urban and Rural Water and Wimmera Mallee Water. Four regional water authorities maintain facilities for the storage and distribution of water (and management of sewage disposal) within the study area: Coliban Water; Goulburn Valley Water; and, North East Water.

All land upon which water authority assets are located, whether Crown land or freehold, is considered public land under the *VEAC Act 2001*. For example, Goulburn Valley Water has around 40 treatment plants, 27 wastewater facilities, 340 pumping stations, 92 tanks and reservoirs and operates a reclaimed water re-use facility. Goulburn Murray Water is a major holder of public land. Some key areas or sites falling within Goulburn Murray Water's portfolio include land adjacent to Green Lakes former farmland in the Kanyapella Basin Wildlife Management Cooperative Area, Lake William and Lake Little drainage areas (Mystic Park) and Yarrawonga Weir as well as numerous areas of Crown land.

Coliban Water also manages and maintains over 50 reservoirs and water storage basins, 213 water and wastewater pumping stations, 23 water treatment facilities and 16 reclamation facilities, mostly on Crown land. Similar situations exist for other water authorities such as Lower Murray Water, North East Water and Grampians Wimmera Mallee Water.

As described in chapters 4 and 15 the study area is associated with some of Victoria's most significant irrigation regions. The most notable of these are the Shepparton, Campaspe, Rochester and Torrumbarry Irrigation Areas (see Map D). Such areas are dependent on an extensive network of irrigation channels. Some of the more extensive main channels include East and West Waranga Main Channel, with the latter also supplying stock and domestic water and the Yarrawonga channel heading south west from Lake Mulwala. These irrigation channels are located on public land, owned or managed by Goulburn Murray Water. Such areas maybe of interest in this Investigation, particularly where lakes associated with the provision of irrigation water for agricultural purposes are also important locations and sources of habitat for a variety of wetland species.

As well as the network of irrigation channels within the study area there is also a network of surface water drains. The purpose of these drains is to drain away excess surface water from irrigated land to prevent water logging, rising water tables and salinity problems. Some of the major surface drainage channels associated with the study area are the Muckatah, Mosquito, Timmering and Minchins Depressions drains. In this situation Goulburn Murray Water has easement rights rather than ownership rights over the land. A network of subsidiary drains established on public land, have been largely sold to adjoining landowners. Privately owned land associated with these subsidiary drains is not public land and hence will not be considered in this Investigation.

Sewerage

Towns and regional cities located throughout the study area are serviced by sewage treatment systems. These systems vary in scale and level of treatment. The larger urban centres have more sophisticated treatment facilities, often providing up to tertiary level treatment (to a standard suitable for environmental discharge). Smaller towns are serviced by secondary treatment plants (for removal of biological material).

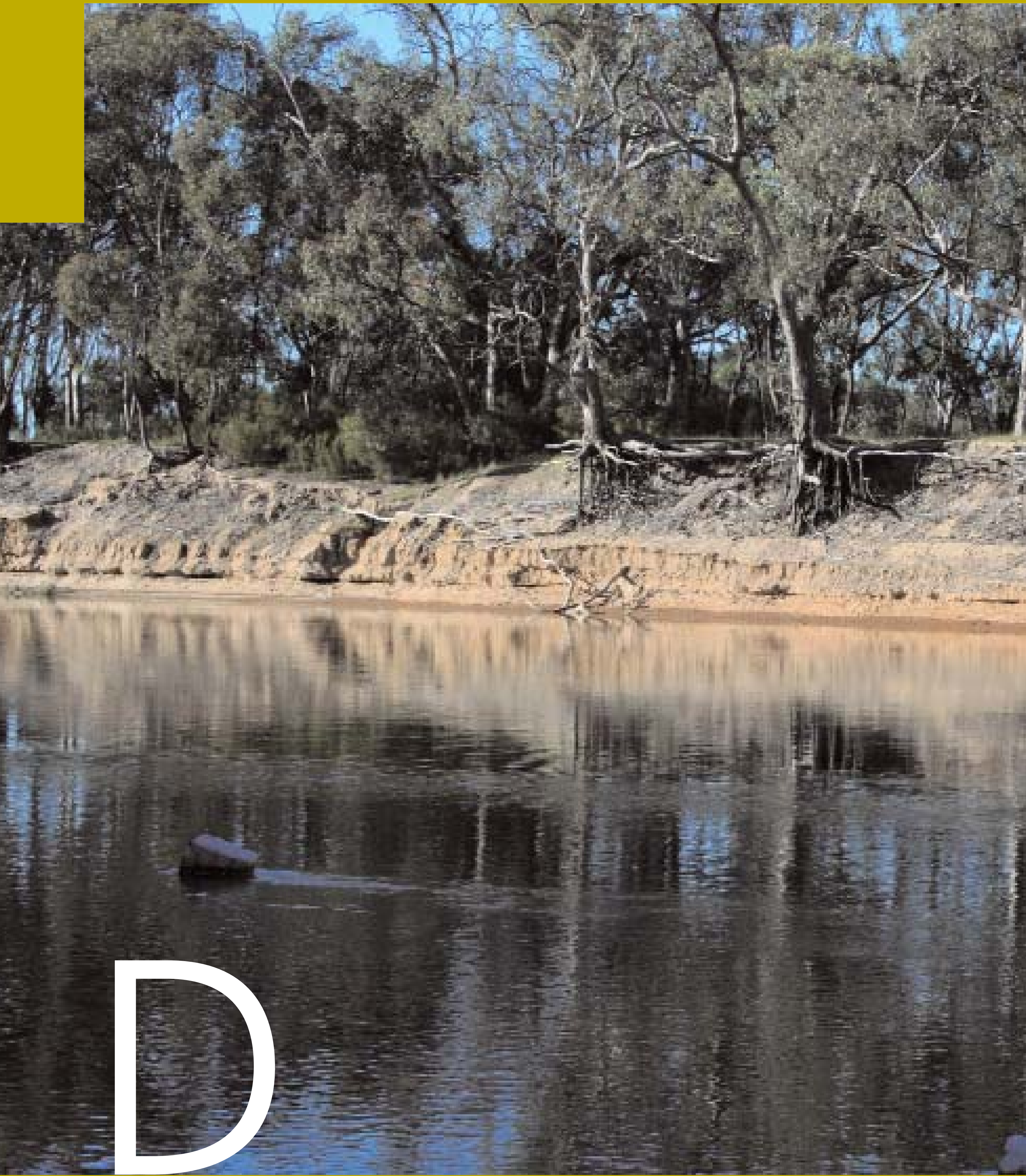
Both secondary and tertiary level treatment plants utilise evaporation basins and lagoons as part of the treatment process. Basins and lagoons require large land areas for construction and operation. They also require an adequate buffer zone between the basin and the surrounding land or watercourses. This is a requirement of the Environment Protection Authority (EPA). All sewage treatment facilities require licences issued by the EPA.

Water from treatment plants is used for irrigation purposes or in some cases is discharged back into the rivers. One particular use of this irrigation water is for plantations such as those owned by Goulburn Valley Water on the northern outskirts of Shepparton.

Cemeteries

Cemeteries in the study area (other than private family cemeteries and some Indigenous burial grounds) are located on Crown land. Cemeteries operate under the *Cemeteries and Crematoria Act 2003* which replaced the *Cemeteries Act 1958*. They are managed by Cemetery Trusts, which fall under the responsibilities of the Department of Human Services. Cemeteries are zoned as public use in local government planning schemes and in some cases changes in land use or development proposals within cemeteries may require a planning permit. Land for graves within a cemetery cannot be purchased privately, only the right to burial is purchased.

Because of declining population levels in many parts of the study area many smaller cemeteries today are used less frequently for burial purposes. Often these cemeteries contain areas of relatively undisturbed native vegetation and may be important for the preservation of some plant species or communities, particularly grasslands.



D

Discussion of Issues

Part D explores the issues emerging from the material in Part C and raised through community input to the investigation processes. This part of the Discussion Paper covers chapters 18 and 19.

18 Views from the Community

This chapter provides a summary of the major issues and proposals submitted to VEAC for consideration in preparing the Discussion Paper for the Investigation.

THE SUBMISSIONS

The submission process is one of the key methods for VEAC to seek community views on issues and values. VEAC received more than 500 submissions following the publication of the Notice of Investigation indicating the strong public association with, and interest in, river red gum public lands and their future. Submissions were received from a wide variety of locations, particularly from the local community within the study area but also from Melbourne and further afield. Nearly 50 percent of submissions came from within or near the study area. Appendix 3 lists the submissions received.

Many of the submissions were from people who live or have lived in the area, people who work or have worked in the forests, people who have camped in the forests regularly since they were young, and also people who are infrequent visitors to the region but still feel it is special. Submissions were contributed by community groups, businesses, scientists, consultants, property owners and recreational users. The varied backgrounds and interests of contributors resulted in the coverage of a wide range of topics including interest in particular sites or areas, recreational activities and industries. Many submissions called for an increase in the size of the conservation reserve system while many others proposed that the present industries such as timber harvesting, grazing, apiculture and tourism be maintained at a similar level to today.

The number and nature of submissions illustrate the enthusiasm and passion people have for the study area. The submissions contained not only proposals for public land, but also a large amount of valuable and useful information to assist VEAC in carrying out its Investigation.

In addition to this phase, VEAC has also received input from the Community Reference Group (Figure 18.1) it has established specifically for this Investigation (see Appendix 2 for membership of the Group), from other Government and semi-government agencies (Victorian, interstate and Commonwealth) and from meetings with representative interest groups.

THE ISSUES

Below is a summary of the major issues raised in the initial consultation process for the Investigation. This chapter focuses on the major and more general issues and does not endeavour to cover issues relevant only to restricted areas or raised only infrequently. Where appropriate, comments have also been made on the issues raised in the context of the broader background outlined in earlier chapters of this report. These comments do not attempt to resolve issues—but are intended to help clarify related matters or the approaches VEAC will need to consider in developing a position on an issue in future stages of the Investigation.

Figure 18.1 Members of the Community Reference Group at a meeting in Echuca.

Different stakeholders often maintain strongly divergent views on the importance of different issues and the time that should be devoted to them. At this early stage of the Investigation, VEAC will give fair and balanced consideration to all matters raised by stakeholders.

INVESTIGATION PROCESS

Many submissions discussed VEAC's role and the process for undertaking the Investigation, specifically the approach, scope and information sources that Council uses in developing recommendations. The consultation process itself was also raised, and a number of contributors were concerned that their submissions may not be fully considered or that the information, experience and views held by contributors would not be fully utilised.

Public consultation is a central part of VEAC's investigations. Council has given, and will continue to give, thorough and equal consideration to all groups and people who have an interest in the Investigation. The methods used to inform and consult different groups will be regularly reviewed for their effectiveness as the Investigation proceeds.

There are three submission periods throughout the course of the Investigation and a number of additional opportunities during which the public can discuss issues with the Council. As the Investigation progresses, VEAC will hold widely-publicised public forums throughout the study area and meet with stakeholders. Following each stage of the Investigation, a newsletter will be distributed to all contacts on VEAC's register of interest. There are currently approximately 8,000 groups and individuals on the register of interest for the River Red Gum Forest Investigation.

INDIGENOUS ISSUES

A large proportion of contributors felt that Indigenous communities should be partners in joint management of any new or expanded parks and reserves. A considerable percentage of these submissions specified Barmah forest and Gunbower Island as areas where this type of management should be established.

Many people felt that the Yorta Yorta people, in particular, should have responsibility for—and a much greater role in the management of—public land with which they have a strong and long association. This increased responsibility and management was proposed as a means to acknowledge and strengthen the special relationship that many Indigenous people have with their traditional lands, given that for many people this relationship has generally been poorly recognised and supported within the broader community. Some contributors called for greater consultation and involvement in decision-making with Traditional Owners while others would like to see more opportunities for Indigenous employment as guides or rangers in protected areas or on other public land.

Full consideration of Indigenous issues associated with public land in the study area by VEAC is required under the Terms of Reference of the Investigation, particularly Indigenous involvement in public land management and the Yorta Yorta Co-operative Management Agreement. VEAC has retained a specialist consultant to seek input from Indigenous groups and individuals with interest in the Investigation.

PRIMARY INDUSTRIES

As part of its Terms of Reference, VEAC is required to assess appropriate access for commercial ventures including timber extraction, grazing, apiaries and other resource-based industries. These matters were widely addressed in a large number of submissions.

Timber

Views on timber harvesting ranged along a continuum from abolishing all harvesting and firewood collection in some or all areas, to developing plantations on private land, to allowing environmental thinning, through to continuing with the present regimes. There was substantial support for retaining timber harvesting both within the study area in general and at specific locations (such as Barmah State Forest, Gunbower State Forest, and Nyah State Forest among other areas). These proposals generally put the position that the major benefit of timber harvesting was the economic and social advantages brought to small towns and surrounding communities. These submissions also raised the issue of the contribution to skill levels from the manufacture of high-end products such as fine furniture, and the cultural heritage of this industry. Many of these submissions were also of the view that the forests as they exist today have not been harmed by 150 years of harvesting and may actually have been ‘enhanced’.

Many of those opposed to timber harvesting in river red gum forests saw an incompatibility between biodiversity conservation and such practices. Some also argued that it was inconsistent to spend significant resources on environmental water to improve the health of the river red gums if many of these trees were subsequently harvested.

Numerous submissions that came from the study area saw continued access for firewood collection as important, especially in rural towns with no opportunity to substitute cheaper natural gas for heating and cooking.

The utilisation of river red gum forests on public land for timber extraction is a complex subject outlined in more detail in chapter 14. Current patterns of forest use have been shaped by past extraction practices and water management strategies. Future productivity of the forests is dependent on a wide range of variable factors including climate change. Further consideration of the complex social, economic and environmental issues surrounding timber extraction will be given in chapter 19.

Grazing

Public land grazing by domestic stock was a major issue and prompted numerous proposals across a broad spectrum of views. Many submissions wanted to see stock grazing retained, particularly in the Barmah and Gunbower areas (although there is currently no grazing in Gunbower, there is provision for agistment). Some argued that public land grazing makes a significant contribution to the viability of their farms and that public land is only grazed when sufficient feed is available on that land. In addition, many maintained that grazing is a positive management regime for conservation in that it reduces fire risk and weeds. Some submissions stated that fence maintenance on public land on the floodplain was costly and extremely difficult (due to flood damage) and thus it is difficult to confine stock to certain areas.

In contrast, many other submissions stated that grazing on public land causes significant environmental damage in spreading weeds, increasing erosion, pugging the ground, and affecting native animals. Many of these submissions proposed a complete cessation of public land grazing in particular areas or in the whole study area. Some submissions proposed that grazing should be excluded from public land in particularly sensitive environments such as riparian zones, wetlands and cypress-pine sand hills.

Some submissions sought an independent study into the relationship between grazed and ungrazed areas and the extent of pest plants and frequency and intensity of wildfires. It was argued that such a study could go some way to resolve the divergence of views described above. Grazing on public land presents a challenging combination of cultural, social, economic and environmental priorities which will also be addressed further in chapter 19.

Apiculture

A number of submissions proposed that access should be maintained for the apiculture industry, and emphasised the need for a healthy forest to ensure a steady rate of honey production. Also highlighted was the need for flooding to ensure forest health. Some felt that a healthy forest would be best achieved by establishing a national park that allowed access to the beekeeping industry. Some submissions stressed the importance of the knowledge held by apiarists regarding both the historic and present ecology of the forest. A number of submissions also put the position that the beekeeping industry is vital for agricultural production through pollination of crops and pastures, and that continued access to public land was vital to the viability of the industry.

While some submissions asserted that the apiary industry does not affect biodiversity and in fact aids biodiversity by increasing pollination, others argued there was a conflict between introduced bees and native flora and fauna. They maintained that there is competition for nectar and also from introduced feral bees competing with native species, such as birds and mammals, for use of hollows. Resolution of conflicting arguments about the impact of European bees in native forests is difficult due to the paucity of scientific evidence on bee impact and the logistical difficulty of obtaining that information.

Other Primary Industries

Relatively few submissions were received on other primary industries either currently or potentially in the area such as mining and stone extraction, perhaps because of the small scale of these industries in the study area. Despite their size, these industries can still be important locally - and perhaps more broadly - and will be fully considered by VEAC as the Investigation proceeds.

TOURISM

The tourism industry was an important consideration in many submissions. For many of the towns in and around the study area, tourism contributes substantially to their economies and is vital to the livelihood of many local business owners. Some submissions wanted to ensure that tourism in their area was maintained at current levels, while others would like to see tourism developed further in an "eco-friendly" manner. There was a mix of views on whether the development of, say a new national park, would be beneficial or detrimental to the tourism industry. Some submissions suggested that the creation of a new park would remove (for example) hunters and some other user groups and would therefore be bad for tourism; others suggested that a new park would attract more visitors and therefore be good for tourism. VEAC has responded to this need for further information on the economic value of environmental protection by commissioning a socio-economic research study to shed light on some of these issues.

BIODIVERSITY CONSERVATION

Numerous submissions included proposals to improve the conservation of biodiversity. These proposals included measures to protect flora and fauna particularly threatened species and communities and habitats such as wetlands and Moira grass plains, and specific habitat elements e.g. hollow-bearing trees. Generally, protection was sought through additions or enlargements to the conservation reserve system. Numerous specific areas were identified in this context, and many contributors passionately advocated national park status for Barmah State Park and State Forest. A number pointed out that reserve system additions should follow the comprehensive, adequate and representative

(CAR) reserve system criteria and should link to the system of reserves and management priorities in New South Wales and South Australia.

Some contributors sought improvements in biodiversity conservation through changes to management practices. Timber harvesting and grazing were commonly regarded as the greatest threats to biodiversity conservation and some contributors recommended they be phased out or ended immediately. Many also sought improved water management for biodiversity conservation (see below). Pest plant and animal control was seen as an important issue in many submissions from all sides of the biodiversity debate. These submissions emphasised the necessity for adequate resourcing of control programs on public land.

While very few submissions were opposed to protection of biodiversity values, many put the view strongly that biodiversity conservation was compatible with some, most, or all other activities as currently practised or with minor modification. These submissions argued in favour of minimal change or what was termed a multiple-use approach. Achieving a balanced use of resources across Victoria, including biodiversity conservation, is one of VEACs founding principles and emerges as one of the major themes in chapter 19.

WATER ISSUES AND THE HEALTH OF THE FORESTS AND FLOODPLAINS

Many submissions raised issues regarding water and particularly how this related to the health of the river red gum forests and other ecosystems along the length of the River Murray and the other rivers in the study area. Virtually all water-related submissions supported enhanced environmental river flows to improve the health of the forests along the rivers and on the floodplains. The lack of regular flooding in some areas was seen as a major issue while in other areas excess flooding or flooding at the wrong time of the year were seen as the major problems.

Some submissions argued that water was such an overriding issue that worrying about things such as timber harvesting and grazing was a waste of time if the water issues were not resolved. Many contributors argued that 75 percent of the river red gum trees along the River Murray are dead or nearly dead while others argued that this figure is simply not correct and that the forests are very healthy. A recent study (Brett Lane & Associates Pty Ltd 2005) showed that in 2004 about 75 percent of the trees on the sampled sites were dead, nearly dead or stressed (i.e. in decline). All the Victorian sites sampled in this research were downstream of Swan Hill and also off the main watercourses. It is regrettable that these results were commonly and incorrectly reported in the media as applying to all river red gums in the River Murray catchment. However, the survey results confirm and document a major problem with tree health in the lower reaches of the River Murray in Victoria.

In previous investigations, the Land Conservation Council (LCC) did not investigate environmental water management in detail. VEAC recognises that this is an important issue for the health of the river red gum forests and will give the matter full consideration.

SOCIAL AND ECONOMIC ISSUES

Many submissions emphasised the effects of any change in land category, and particularly changes that led to the cessation of current activities, on the local community. Some submissions asserted that any new national park would reduce employment in timber and grazing industries while others maintained that new parks would bring economic benefits through increased tourism.

A popular proposal was that a comprehensive assessment be undertaken and published regarding the positive and negative impacts of VEAC's recommendations on the social and economic attributes of the study area.

VEAC recognises that the social and economic implications of possible changes are extremely important and need detailed consideration. Accordingly, chapter 8 profiles the existing socio-economic characteristics of the local government statistical areas associated with the study area. VEAC will commission a study into the importance of existing activities for both the Draft Proposals Paper and Final Report.

RECREATIONAL ACCESS

A large number of submissions emphasised that much of the study area is popular for a wide range of recreational activities. These include camping, horse riding, bush walking, fishing, boating, birdwatching and other nature study, 4WD and general car touring, trail bike riding, dog walking, and hunting. Many submissions urged VEAC to maintain access for one or more or all of these activities, or strongly supported the principle of multiple-use land categories more generally.

Camping is an increasingly popular leisure interest in many parts of the study area. Several submissions discussed camping and many do not want to see further restrictions - particularly those perceived to be imposed by national park status. Many submissions expressed the view that any alteration to the existing public land use category may result in heavily restricted use or poor management regimes. Camping was seen largely as a family-based activity undertaken by locals and other tourists who understand the need for sustainable forest use, and thus behave accordingly. In addition, some submissions sought an education campaign for campers to minimise environmental damage. Rather than have any areas closed off to recreational users, those who regularly visit the study area would prefer to be better informed about sustainable use.

Several contributors also called for the continuation of access for horse riding, particularly in the Gunbower and Barmah areas. Riders would like to continue using the public tracks that are already available to them in all public land use categories, and some would like to see improved maintenance of these tracks.

A number of submissions proposed more control at public land access points on the basis that heavy use leads to wetland degradation, erosion and increased illegal activities. In addition, some sought greater control of recreational use of public land, such as improved management of camping areas and stricter penalties for the improper use of four wheel drives, and to reduce erosion from ski and wake-board boats.

It is clear that the study area is greatly valued for recreational use and that this use has significantly increased in many areas over the last decade. VEAC will incorporate both the region's popularity and the need to effectively manage increased pressures resulting from this popularity into its recommendations.

LAND MANAGEMENT

Land management was widely addressed in submissions. Fire, community education and funding issues were considered important, as were appropriate joint arrangements with interstate bodies, an increase in local involvement in land management, pest plant and animal programs, and the suggestion to undertake more research to evaluate a greater range of management options.

Fire Management

A significant number of submissions argued that any creation of new parks would greatly increase the fuel load within the park as a result of poor management practices including a lack of fuel reduction (by burning, cutting or grazing). Conversely a small number did not want to see any more fuel reduction burns taking place, especially in river red gum forests. Some submissions simply called for the appropriate fire regimes to be applied in the relevant areas.

Although there were a significant number of submissions linking wildfire frequency and national park status, no strong evidence was provided to support this position. DSE has clear responsibility for fire related matters across all public land whether it is in state forest or in a national or other park or reserve.

Education Programs

A number of contributors mentioned the development of community education programs to inform locals and visitors of the best ways to contribute to the protection and management of the forests, reserves and parks. It was felt that with a greater knowledge of the area and the environment in general, people would have more insight into environmentally sensitive practices when visiting river red gum forests.

Funding for Public Land Management

Current land management was widely criticised for a lack of funding and the consequent failure to produce positive outcomes in particular areas. A number of contributors wanted sufficient funding to be made available to ensure adequate ongoing management of public land and implementation of VEAC's recommendations.

It is important to note that VEAC does not recommend funding for the implementation of its recommendations. This is a function of Government and its State Budget processes. However, in previous investigations, VEAC has stressed the need for adequate funding to cover the costs of any additional management requirements.

SUMMARY

An extremely wide range of viewpoints regarding the most appropriate uses of public land was presented in the submissions. VEAC will take all these views—as well as those in submissions to this Discussion Paper—into full consideration when developing its Draft Proposals.

19 Emerging themes

This Discussion Paper describes the values, resources, uses and categories of public land in the study area, as well as summarising community views and exploring key themes and issues. This chapter explores the major themes and issues emerging in submissions and identified during the research and consultation undertaken for the development of this Discussion Paper. VEAC is keen to receive submissions that add to, clarify, correct, and comment on these things. Ultimately, however, the next stage of the Investigation - leading up to the Draft Proposals Paper – will be primarily focussed on developing a suitable pattern of public land use for the study area. This chapter is intended to promote discussion and encourage contributions on appropriate public land use within the study area.

Previous chapters have described the environmental, social and economic setting of the study area and the current uses of public land in relation to Victoria's public land use category system. Chapter 18 summarised the views of the community as presented to VEAC during the first public consultation period for the Investigation. This chapter discusses in greater detail the key public land themes and issues that seem to be emerging from the consultation and research. These are broadly grouped as follows: efficiency and effectiveness of environmental water flows; resource utilisation including both timber harvesting and grazing and models of public land management (including indigenous management models, biodiversity protection, fire management long-term planning for population growth and climate change). The purpose of chapter 18 and this chapter is to promote discussion on issues and emerging themes. References are not generally cited in this discussion. Where relevant, the chapters in previous parts of the Discussion Paper which provide detailed referenced information on a topic are cross-referenced.

EFFICIENCY AND EFFECTIVENESS OF ENVIRONMENTAL WATER FLOWS

Water is central to this Investigation. It underpins all uses of public land within the study area as well as many land use activities on surrounding private land. However, the requirements of different water users and uses can be in conflict. Agriculture, recreation and tourism require predictable, stable and secure water supply regimes. In contrast, the environment requires seasonal and yearly irregularities, particularly in the extent of flooding and temperature variations. Regulation of the River Murray system and the resulting changes to its natural flood regime have caused major damage to the river red gum forests and their associated ecosystems across the study area. Put simply, without more water in the right seasons, the river red gum forests as we now know them are likely to reduce, further degrade and in places disappear entirely.

Historically, the requirements of irrigation and other offstream uses have taken precedence over the more intangible and non-economic outcomes of water for the environment. Today, this imbalance is changing with a range of strategies and programs being implemented, including the contribution of significant volumes of water from the irrigation industry, to address environmental outcomes (see chapter 15).

VEAC's scope to make recommendations on water management issues is limited. Although many states have rights to utilise the River Murray and its waters, legal jurisdiction of the river falls to NSW. The entire Murray catchment is managed by a complex set of cross-jurisdictional institutional arrangements, involving the Murray-Darling Basin Ministerial Council and Murray-Darling Basin Commission (MDBC) as well as the Queensland, New South Wales, South Australia, Australian Capital Territory and Commonwealth governments.

Two major water-related issues are central to this VEAC Investigation. The first is the volume of water and timing of its delivery for environmental outcomes and the second is how such water allocations are to be delivered across public land.

Water Requirements for Environmental Outcomes

Understanding the different water requirements and their timing across the study area is crucial for sustaining the river red gum forests. Chapter 15 describes the arrangements for achieving an average of 500 GL/year of recovered water after 5 years under the First Step Decision of the Living Murray Initiative. This water is intended for the six significant ecological asset sites along the River Murray. Other sites and areas with nature conservation values within the study area receive less consideration when determining environmental water allocations. Against this background some groups believe that an additional 1500 GL/year of water over 10 years (making a total of 2000 GL/year) is a more realistic amount to ensure the viability of the river red gum forests and their associated ecosystems.

The proposal for 2000 GL/year of water is not without its limitations. To date, there has been limited research conducted into the optimal amount of water required to support the forests and their associated ecosystems along the entire river system and variations across the study area. Current water allocations for environmental outcomes may not therefore reflect the necessary amounts of water. It is possible that improvements in irrigation practices could increase water available for the environment; however, this would require a concerted effort and active management.

Water requirements for environmental outcomes are also related to the range and/or scale of the managed floods and the timing of those floods. For example, a flood that mimics a natural one-in-ten-year flood, with its extensive floodplain coverage, requires a greater volume of water over a longer time than a smaller eight-in-ten-year flood. Further, the timing of these managed floods should ideally coincide with naturally-occurring flooding patterns, typically in late winter to early spring. However, this timing would in many cases compete with the water requirements of irrigators who require high water flows during late spring, summer and early autumn.

Water requirements to achieve successful environmental outcomes are also influenced by the diversity of the physical characteristics of the river system itself. By way of illustration, the Barmah Choke acts as a physical constraint, limiting the volume of water able to flow through the Choke. Once the capacity of the Choke is reached the water is forced down alternative routes such as the Edwards River or over the immediate river flats forming the wetland systems. Any large scale environmental flow event downstream of the Barmah Choke (or major irrigation use) is therefore dependent on either a massive amount of water coming down the river or alternatively is dependent on sufficient additional water flows coming down the Goulburn River.

Water allocation accounting systems also influence the amount of water available for environmental outcomes. Water flows for environmental outcomes, once allocated and used, are regarded on paper as "used" water; however, once it flows out of the forests and returns to the river it becomes available for reuse by "secondary" downstream users. Hence the environment is not the sole user of this water allocation even though on paper the water assigned to it is seen as being "consumed" and lost from the system. It is estimated that 80% of environmental flows into the Barmah Forest are returned to the river system. While irrigation and other uses may also return a component of their allocation to groundwater and drains and ultimately, the river, the proportion is likely to be reduced by the distance from the river. Work is currently being undertaken to develop more sophisticated models to simulate this movement of water flows. Acknowledging the capacity for "double" uses of this environmental water could result in greater effectiveness for the environment than is currently the case.

Efficient and Effective Delivery of Water for Environmental Outcomes

With such intense competition for water it is crucial that water allocated to the environment is delivered in an efficient and effective manner to achieve the best environmental outcome for the minimum amount of water. This also holds for water allocated to irrigation and other offstream uses.

Currently, decisions on how water is delivered to the environment are made using best available information and the volumes of water available, at a particular point in time. This often results in decisions on the delivery of environmental flow being made on the run. This decision process reflects the unpredictability of rainfall and floods and the limited ability of environmental flow managers to use available water within the current water management arrangements. It also reflects the relative infancy, especially on such a broad scale, of environmental flows as a management tool. To some extent these concerns are being addressed by agencies such as Department of Sustainability and Environment, Catchment Management Authorities and the Murray-Darling Basin Commission, who are undertaking various research, monitoring and evaluation activities for each environmental flow event. To maintain public confidence, the information on which decisions are based, and the process by which decisions are made, need to be open, transparent and readily available.

The ability to deliver water for environmental outcomes is also affected by the existing water infrastructure, an infrastructure that is relatively inflexible due to its original purpose of providing flood mitigation services and water for irrigation. For example, the infrastructure supporting river regulation is extensive and highly capital intensive in its construction. However environmental flows may be more effectively delivered through small scale, less capital intensive structures and more interchangeable structures.

Chapter 15 discusses the factors influencing how water can be delivered for environmental outcomes. One factor of significance is the operating rules and protocols associated with the Murray-Darling Basin Agreement for water management across the River Murray basin. These operating rules and protocols have evolved from the original arrangement with its focus on water allocation for irrigators and other offstream users. Today, these arrangements have been modified to better serve environmental interests but it has been suggested that these still restrict the ability of environmental flow managers to deliver water in the most efficient and effective way into areas needing environmental flows.

Currently, the ability to efficiently and effectively deliver water for the environment is strongly influenced by the water flow patterns required to meet the demands of other water users. For example, the natural wetland systems associated with Barmah are adapted to late winter early spring flood patterns. However, irrigators require relatively high river flows during late spring through to early autumn. Where these irrigation flows are in the system and there are rains the water flows reach the Barmah Choke and are forced out onto the wetland areas. In this regard, irrigator demands make it difficult to deliver and manage environmental flows in an efficient and effective way to achieve environmental outcomes. There are many who believe that this mismatch between demands of irrigation and other offstream uses and the environment will need to be seriously addressed if the river red gum forests are to be sustained into the future.

Future Considerations

Environmental outcomes on public land would appear to require an integrated approach by water managers and natural resource managers. Given the current system, this will need high levels of intervention, some which will be energy and resource intensive, e.g. the use of pumping as a water delivery method. With the current concerns around energy consumption and greenhouse gas emission there may be questions concerning the feasibility of some methods for delivering environmental flows.

A further consideration is that climate change will compound the current situation and may ultimately contribute to the decline of the river red gum forests and associated ecosystems in the future. Climate change is predicted to decrease the amount of water available for economic and community uses, placing considerable pressure on water allocation systems to maintain adequate water for environmental flows. This issue is raised in the Victorian Government's White Paper on Water which states that if the absolute amount of the water volume decreases due to climate change, both the environment and consumptive users will be reduced in the same proportions. Further, where there is increasing competition amongst users for an ever decreasing quantity of water, public accountability regarding when, where and how environmental flows are to be allocated across the entire River Murray system relative to other users is vital.

RESOURCE UTILISATION ON PUBLIC LAND

It was noted in chapter 18 that the community has expressed a lot of interest in resource utilisation from public land. In particular, a wide range of views were put to VEAC about timber harvesting and domestic stock grazing in the river red gum forests of the study area.

Forest Management and Wood Products

Forest practices have changed greatly since the uncontrolled cutting of the early 1900s when about 190,000 sleepers per year were harvested. Forest management was focused primarily on wood production until at least the 1970s. The structure of the forest today is a product of these past practices, rather than current uses. Timber harvesting, and particularly its effects on the natural environment, has been a controversial issue in many public land debates in Victoria and around the world. The following discussion is divided into the major themes of this issue, drawing significantly on background information about forest management and wood products in chapter 14, and the relevant threats to biodiversity specifically in chapter 5.

Sustainability and monitoring

Silvicultural sustainability (harvesting trees at or below the rate at which they are replaced by the growth of retained trees and regrowth) and ecological sustainability are fundamental to public confidence in timber harvesting on public land. However, sustainability can be difficult and expensive to determine. In addition, river red gum forests are generally uneven-aged and sensitive to unpredictable changes in flooding regime—additional difficulties compared to most other forest types. Accordingly, the sustainability of river red gum forestry is currently based on the professional judgement of forest managers and resource estimates that acknowledge the inadequacy of the data on which they are based. Ideally, sustainability would be based on a clearly-documented formal process of explicit, ongoing, transparent monitoring and auditing, the results of which would be continuously used to revise and improve the data and analysis on which harvest volumes are based and the actual volumes harvested.

In other parts of Victoria, sustainable yield calculations have been based on analysis of data such as the Statewide Forest Resource Inventory (SFRI, see chapter 14 Forest Management and Wood Products), but such analysis has not been completed for the river red gum forests. In recent years the state government has undertaken a number of initiatives intended to improve both the sustainability and the public accountability of wood product harvesting*. However, the emphasis has mostly been at the statewide level or in the coastal and mountain forests of eastern Victoria where much larger volumes of timber are harvested than elsewhere.

Some of these initiatives have direct application to river red gum forests, but specific issues arise relating to the nature of these forests and the industries using them. The relevant Estimates of Sawlog Resources are based on inadequate data, for example, and there are no estimates of the resource availability of the other products that make up the overwhelming bulk of wood volume harvested. Although considerable data have been collected for the Continuous Forest Inventory, SFRI and other programs (see chapter 14 Forest Management and Wood Products) these data have not been fully utilised or backed up with ongoing sampling. Environmental Protection Authority auditing is a transparent process but is restricted to auditing compliance with the Code of Forest Practice for Timber Harvesting. It is not the function of the audit process to assess the Code itself, but there is a question about whether the prescriptions contained in the Code (developed more for clear-felling in mountain and coastal forests) are applicable to selectively-harvested river red gum forests. Although audit findings are documented and reported to the public, the process does not provide for penalties to be imposed for breaches, nor is there a requirement to report on any remedial actions that are undertaken in response to recommendations of the audit.

** including, under the 'Our Forests, Our Future' Program, Monitoring Annual Harvesting Performance, and Estimates of Sawlog Resources; but also Environment Protection Authority (EPA) auditing, the Sustainability Charter, State of the Forests Reporting, the Sustainable Forests (Timber) Act 2004, and Environmental Management Systems*

Issues associated with silvicultural sustainability also relate to assessments of the ecological sustainability of wood product harvesting. Ecological sustainability includes the maintenance of ecosystems, their components and the services they provide. Hence, silvicultural sustainability—harvesting trees at or below the replacement rate—is necessary for achieving ecological sustainability. Forest structure is an integral component of ecological sustainability in river red gum forests harvested for timber. This involves maintaining a range of tree age classes and leaving some trees to die naturally. In some cases, the current forest may require greater structural diversity and accomplishing this may involve re-assessing the volume of timber harvested. There is little systematic monitoring and assessment of the short and long-term effects of timber harvesting on plant and animal species, communities and their habitats to determine whether or not operations are ecologically sustainable.

Confidence in sustainability is a significant issue for VEAC as, when developing its draft proposals, Council will be seeking to ensure that the implications of various options for wood product availability have a reliable basis.

Silvicultural Treatment

One of the fundamental tenets of forest management in the study area (as in many other places) is that larger trees can be more rapidly produced from artificially or naturally dense regrowth by removing competing trees (i.e. thinning) so that the retained trees grow larger more quickly. The resultant larger trees, it is reasoned, provide timber production and biodiversity benefits. However, a number of concerns have been raised about this management and these are considered below.

Although there have been no published studies in river red gum, all thinning experiments in other eucalypt species have shown that releasing trees from competition leads to increased growth on the remaining stems. Observations that trees in dense regrowth are frequently much smaller than trees of similar age in more open stands, provides some anecdotal support for this in river red gum forests. It is unclear whether confounding factors—such as the tendency for cut red gums to coppice, leaving the roots to continue to compete with retained trees for moisture and nutrients—have an impact on the silvicultural utility of thinning in practice.

While a seemingly minor detail, the size of the trees cut in thinning operations may also be relevant in river red gum forests. In recent decades with the absence of cheap labour and significant reductions in staff employed to do such works, this cutting is now nearly all done as part of firewood harvesting operations (by commercial cutters or contractors to generate wood for domestic permit collection areas). The rationale for this approach is that firewood can be produced from relatively small trees (compared to those preferred or required for sawlogs or sleepers, for example) and the thinning treatment can be achieved through firewood harvesting. However, in nearly all stands requiring thinning, the highest priority trees for removal—that is, the smallest trees—are too small to harvest for firewood (or any other product) and so are not cut. Furthermore, of those trees that are large enough to supply firewood, the largest trees are more economically attractive as a source of firewood. That is, thinning through harvesting for firewood may lead to the harvesting of the larger rather than smaller small trees with the result that in the longer term fewer trees grow on into the larger size classes. The same problem can also operate at the coupe selection level: ecologically, the highest priority areas for thinning are those with the greatest density of small stems. However, these areas may have few or no stems suitable even as firewood and so are left untreated.

As with the silvicultural benefits, the presumed ecological benefits remain unsubstantiated and may be doubtful if larger small trees are cut. The issue of thinning highlights the number of complex and sometimes competing goals that must be met in managing river red gum forests. For example, while habitat objectives and prescriptions would lead to retention of crooked, hollow, low-branching trees, silvicultural objectives would favour retention of straight, solid, high-branching trees.

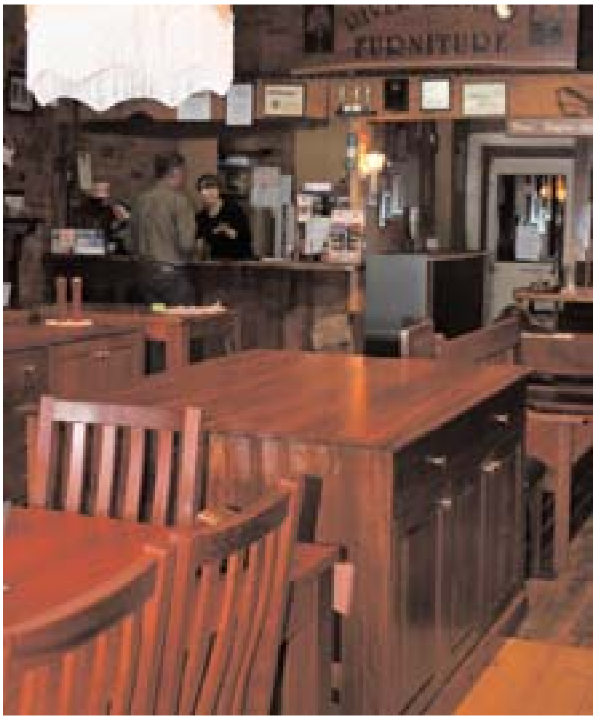
Finally, thinning does not automatically produce more large old trees—it causes small trees to grow faster. If the retained trees are subsequently harvested for sawlogs or sleepers before they reach ecological maturity, the biodiversity benefits may not be fully realised.

Maximising the Value of Harvested Wood

Chapter 14 discusses the major products sourced from public forests in the study area: sawn timbers for furniture, bridges and wharves, building features and construction, sleepers, landscaping, and fence posts; lower grade logs, thinning residues and off-cuts for firewood; and by-products for garden wood chips and sawdust. Many operators take pride in their ability to generate a product from virtually all of the wood taken from the forest.

While the range of products possible from small logs and offcuts is more limited, virtually all products can be made from large logs. Larger logs are generally a more cost-effective source for most uses, even small products such as firewood, as they have less handling time per unit volume of product generated and leave less waste. Of course, there is also ‘competition’ for large trees because of the values that they provide when left standing in the forest (habitat, landscape etc). A tree that is currently feasible as a sleeper log still has the potential, if left for a further 10–20 years, to become a more valuable sawlog tree.

For logs of all sizes—but especially the rarer and in-demand large logs—there are clear advantages in extracting the maximum value from the wood harvested, and value adding has become a major objective in many industries (especially the timber industry) in recent decades. In the river red gum industry, value adding is exemplified in kiln drying of large timbers and the production of furniture, which is sold at a considerably higher price than other products. In general, the benefits of value adding flow to local communities through direct and indirect local employment. That is, value-added products are generally more labour intensive and thus create more jobs than non-value-added products such as sleepers. Increased employment leads to many social advantages especially for small towns (see chapter 8). The higher price of value-added goods equates to greater economic value, which again can be especially important to relatively small regional economies. Value-adding can also be seen as benefiting nature conservation in that fewer trees—especially the large trees—are removed for the same level of employment and economic value.



However, the advantages of value adding do not necessarily bring about a shift in the industry to more value-added products. Firstly, a higher commercial value for a product does not necessarily mean higher profitability. For example, fine furniture is clearly a higher value product than, say, sleepers but it also costs considerably more to produce. If the difference in the cost of production is so great that sleepers are more profitable, the incentive for businesses may be to shift from the higher to the lower value product rather than the other way around, all other things being equal.

Secondly, repositioning a business to produce greater volumes of value-added products usually requires significant capital investment and identification of new markets. Value-added products need to be marketed and developed carefully to ensure that they have a long-term future. Some businesses may use more profitable lower value product to fund such capital investment. The significant costs are only likely to be borne if timber supply can be guaranteed in the medium to long term.

Thirdly, some businesses are likely to be reluctant to abandon lower-value products altogether, preferring to maintain a certain level of diversity to protect against short-term fluctuations in particular product markets. Successful sawmills require a range of order mix to gain the maximum value from a log and each log has to be looked at on its individual merits to see how the most commercial value can be gained from it.

Finally, economic factors may confound shifts to higher value products—for example, if many operators shifted to a high value product, the increased supply may lower prices, while the reverse could apply to the lower value, now less available, products from which they have shifted. The combination of these factors may act as an impediment to the industry moving to a greater proportion of value-added products, even though there is widespread support for the concept.

Market demand may also shift the trend away from value-added products. Two decades ago, Victoria's Timber Industry Strategy raised the concern that extending residual wood harvesting for firewood would generate its own momentum and become the force driving timber harvesting in localised areas to a 'firewood-driven' industry, rather than the more desirable (from a value-added point of view) 'sawlog-driven' industry. This has eventuated in the Mildura Forest Management Area where no sawlogs or sleepers are currently produced from public land but where there is pressure for it to re-commence in order to continue to supply firewood. The potential for change (including through processes such as this Investigation) further complicates the planning difficulties facing businesses in the timber industry.

Firewood and sleepers

Firewood is favoured by many people, locally and in Melbourne, for household heating and sometimes cooking because it can be comparatively economical (especially for people with no access to mains gas), it may be expensive to change to an alternative heating system and because open fires offer a unique ambience. Firewood is also sought for some commercial uses such as to power paddle steamers. In addition, a considerable amount of firewood is consumed in recreational campfires (see 'Recreation and Tourism' in this chapter).

A potentially positive aspect of firewood use is that, if produced sustainably and used efficiently (see discussion of 'Climate Change' in this chapter), it may generate fewer greenhouse emissions than most alternatives. However, firewood harvesting greatly reduces the amount of fallen timber (coarse wood debris) in red gum forests, upon which many species depend. Firewood combustion is also a major source of fine particle emissions in woodsmoke, often exceeding air quality thresholds in main towns and cities and contributing to health problems such as asthma. In some particularly affected areas (e.g. Launceston, see chapter 14), successful programs are in place to accelerate the conversion from wood heaters to other forms of heating and to educate those still with woodheaters about how to reduce woodsmoke (see chapter 14). Woodsmoke pollution is likely to be a much smaller problem in rural areas and smaller, more dispersed towns. These problems may negate some of the benefits of wood products such as lower greenhouse gas emissions (see 'Sustainability and Monitoring' above).

The level of firewood consumption and woodsmoke emissions is influenced by the type and dryness of firewood and the efficiency of heater and house design (see chapter 14). Firewood consumption is expected to decrease as the efficiency of these designs continues to improve, the natural gas network expands, the price of firewood increases and as wood heaters and stoves are gradually replaced or upgraded as old appliances wear out.

The long-term trend of decreasing firewood demand is likely to continue, although the rate of decline may decrease. The implications of rising oil prices for domestic heating in rural areas is also unknown.

The effects on pricing of measures to maintain commercial firewood production at or near current levels when the demand is declining is unclear. It is also unclear how any changes to firewood production from Victorian red gum public lands—which supply around 20 percent of total Victorian firewood use and a considerably higher percentage locally in the study area—would influence the overall market. Potential for change may be limited to approaches such as assisting the early establishment of a supply from plantations.

The issues arising from the production and use of sleepers for railways are similar to those in firewood production and use. For example, red gum sleeper production and use is—in many contexts—less expensive in the short-term than concrete sleepers and would generally be expected to produce lower greenhouse gas emissions than concrete sleepers if produced sustainably. Red gum sleeper production is a 'traditional' industry, which is likely to experience reduced long-term demand as improvements in concrete sleeper design occur, with all new lines currently being built with concrete sleepers. In addition, red gum sleepers are largely derived from sources other than Victorian public land (much comes from NSW public and private land—see chapter 14). In the short term however demand may remain high, and there may be an ongoing demand for specialised products e.g. larger section sleepers which have traditionally been sourced from Victorian logs.

Domestic Stock Grazing on Public Land

Domestic stock grazing on public land (see chapter 13) engenders considerable debate. Grazing on public land occurs along the length of the River Red Gum Forests study area and is authorised and managed in three ways: Crown land licences (over 1600 licences, 65 percent of which are less than 10 ha in area), agistment permits (Barmah forest and, until recently, parts of Gunbower forest) and commercial contracts. The key issue for this Investigation about public land grazing is whether the benefits of grazing on public land outweigh the costs associated with the environmental and management impacts of cattle grazing.

Grazing on public land has a long tradition. Practices that have evolved over time, including the annual Barmah muster, mean that grazing is seen as an important part of the heritage of the area. Grazing also enables private landholders to develop farm management plans that are more flexible and responsive to seasonal variations through the use of external feed sources. In doing so, landholders are able to supplement their incomes over and above those derived solely from on-farm practices. It is also argued that cattle grazing has benefits for public land managers, by providing an extra level of vigilance on public land that limited management resources may not otherwise provide for, such as reporting weed outbreaks or damage to fencing or irrigation regulators. Grazing is also thought by some to control weeds, including Paterson's curse, and reduce fuel loads and hence reduce the risk of wildfire.

However, others have raised a number of concerns about the use of public land for cattle grazing—particularly in environmentally sensitive locations such as water frontages and riverine forests and floodplains. Intensive grazing has been identified as a major cause of biodiversity loss through selective loss of the most palatable plant species, loss of vegetation structure and impacts on habitat values, particularly in riparian landscapes. Studies have shown that such grazing reduces the capacity of riparian zone vegetation to act as a nutrient filter, by compacting the soil and increasing erosion, and therefore allowing greater sediment input into waterways. Environmental health of water frontages and downstream water quality have been found to improve when cattle are excluded from riparian zones. In contrast, low intensity grazing (usually with sheep) for short time periods is beneficial for some non-riparian vegetation communities, such as grasslands where it may serve as a surrogate for displaced native herbivores (see chapter 5).

Although domestic stock grazing is said to reduce weed infestations, livestock can introduce weeds in their dung and, following severe soil disturbance and reduction of native vegetation cover by heavy grazing, weed species are often able to re-colonise rapidly and out-compete native species. Thus when grazing is initially removed, an obvious flourish of weeds may give the impression that grazing reduces weeds, but some argue that it is more likely that the weeds—particularly annuals—have always been present but simply become more visible.

Livestock grazing is viewed by some as a management tool for reducing fuel load and providing protection against wildfires. There is little information about which fuel types contribute to wildfire fuel loads in these riverine environments. In alpine and sub-alpine areas, cattle may reduce some of the fine fuels, but do not eat the most flammable fuel types (Williams et al. in press). The Alpine Grazing Taskforce found that fire severity in the 2003 alpine fires was not determined by whether an area had been grazed or not (Alpine Grazing Taskforce 2005). While the alpine research demonstrates that grazing cannot be assumed to reduce fuel load, specific research is required in the very different ecosystems of the riverine forests to provide evidence to support or refute a hypothesis about grazing reducing wildfire fuel loads. Currently there is no available scientific evidence either way.

Effective management and protection of areas where grazing is excluded (e.g. sensitive ecological sites, Indigenous sites of significance and reference areas) is dependent on adequate fencing. Fences on the floodplain are often damaged by floodwaters and coarse woody debris that is transported by floods. This may require labour-intensive repairs or expensive repair bills, and breaches of the fence allow livestock into prohibited areas. In addition to the damage to the protected assets, breaches allowing livestock into non-grazing areas mean that the integrity of the "non-grazed" site is violated, limiting the ability to assess the impacts of grazing. However, fenced Aboriginal archaeological and cultural sites in Barmah forest demonstrate the potential for successful fencing on the floodplain.

Improved administrative processes for public land grazing have the potential to improve consistency and accountability. The length of tenure varies significantly and valuations are conducted using different methodologies, and in some places the administrative instrument chosen does not authorise grazing.

Given the range of environmental concerns, public land grazing arrangements have been questioned by some groups and individuals, particularly where conservation is a primary objective of the public land use category (e.g. Barmah State Park, Goulburn River Heritage River Area, River Murray Reserve, Ramsar wetlands). Public agistment costs (around $14.10 per head (steer) for the six month summer term at Barmah forest) are well below the commercial market price of $100 to $200 per head or higher for six months, although the higher cost of management for stock owners may need to be considered in this pricing comparison. This situation provides graziers with access to public land for grazing with a competitive advantage over those graziers without access to public land for grazing. Licence fees are charged per area of land and do not appear to fully cost the use of the public land resource. There are also costs to the broader Victorian community for maintaining access to public land for grazing including administration, monitoring, compliance as well as on-ground works.

In addition to these direct economic issues, there are equity issues relating to allocation of licences. While public land water frontages and unused roads are usually licensed to the adjoining land owner, as it is not feasible to license this public land to anyone else, access to many state forest areas is usually a result of an historical implied right or default allocation. Allocation of agistment permits may be by a tender process or exclusively assigned to membership of an organisation (e.g. Barmah and Yielima forests graziers' associations).

Consideration of the cultural, historical and economic benefits of public land grazing requires careful consideration against the environmental and economic costs to those public lands and to the public purse. This Investigation signals the first stage of an ongoing consultation process to establish current community demands and expectations in relation to these issues.

PUBLIC LAND MANAGEMENT

Many issues have been raised by the community in relation to the management of public land. These include specific matters such as recreational access, resource allocation, fire management, biodiversity protection, administration (including community participation) and impacts from and on neighbouring land-holders. In the broadest sense, these issues relate to the ability of public land management agencies to meet community expectations about how public land should be managed. Embedded within these expectations is a wide spectrum of interests that need to be balanced: economic, political, social, historical and environmental. In some cases community concerns are based upon particular circumstances or events, while others represent overall unease or dissatisfaction with current arrangements that may or may not be based on factual information.

The adequacy of resourcing for public land management is a particular concern for many people. Given that the area of public land managed does not increase or decrease as a result of changes to the land category, these concerns can be categorised as (i) an overall impression that resourcing is inadequate across the whole public land estate; (ii) that the resources allocated for each park or reserve do not meet community expectations; or (iii) as a disagreement with the land category assigned.

The community's ability to participate meaningfully in land management decision-making has been raised as an important issue. In part, this issue arises because multiple agencies have different land management arrangements and objectives for public land management across the state, as well as different consultation and engagement processes. Public land managers may need to demonstrate a willingness to inform and engage public land users prior to decision-making and implementation, and to provide greater transparency and accountability in their planning processes. There is, however, also an obligation on public land users to inform themselves about their responsibilities and obligations for the places they visit and the activities undertaken.

The interface between public and private land is of particular concern for adjoining landholders. Pest plant and animal control as well as water and fire management are important issues in this regard and attract considerable funding from government. The land management practices of private landholders also impinge significantly upon public land. For example, in heavily irrigated areas groundwater changes have caused significant salinity problems on public land and these effects cannot be restricted or controlled by land tenure boundaries.

Cross-Border Administrative Arrangements

The state border between New South Wales (NSW) and Victoria is defined by the high water mark on the southern bank of the River Murray as it flowed in the 1850s (see chapter 9). In practical terms, the state border isolates a portion of NSW land on the southern side of the River Murray when the water level is below high water mark. In other places, meanders have changed the course of the main river channel and several hectares of both NSW and Victoria occur as enclaves within the adjoining state.

Co-ordination of administration for both land and water, while desirable, can be difficult in practice. For example, solid fuel fires are banned under NSW state forest summer restrictions, including on the southern banks of the River Murray which are nominally in NSW. However these areas are contiguous with state forest and the River Murray Reserve within Victoria where no such ban is in place. Similarly an angler may be standing on the top of the southern bank in Victoria catching fish from the River Murray in NSW, for which a NSW fishing licence is required. Agreements have been reached between the responsible departments for each state to share responsibilities for administering recreational fishing in the lakes formed by damming of the river. As a result, NSW fishing rules and regulations apply to Lake Mulwala and Victorian fishing rules and regulations apply to Lake Hume. In 2001, legislation was passed in both Victoria and NSW providing the NSW Waterway Authority and the Victoria Police with the powers to enforce both NSW and Victorian marine safety legislation on these lakes where the state border is unclear. Boating licence and registrations within each state are acknowledged in waters of both states, although some additional safety equipment may be required in NSW waters.

Coordinated management arrangements—similar to those adopted for recreational fishing and boating—would seem to be desirable for managers of public land and waters adjoining the state border.

As part of its Terms of Reference, VEAC must take into consideration opportunities for a joint management regime with the New South Wales Government for the Murray River and public land on its floodplains.

Indigenous Involvement in Public Land Management

The associations of Indigenous communities with the study area, developed over thousands of years, are profound and deeply spiritual. Chapter 6 describes the special relationship that traditional owners have with Country and the current levels of Indigenous community land ownership and management—including management models—both within Victoria and throughout Australia.

Indigenous communities have in many places called for the return of ownership of traditional lands. Return of land has occurred to varying degrees throughout Australia, largely where lease-back arrangements have been negotiated through Indigenous Land Use Agreement (ILUA) processes or under specific legislation for each jurisdiction. These agreements are largely focussed on pre-existing national parks or historic reserves. In some places, the lease revenue and enterprise opportunities—predominantly for iconic national parks—have generated sufficient funding to support natural resource and land management. In other areas that do not have a high visitor or tourism potential or agricultural opportunities, there is likely to be insufficient funds to supplement the lease revenue and resource land management. In such cases there may be limited capacity for Indigenous communities to manage land in isolation from government, or from additional financial support in some form.

Co-management offers the Indigenous community the support of government structures and economies of scale whilst, in some models, including traditional owners equally in decision-making processes. Indeed traditional owner groups have a majority on some land management boards or councils. This model of land management tends to provide good outcomes where low economic returns are expected, but may lack the appeal of Indigenous owned land or joint management (hand-back, lease-back) for some communities. Holding a majority on a joint government - traditional owner management body allows Indigenous communities to pursue employment strategies and capacity building by aligning the organisation's structure and service delivery to Indigenous decision-making processes.

In most joint management examples the land use is closely prescribed. For example, the land must continue to be managed as a national park, or land will be returned to Indigenous ownership or the government and the lease void if certain conditions are not met.

If Indigenous managed land is to be considered in Victoria, new land tenure arrangements would need to be established. The existing public land use framework provides for committees of management to be appointed under the *Crown Land (Reserves) Act 1978* and the *Forests Act 1958*, but there is no existing provision under the *National Parks Act 1975* for either joint or co-management arrangements. Amendments may also be required to municipal planning schemes, earth and mineral resource provisions.

Progress towards reconciliation and land ownership or land justice has been slower in Victoria than in other states with a larger surviving Indigenous community (i.e. South Australia, Northern Territory, Queensland). Recently in Victoria however there has been considerable publicity over the signing of the Yorta Yorta Co-operative Management Agreement and the ILUA with traditional owners for parts of the Wimmera region (see chapter 6).

It does not appear that the government funded Yorta Yorta Joint Management body established as an intermediary between Government land management agencies and traditional owners has so far provided an effective mechanism for consultation and communication. This may be because there was no previously established dialogue or consultation mechanism between the traditional owners and government regarding land management, and therefore no existing capacity or established relationships upon which to build on the formal agreement.

The challenge for future agreements to be negotiated between government and traditional owners groups is to create a framework that can withstand such factors and move ahead in a positive way. It also appears likely that the absence of previous capacity and/or working relationships, specifically those designed for land management decision-making, has limited the initial progress of the Agreement. The expended funding is likely to have supported Indigenous community capacity building, but has not yet generated the outcomes intended under the agreement.

Water has a profound and spiritual value to many Indigenous groups and beliefs are particularly entwined with the Murray River itself. Native title rights to water have been granted in some cases, and largely reflect access for continuation of traditional practices and customs. Some traditional owner groups have expressed a desire for a water allocation for cultural flows, as well as for economic purposes. This allocation may be utilised to exercise custodial responsibilities for the care of river systems, and would be allocated to each traditional owner group for environmental flows or to create an economic resource for their people (Farley Consulting Group 2003). Arguments for compensation for industry users in relation to such cultural flows are often countered by arguments for compensation for Indigenous communities over their loss of access to water and their associated traditional values.

Consultation undertaken by other government bodies or previous studies reflect a consistent message from traditional owner groups with an interest in natural resource management: that Indigenous cultural heritage and spirituality must be incorporated with environmental values in management and decision-making. These concerns could be addressed by increasing the representation of Indigenous people in natural resource management and decision-making processes. In addition, cultural heritage management and custodial responsibilities could be reflected in land management and be the responsibility of traditional owners in partnership with government. Reflection and acknowledgment of the cultural significance of many places within the study area—such as dual naming of streams or places—and recognition of related dreaming or creation stories, may provide a vehicle for reconciliation.

Greater Indigenous community involvement in public land and natural resource management assumes Indigenous communities having the capacity to set agendas for, participate in, and implement management activities and make decisions. Capacity at a general level may be broadly described as having responsibility for, authority over, access to and control of resources, or knowledge and skills and capability to perform tasks.

Despite considerable effort to build capacity by both Indigenous communities and government, there are perceptions that these exercises have had limited success or have failed. Clearly the measure of capacity and success is highly relative and subjective. Indigenous community collective and consensus decision-making processes contrast sharply with rigid government planning and consultation cycles. Greater flexibility is required in delivery of capacity building exercises so that all participants have a role in setting priorities, and the ability to modify expectations and outcomes.

Many Indigenous land management models mirror the levels of empowerment and ownership of decision-making described above. Underlying tenure also plays a role in self-esteem of Indigenous communities. However, some management agreements, despite the language of 'partnership' implying equality and mutuality, in reality operate with the Indigenous organisations essentially being a service provider to government.

One specific way of improving Indigenous capacity for involvement in natural resource management and public land management particularly in the long term is through recruitment and employment strategies within which Indigenous people work within agencies responsible for managing public land, such as Parks Victoria and DSE. Many government agencies have made progress towards addressing the under-representation of Indigenous people within their workforces and have created employment opportunities (i.e. Wur-cum barra: DNRE 2002). There is also progress towards greater involvement of Indigenous people in government agency boards e.g. Victorian Catchment Management Council. Opportunities are also available for Indigenous employment in private enterprise particularly in the fields of recreation and tourism, teaching natural and cultural heritage, and in forestry enterprises.

Aboriginal people have strongly indicated a desire to gain employment on Country. This arrangement enables the spiritual connection to their land to be maintained, provides local environmental knowledge as well as enabling individuals to maintain their relationships with family and their broader community. Flexibility to provide on-Country employment is an important component if these strategies are to be successful and would desirably include a range of employment opportunities (e.g. direct on-ground land management, strategic planning, resource use, tourism).

Management Models for Biodiversity Conservation

Many threatening processes have lead to widespread and continuing declines in biodiversity, from which the study area is not exempt (see chapter 5). One of the main approaches to conserving biodiversity in Victoria and throughout the world is through the protected area network or conservation reserve system (see chapter 10), although there are many additional or complementary conservation approaches.

Protecting areas for biodiversity conservation has strong support from many sectors of the community. However, some argue that it is more cost-effective to manage multiple-use land categories, such as state forest, for conservation than to expand strictly protected parks. This debate depends on many factors, particularly understanding what level of protection, and cost, is acceptable to both local and broader communities. Achieving a balance between environmental protection and other uses for public land has given rise to the current reserve and public land-use system in Victoria with its continuum of protection and use from a few fully protected wilderness areas to broader multi-use forests allowing varying levels of resource extraction and recreation.

Protecting areas (or *in-situ* conservation) is the most cost-effective means of protecting the widest range of species and ecosystems when compared to *ex-situ* conservation measures such as captive breeding (see chapter 10). International studies have found that countries with a high proportion of protected areas have a lower proportion of threatened species. Such reserves also have a significant unknown potential value, in the form of species or processes that might contribute greatly to our future well-being but which have not yet been identified.

Contrary to common perceptions, parks benefit from a high level of maintenance and management in order to achieve their conservation goals. Many parks require rehabilitation from past activities and the artificial replication of natural processes such as flooding, fire and pollination. Animal and plant pests require active management in parks. It is sometimes argued that pest plants and animals are more abundant in conservation reserves than surrounding private land. However, the vast majority of Australia's plant and animal pests are pests of farmland, pasture and disturbed habitat. Intact native ecosystems, without disturbance or intrusion by humans, are strongly resistant to pest invasion, with only a few possible exceptions. Weed and pest infestation in reserves is often worst on the edge of private land due to disturbance and dispersal into the park. Pest and weed invasion is generally greatest on public land with the highest amount of use, particularly use which causes high levels of disturbance.

As an example, it is frequently argued that fox numbers are higher in parks than on private land or in state forest because recreational hunting is not permitted in parks. There is no evidence, however, that fox numbers are higher in parks than on private land, and research in eastern Australia has found a correlation with distance from private land in that foxes are most abundant in forests that are closest to freehold land and are absent in forests furthest from freehold land (Catling and Burt, 1995). Furthermore, recreational hunting alone does not reduce fox populations sufficiently, over a wide enough area to result in a general population decline (Saunders et al. 1995). Analysis of the results of a fox bounty trial in Victoria indicated that it did not provide for large-scale fox population reduction (DSE 2003c). Increases in mortality (such as those resulting from an increase in hunting) are countered as fewer animals compete for the same resources and social groups are disrupted, resulting in an increase in reproductive rates the following season. The absence of hunting may, however, make foxes more visible in parks than on private land, just as it does in urban areas.

Despite the extinction of many mammal and bird species in the last two hundred years from radical land use change, modern conservation methods do appear to have prevented further extinctions in recent years. This has lead some to argue that additional biodiversity conservation is unnecessary. However, a great many species, such as the superb parrot, regent honeyeater and spotted bowerbird, have continued to decline in numbers and distribution over recent decades and years. The platypus, and many possums and gliders also show reduced reporting rates from a contracted range despite increased survey intensity. Many species survive in such small areas and in such low numbers that a single catastrophic event (such as a large-scale forest fire) or a slight change in climate, could wipe them out. A great many species are so poorly studied that it is difficult to tell whether their population is sustainable. Some ecosystems and species face such a high risk of extinction that only the highest level of protection offers them any chance of survival at all. Protected areas complement other strategies and form part of the overall package of biodiversity conservation measures. Reserves alone, however, may not be enough for highly endangered species, which require a high level of intervention (as outlined in endangered species recovery plans).

Fire Management

Fire is an important issue for most people, particularly those in fire-prone rural communities. The occurrence of catastrophic wildfires, while part of the Australian landscape, can threaten lives, livelihoods and property. Although fire is a natural part of the Australian landscape, it can also potentially threaten aspects of the environment, depending on timing and intensity. Details of the occurrence, effects on biodiversity and management of fire within the River Red Gum Forests study area are provided in chapters 4, 5 and 9 respectively. There are three issues commonly raised regarding fire on public land.

Many sections of the community believe that the risk of wildfire is greater in national parks than on private land and even in state forests. National parks are thought to accumulate large fuel loads through inadequate management and/or conservation objectives that favour 'letting nature take its course'. Prescribed burning for fuel reduction in parks, however, also comes under attack, due to the perception that prescribed burns often escape. Evidence does not support this, however, with only a small proportion of fires originating from controlled burns on public land (see chapter 4). Although some fires are started naturally from lightning, the vast majority of fires are started from humans. Proximity to humans is thus the greatest risk of wildfire either deliberately or accidentally (through campfires and machinery). Factors which may increase the risk of fires in some national parks include higher fuel loads than cleared land, less accessible terrain, greater public access in high use areas and lower reporting rates in low use areas. Factors which may decrease the risk of fires in some national parks are most notably controls on campfires and machinery, reduced fuel loads through controlled and ecological burning and reduced exposure in some areas to the main cause of fires: humans. By comparison, fires in state forest may be increased by broader public access and machinery, but are also more readily brought under control by those same factors.

Fire severity is also an important factor in assessing fire risk. While fires are more commonly started near human habitation, they are also more rapidly reported and extinguished, making them lower in severity. Fires in national parks which are started by thunderstorms, however, often have multiple points of origin from a number of lightning strikes, are reported late and are difficult to access, all of which make them difficult to control. A large fire in a national park, however, may have less social or economic impact than a similar fire in an inhabited area. These complexities probably explain why there is currently no clear evidence for meaningful differences in fire risk or severity between parks, state forests and private land. Many fire authorities believe that any potential difference in fire patterns is not a result of land tenure alone but is due to a combination of the many factors listed above.

Fuel reduction burns are often argued to be environmentally appropriate for river red gum forests. However, there have been few major wildfires within river red gum floodplain forests, and those that have occurred are typically of limited extent. Fire distribution and frequency over the last 30 to 40 years indicates that river red gum forests are not highly prone to wildfire, partly due to their position on a floodplain, although there have been a small number of fires up to 50 ha in size within the region (see chapter 3). Although fire ecology has not been studied in detail for river red gum floodplain forests, these forests seem to respond differently to fires depending on season, flood characteristics both before and after the fire, longer term climatic conditions (e.g. drought) and fire characteristics (such as intensity, rate of spread and heat). River red gum forest species do not have the typical features of fire-dependent flora to promote regeneration after fire, suggesting that fire does not naturally play a major role in this ecosystem. Increased fuel reduction burns, which are often requested for public land to protect rural communities, are likely to impact negatively on these environments.

Domestic stock grazing is sometimes suggested as a preferable alternative for reducing fuel loads and fire risk (see the 'Domestic Stock Grazing on Public Land' issue, above). However, heavy grazing in the high country prior to the 1939 fires had little preventative effect (Esplin 2003). Grazing is also unlikely to affect the accumulation of larger fuels that contribute more towards fire intensity. The Victorian Bushfire Inquiry, established as a result of the 2002-03 alpine fires, concluded that there is currently no scientific support for the view that 'grazing prevents blazing' in the high country and it is reasonable to extend this finding to other forested ecosystems throughout Victoria (Esplin 2003).

In the summer of 2004-05, the number of wildfires in NSW riverine forests was substantially less than in Victoria, suggesting that the NSW campfire ban over the summer fire season has been effective in reducing wildfire occurrence (see chapter 4). Reducing the origins of many fires may be a more effective means of protecting both the environment and surrounding communities, than reducing fuel loads.

LONGER TERM PLANNING

During its consultation so far in the Investigation, VEAC has heard concerns about the pressures of increasing population and increasing visitation to public land in the study area. The impacts of climate change are also increasingly important considerations for public land use planning.

Recreation and Tourism

The River Red Gum Forests study area is popular with visitors for many reasons. These include its sunny climate, accessible bodies of water bodies and opportunities for isolation and tranquillity in aesthetically attractive and biologically-rich open forests. The area is well suited to low cost, unstructured recreation. As a result, the study area is a major focus for a range of activities including camping, fishing, swimming, boating, water skiing, horse riding and four-wheel driving (see chapter 11 for details). In addition, new activities—such as wake-boarding—have become popular in recent years, and undoubtedly there are other recreational and tourism opportunities that are currently not extensively utilised and have considerable potential for expansion.

The study area is characterised by a long-term trend of increasing popularity for recreation, tourism and related developments both in, and away, from regional towns. This has led to an influx of retirees and so-called 'tree-changers', and an expansion of facilities and infrastructure, particularly accommodation and related service industries. This has, in turn, brought considerable social and economic benefits to these towns but, in several places, these developments and recreational uses are placing pressures on public land, and some activities appear to be close to capacity— for example, camping on riverbank during holiday periods.

Recreation is one of the major uses of public land. As population and visitation increase, however, increasing use can lead to unacceptable negative impacts on natural, cultural and other recreational values. For example, the popularity of both wake-boarding and the Southern 80 water ski race has increased considerably despite increased river bank erosion. Similarly, tourism development along the shores of Lake Mulwala and the related recreational activities have resulted in strong local opposition to variations in the lake level that could assist in improving environmental water conditions in Barmah forest (see 'Water and Environmental Flows', above). In addition, intensive camping can result in permanent loss of native ground vegetation through trampling, total removal of fallen timber and cutting of live and dead standing trees for firewood. Other major problems caused by intensive use include waste management, particularly the difficulty of human waste disposal in areas that flood (see chapter 11 for further examples). These impacts are undesirable in their own right and, if severe enough, can reduce the recreational value itself over considerable areas —particularly when the recreational values people are seeking include 'peace and quiet', isolation or a relatively unconstrained camping experience in a natural setting. This problem can be compounded when activities that are not compatible occur in close proximity, for example, hunting with firearms near campsites used by families or those seeking tranquillity.

At present, there appears to be no long-term overall planning or clear direction for recreation, tourism and related developments, unlike that set out for coastal areas under the Victorian Coastal Strategy, for example. It is probable that with good planning the region could accommodate more visitors while providing an improved visitor experience with fewer impacts. An associated advantage of wider-scale planning is that it often results in the compilation of comprehensive information and analyses covering broad areas. In the River Red Gum Forests study area, a need for research on current and predicted visitor use of public land has been identified, as well as an assessment of the capacity and impacts on various areas for particular uses. Ideally, such planning would cover relevant areas in Victoria and New South Wales as a single region. Broad-scale planning could maximise the recreational opportunities and related tourism benefits of public land in a sustainable manner without undermining the recreational resource itself, either directly or through the loss of natural or cultural values. Such an approach might address issues such as the long-term trends in various forms of recreation and tourism, the appropriate mix of recreational activities across the region, and the location of various activity or development nodes.

Strategic planning, which leads to a more structured approach to the allocation of areas for particular recreational uses or development of facilities, may compromise the relatively unstructured and unconstrained feel of recreation in river red gum forests. However, regardless of changes to public land status, the need for more planning for and management of increasing tourism and recreational use seems inevitable if river red gum forests are to be sustainable in the future.

Impact of Climate Change

As detailed in chapter 4 Climate and Hydrological Systems, climate change is likely to significantly reduce consistent rainfall patterns, river flows and run-off, and increase average temperatures and extreme weather events. Despite debate about the extent and causes of climate change, there is widespread scientific agreement that climate change is occurring and that these changes are likely to adversely affect a number of natural resources. Reduced water availability and reliability is likely to directly alter habitats and increase wildfire and pests. Indirectly, reduced water availability is likely to degrade wetlands, stress or kill trees, lower timber yields, and lower nectar yields for apiculture and nectar-feeding native animals. Water management infrastructure such as regulators and levees are also likely to require significant modification. On the other hand, climate change may reduce dryland salinity by lowering the water tables in some areas, although reduced water availability would limit options for salinity management.

Climate change effects within the study area are predicted to be significant. For example, annual stream flows across the Murray-Darling Basin are predicted to decrease by 1100 to 4000 GL by 2020 (twice as much as the 500 GL sought in the Living Murray First Step Decision annual environmental flows). Scarcity of water, exacerbated by climate change, is likely to be the most significant challenge facing natural resource managers in the study area and a number of useful approaches will need to be considered.

Other things being equal, those values and uses that inevitably rely more heavily on public land than other parts of the landscape would generally have high priority in VEAC's deliberations, especially where they are susceptible to climate change. For example, although public land occupies only around 20 percent of the study area, it supports around 60 percent of the remaining native vegetation—much of it fronting water bodies. As a result, public land is particularly important for biodiversity conservation, apiculture, wood products, and recreation and tourism. The first two of these in particular are susceptible to the effects of climate change and could be under long term threat in the study area if greatly diminished on public land. The supply of wood products from the study area is also susceptible to climate change but—although currently largely sourced from public land—is more likely to be able to shift to private land than biodiversity conservation and apiculture.

Even maintaining the status quo for many uses and values will require greater capacity and flexibility, solely to overcome the uncertainty and costs resulting from climate change. In order to maintain existing public land timber production volumes, for example, it may be necessary to increase either the intensity of harvesting (assuming it is currently below the sustainable level) or the area available for harvesting in order to offset any effects of climate change in reducing tree growth and survival rates. The key point here is to ensure that the effects of climate change are factored into any assessments of the effects of VEAC's recommendations on the viability of various values and uses.

Under conditions of limited resources to assist a large array of competing demands, it may be necessary to adopt the triage approach used in medical emergencies. Essentially advanced triage provides for the decision not to provide for some demands in some areas in order to be more confident those values and uses that are catered for will endure in the long term. Certainly planning for climate change requires that short term benefits are properly balanced against likely long term benefits and impacts. In the River Red Gum Forest study area, significant ecological assets sites are likely to be allocated water resources in preference to areas with lower conservation values.

Particular attention may need to be given to the long term security of environmental flows, and especially to existing and potential arrangements that determine the extent to which shortfalls in water resources—including as a result of climate change—are borne by other users of water relative to the environment.

There are a number of specific impacts of climate change that, once recognised, can be addressed through specific measures. For example, plant or animal species that are rare, have a restricted distribution, narrow climatic tolerances or sensitivity to environmental change could be targeted for protection in relatively unfragmented areas of consolidated habitat linking to secure areas with different climates. In general, greater emphasis could be given to securing 'biolinks' that connect habitats spanning long continuous climatic gradients.

As well as the consequences of climate change, the human-induced causes of climate change may also be relevant factors for consideration. For example, in theory at least, sustainably-produced firewood, timber railway sleepers and some sawlog products generate fewer greenhouse gases than most alternatives. On the other hand, relying on pumping water as a long-term solution to sustaining wetlands and riverine forests in some areas will produce additional greenhouse emissions (assuming pumps are powered by fossil fuels).

DEVELOPING DRAFT PROPOSALS

VEAC's public land use planning process under the *Victorian Environmental Assessment Council Act 2001* requires the Council to take into account the matters listed in Section 18 of the VEAC Act, and the additional matters listed in the River Red Gum Forests Investigation terms of reference. As part of its Investigation VEAC describes all relevant values, resources and uses, gathers information on present and predictable future needs for resources, uses and services and seeks information and views from individuals and the community by comprehensive consultation.

In particular, VEAC is required to quantify the status of several key factors, including biodiversity conservation, timber, minerals, stone, honey, grazing and other resources, and various recreational uses. Social and economic appraisals describe the current situation and explore the implications of proposals, to inform VEAC's development of recommendations. VEAC combines data from relevant key sources, including public submissions, and sets broad targets for main public land uses, taking into account major uses, the impacts of each use on other values or uses, and the appropriateness of each use in certain land use categories.

Initial working plans will be developed by combining key conservation sites, resource areas for timber, minerals, stone, grazing, other resource uses, key recreation areas, and the framework of 'given' uses, with land use proposals arising from submissions and other consultation. Many areas will fall into place without land use category conflict. Other locations where there are likely areas of competing uses to be resolved are highlighted, and gaps to be filled by more detailed work are evident. Localised data from submissions and further research will refine the plan.

Key Factors

Biodiversity conservation is best quantified at a strategic planning scale using ecological vegetation class (EVC) mapping and data analysis. This describes the conservation status of each EVC and its current representation in protected areas in the context of its pre-1750 extent. Amongst other things, VEAC is required under its Act to have regard to the need to conserve and protect biological diversity and the need to provide for a comprehensive, adequate and representative system of parks and reserves. Possible protected areas will be identified from sites of significance (or high conservation value) data, records of threatened flora and fauna species, Flora & Fauna Guarantee Action Statement objectives for threatened species, large old tree mapping, biologically intact sites, and data on biological values and other important habitat elements. Areas previously identified in FMA Plan Special Protection Zones and Special Management Zones will contribute to this stage.

Under its Act VEAC is required to have regard to any existing or proposed use of the environment or natural resources, and the potential environmental, social and economic consequences of implementing its proposed recommendations.

Timber resource quality data, location of mills, processing, value-adding and sales outlets, and other timber resource information—together, serving to identify key timber resource areas—is obtained from DSE and industry. Existing Forest Management Area plans show the current forest availability and zoning. As any proposed land use changes are considered, estimated future yields and associated implications will be assessed.

Mineral resource data from DPI locates existing and possible mining and processing sites, and any other mineral resource issues.

Stone resource and extraction site data—to the extent they are relevant to the River Red Gum Forests Study area—will be assessed.

Public land grazing is notable for its large number of small licensed areas, as well as Barmah forest grazing under permit. Relevant information will be considered in this process.

Apiculture will be addressed through the collation on available data on nectar sources.

Recreation represents a spectrum of activities that will all be considered by Council in making its recommendations.

Given Uses

A set of given uses provides a partial framework for the working plan:

- existing national and state parks
- community facilities—recreation reserves, parklands & gardens, schools, other educational institutions, public halls, education areas, recreation trails and shooting ranges
- various services and utilities—roads, railways (if in use), bridges, locks, airports, communications facilities, hospitals, public offices, courts, police stations, gaols, Defence land, other Commonwealth land, survey points etc
- water infrastructure for urban and irrigation—weirs, reservoirs and town water towers
- water distribution infrastructure—water supply channels, pipelines, drains and floodways (unless disused and open to alternative uses)
- public land infrastructure—caravan parks, boat ramps, piers and related structures
- public authority freehold land, committed to a range of purposes (unless surplus), and
- other 'given' uses described in submissions.

As well as the above, VEAC also considers user access, and practicality for land management activities—recreation facilities, fire management, pest plant and animal control and so on.

ACRONYMS

AAV	Aboriginal Affairs Victoria, a division of the Department for Victorian Communities
ABS	Australian Bureau of Statistics
AIATSIS	Australian Institute of Aboriginal and Torres Strait Islander Studies
AEMP	Asset Environmental Management Plan (for The Living Murray Icon Sites)
ANZECC	Australian and New Zealand Environment and Conservation Council
ARIER	Arthur Rylah Institute for Environmental Research
ATSIC	Aboriginal and Torres Strait Islander Commission
CAR	Comprehensive, Adequate and Representative (conservation reserve systems)
CD	Census Collection District
CFA	Country Fire Authority
CFI	Continuous Forest Inventory (forest survey plots)
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CRG	Community Reference Group for the River Red Gum Forests Investigation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBH	Diameter at breast height
DCE	the former Department of Conservation and Environment
DCFL	the former Department of Conservation, Forests and Lands
DCNR	the former Department of Conservation and Natural Resources
DEH	Department of Environment and Heritage (Federal Government)
DHS	Department of Human Services
DIIRD	Department of Industry Innovation and Regional Development
DIPNR	Department of Infrastructure, Planning and Natural Resources (New South Wales)
DNRE	the former Department of Natural Resources and Environment recently split into DPI, DSE and DVC
DOI	Department of Infrastructure
DOJ	Department of Justice
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
DVC	Department of Victorian Communities
DWLBC	Department of Water, Land, Biodiversity and Conservation (South Australia)
ECC	Environment Conservation Council
EPA	Environment Protection Authority
ESD	Ecologically Sustainable Development
EVC	Ecological Vegetation Class
EWA	Environmental Water Allocation
EWG	Environmental Watering Group
EWR	Environmental Water Reserve
FFG	Flora and Fauna Guarantee
FMA	Forest Management Area
FRB	Fuel Reduction Burning
FSD	First Step Decision
GBCMA	Goulburn Broken Catchment Management Authority
GIS	Geographic Information System
GL	Gigalitres
GMW	Goulburn–Murray Water
GMZ	General Management Zone in state forests
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature and Natural Resources now generally referred to as the World Conservation Union
JANIS	Joint ANZECC / MCFFA National Forest Policy Statement Implementation Sub-committee
LCC	Land Conservation Council
LGA	Local Government Area
LMEWP	Living Murray Environmental Watering Plan
Ma	Millions of years
MCMA	Mallee Catchment Management Authority
MDB	Murray-Darling Basin
MDBC	Murray-Darling Basin Commission
MDB-IGA	Murray-Darling Basin Intergovernmental Agreement
MDBMC	Murray-Darling Basin Ministerial Council
ML	Megalitres
MLDRIN	Murray-Lower Darling Rivers Indigenous Nations
MSS	Municipal Strategic Statement
NAP	National Action Plan for Salinity and Water Quality
NCCMA	North Central Catchment Management Authority
NECMA	North East Catchment Management Authority
NHT	Natural Heritage Trust
NNTT	Natural Native Title Tribunal
NSW	New South Wales
NTSV	Native Title Services Victoria
PPA	Pest Plant and/or Animal
PV	Parks Victoria
QLD	Queensland
RCS	Regional Catchment Strategy
RFA	Regional Forest Agreement
RMW	River Murray Water
RRG	River Red Gum
SA	South Australia
SAMLIV	Strategy for Aboriginal Managed Land In Victoria
SAP	Special Area Plan
SEA	Significant Ecological Asset (under The Living Murray initiative)
SES	State Emergency Service
SFRI	State Forests Resource Inventory
SLA	Statistical Local Area
SMZ	Special Management Zone in state forest
SQ	Site Quality (of areas in terms of forest growth capability)
SPZ	Special Protection Zone in state forest
TLM	The Living Murray
TFN	Trust For Nature
VCMC	Victorian Catchment Management Council
VEAC	Victorian Environmental Assessment Council
WUP	Wood Utilisation Plan

GLOSSARY

Adaptive management. Adaptive management is a systematic process of continually improving management policies and practices by learning from the outcomes of operational programs by employing management programs that are designed to compare selected policies and practices, by evaluating alternatives about the system being managed.

Aeolian. Wind blown sediments such as sand dunes.

Aggradation. Accumulation or raised level of sediment across a floodplain, river valley or stream bed.

Alluvial. Deposited by running water.

Anabranch. A secondary channel of a river or stream that leaves the main stream and re-joins it downstream.

Apiculture. The raising and tending of bees for commercial or agricultural purposes.

Aquifer. A rock, gravel or sand layer that holds water and through which water can move.

Aquatard. A rock layer that does not allow the flow of water.

Avulsion. A sudden change in a river course or cut-off of a meander, typically during a flood.

Bankfull. The capacity of a channel without spilling onto the surrounding floodplain.

Bank slumping. The falling or slumping of a riverbank into the river. May occur due to removal of riparian vegetation, erosion or bank destabilisation. The term is often used in connection with slumping resulting from a rapid decrease in river height, in which water drains more quickly from the river than it does from the banks, which then collapse under their own weight.

Bar. Well formed ridge or deposit of sand or gravel in a stream bed.

Barrage. A construction across the mouth of a river that prevents the entry of seawater; freshwater lies upstream of a barrage.

Basalt. Volcanic rock erupted onto the Earth's surface usually from volcanoes. Also known as blue metal when crushed into pebble or cobble size pieces as a construction material.

Baseflow. The sustained flow in a river, not the direct result of runoff from a rainfall event.

Base metals. Minerals extracted for resource use such as copper, lead and zinc.

Bedload. The soil mineral material transported on the bed of a river, usually during flood events, which may come from catchment slopes or channel banks.

Bedrock. Well consolidated rocks typically much older than overlying sequences. Sometimes also called basement.

Bendigo-style gold deposits. Orogenic gold mineralisation linked to the Benambran Orogeny, predominantly deposited along major structures such as the apex of folds (saddle reefs) and fault planes.

Benthic. Living on or near the bottom of a body of water.

Billabong. A backwater channel, often formed by a cut-off river bend, that forms an ox bow lake, lagoon or pool when river levels fall.

Biodiversity. The variety of all life: the different plants, animals and micro-organisms; the genes they contain; and the ecosystems they form. Biodiversity is usually considered at three levels: genetic diversity, species diversity, and ecosystem diversity.

Biodiversity Strategy. Victoria's *Biodiversity Strategy* fulfils commitments in the national *Strategy for the Conservation of Biodiversity* and requirements under the Victorian *Flora and Fauna Guarantee Act 1988*. It details strategic frameworks to prevent further loss of habitat, and a focus for better management of existing habitats and the continuation of natural ecological processes.

Biomass. The weight of living material in a unit volume or area at a given time.

Biolinks. See 'habitat links'.

Bioregion. A region determined by vegetation cover and the earth's physical features and climate.

Biota. All living things, including micro-organisms, plants and animals.

Blue-green algae. Naturally occurring, microscopic, primitive photosynthetic bacteria. Under certain conditions, including high nutrients, warm still water, strong sunlight into the water, they can bloom into a dense and visible growth and may become toxic.

Blue metal. See 'basalt'.

Buffer (strip). Under the terms of the Code of Forest Practices for Timber Production, a protective margin of vegetation abutting a stream, spring, wetland, body of standing water or swampy ground, which protects it from potentially detrimental disturbances in the surrounding forest. Buffer width is defined as the horizontal distance from which various harvesting operations are excluded.

Cap. An upper limit on the amount of water that maybe diverted from a river system for human uses. The most notable being the Cap introduced by the Murray Darling Basin Ministerial Council in 1995 for the entire Murray-Darling Basin.

CaLP Act. *Catchment and Land Protection Act 1994*. This Act establishes ten catchment regions and catchment management authorities across Victoria. Their role is to provide strategic advice on natural resource management through the development of a community based Regional Catchment Strategies.

CAR reserve system. A system of forest reserves established by agreement between Commonwealth, State and Territory governments to provide for biodiversity protection. The system is based on the principles of comprehensiveness, adequacy and representativeness.

Catchment. The area of land drained by a river and its tributaries.

Catchment Management Authority (CMA). Regional statutory authorities established under the *Land and Catchment Protection Act, 1994* and who are responsible for the strategic planning and coordination of natural resources, including land water and biodiversity within their catchment region. Catchment management authorities also have floodplain management functions under the *Water Act 1989*.

Channel capacity. The volume of water that can pass along the river channel at a certain point and time without spilling over the tops of the banks.

Chert. Hard, fine-grained silicic sedimentary rock, formed by chemical or biological processes sometimes in nodules in other sediments and is known as flint.

Choke or Barmah Choke. A narrow section of the River Murray near Barmah, Victoria, that constrains the flow of the River Murray.

Clastic rock. Any rock or sediment that is composed of particles (clasts). Particle size is not important—examples include sandstone, mudstone and conglomerate.

Code of Forest Practice. A set of principles and minimum standards adopted by Government for the conduct of timber harvesting and associated works on public land in Victoria. The Code aims to ensure that impacts on environment and heritage values are minimised.

Commence to flow. Volume at which flow spills into a channel or wetland. For instance, commence to flow for a wetland is the volume at which water enters the wetland.

Competition. In the context of forest growth, the contest between plants of the same or different species for limited resources, such as water, nutrient and light, producing differential growth.

Connectivity. The extent of connection between the river and its floodplain and from the floodplain back to the river by overbank flows or through flood runners.

Confluence. The place where two or more streams flow together.

Conservation reserve system. The system of reserves based on public land that are managed primarily for nature conservation. This system aims to represent all vegetation types and land systems in permanently protected reserves via dedicated reserves, informal reserves and protection by prescription. In Victoria, the reserve system is generally considered to consist of national, state and wilderness parks, reference areas and nature conservation reserves (including flora, flora and fauna, and non-hunting wildlife reserves).

Conservation status. An assessment of the susceptibility of a biological entity (usually a species or ecological unit such as an ecosystem or vegetation type) to changes in abundance and extinction. In Victoria, the World Conservation Union (IUCN 2000) classification is used to describe the conservation status of vertebrates. In order to qualify for a threatened category, a taxon must meet one or more assessment criteria, based on features such as numbers of individuals and populations, previous or projected declines in numbers or habitat, extent of occurrence, area of occupancy and extreme fluctuations in numbers or habitat. The categories, in descending level of threat are critically endangered, endangered and vulnerable. Other categories are extinct, near-threatened and data deficient (see Appendices 4 and 5).

Conversion: firewood cubic metres to tonne. 1 m^3 of firewood equals about 700 kg (0.7 tonne) oven dry weight (weight would vary with the species and density of the particular sample of wood).

Conversion: railway sleeper volume. Sleepers usually measure 2.7 m x 25 cm x 13 cm, a volume of about 0.09 cubic metres. Eleven sleepers thereby equal about one cubic metre of sawn timber. However, conversion of round logs to sleepers produces waste.

Coupe. An area of forest of variable size, shape and orientation from which logs for sawmilling or other processing are harvested.

Coppice (ing). Regrowth (adventitious) stems originating from dormant buds on the stump or the base of the trunk of a damaged eucalypt; the process of removing coppice (usually to reduce the number of stems on a stump).

'Country'. Indigenous people regularly refer to the land and natural resources of an area as 'country'. The land and waters of Australia have sustained Indigenous peoples for many thousands of years. This long occupation has resulted in a profound cultural and spiritual relationship between indigenous people and country.

Crossing timbers. Large, 30 cm x15 cm, sections in lengths from 2.7 m up to 8 m, used as sleepers to underpin converging or diverging rail tracks, such as at stations and passing places.

Crown land. At the time of European settlement, all lands in Victoria were claimed as Crown land. Crown land is a class of public land that includes unreserved land, land temporarily and permanently reserved under the *Crown Land (Reserves) Act 1978*, state forest within the meaning of the *Forests Act 1958* and park, within the meaning of the *National Parks Act 1975.* It is managed and held in trust by the Government for the benefit of the Victorian community. Crown lands may be licensed or leased or vested. Crown land does not include freehold land whether or not owned by a public authority.

Cultural heritage value. Historic, scientific, social or aesthetic value for past, present or future generations.

DBH (Diameter at breast height). The diameter of a tree trunk at 1.3 m above the ground.

Declared water supply catchment areas. Under the *Catchment and Land Protection Act 1994*, water catchments can be declared as 'special water supply catchment areas'—a mechanism that identifies the importance of the area for water supply. 'Special area plans' can be prepared for such areas to guide land use.

Dedicated reserve. A term used in the CAR reserve system to describe reserves that are equivalent to the IUCN Protected Area Management Categories I, II, III or IV as defined by the International Commission for National Parks and Protected Areas (IUCN 1994) and have secure tenure that requires action by a Parliament to be revoked. In practice such reserves include natural features reserves (such as bushland reserves and scenic reserves), historic and cultural feature reserves and regional parks, as well as national, state and wilderness parks, reference areas and nature conservation reserves. See also 'informal reserves'.

Deep leads. A miner's term for buried river gravels where mining is needed to win gold. They occur where ancient gold-bearing gravels are buried by younger river gravels, or by basalt flows.

Demographic. The description of communities and their population's social, economic and social characteristics.

De-snagging. The removal of fallen trees and dead branches from a watercourse.

Diversion. Transferral of water from a river, usually into a storage system or for direct use.

Diversion weir. A structure built across a river to enable water flow to be diverted into a water supply system.

Dry Sheep Equivalent (DSE). Level of stock grazing equivalent to a two-year old wether weighing 45 kilograms and maintaining its weight.

ECC – Environment Conservation Council. VEAC's predecessor from 1997 to 2001. See also 'Land Conservation Council (LCC)'.

Ecological Vegetation Classes (EVCs). Components of a vegetation classification system derived from groupings of vegetation communities based on floristic, structural and ecological features (see Appendix 6).

Ecologically Sustainable Development (ESD). Development which aims to meet the needs of Australians today, while conserving our ecosystems for the benefit of future Australians (see Introduction chapter).

Ecology. The study of the interrelationship between living organisms and their environment.

Ecosystem. A community of naturally co-occurring and interacting species and their physical environment in which they live and with which they also interact.

Ecosystem services. The services or benefits humans derive from the interactions of the elements of ecosystems. This might be in the form of production of goods, regeneration of services, stabilising services, life-fulfilling services (e.g., spiritual inspiration) or preservation of options.

Effluent creek. A creek that leaves a watercourse and does not return to it.

Endemic species. Species confined to a particular region or locality.

Environmental Water Entitlement. A water entitlement held by the Victorian Minister for Environment that permits the use of water in a river or storage for a purpose that benefits the environment.

Environmental flows. Any managed river flow pattern provided with the intention of maintaining or improving river health. These flows ensure that the key chemical, geomorphological, and ecological processes necessary for healthy river ecosystems are kept functioning.

Environmental value. A particular value or use of the environment that is conducive to public welfare, safety or health.

Environmental Water Allocation. An amount of water allocated to the environment under an environmental entitlement.

Environmental Water Reserve. The share of water resources set aside to maintain the environmental values of a water supply system and other water services that are dependent on the environmental condition of the system.

Ephemeral stream. A stream that flows for only short periods and then dries up.

Eutrophication. Excessive levels of aquatic plant growth (including algae) resulting from raised levels of nutrients and other factors.

Evaporation. The process by which atoms or molecules in a liquid state gain sufficient energy to enter the gaseous state.

Evapo-transpiration. The process of water being transpired by vegetation.

Even-aged stand. A forest stand where all or most of the trees are of the same age, that is, they have regenerated from the same event (e.g. a particular flood or fire).

EVC complex. A vegetation unit where two or more EVCs are unable to be distinguished in an area but are known to exist discretely elsewhere.

EVC mosaic. A vegetation unit consisting of two or more discrete EVCs, which were unable to be distinguished in mapping processes because of the scale used.

Exempt Crown land. Crown land which, under the *Mineral Resources Development Act 1990*, is in a public land-use category in which exploration or mining is not permitted. Exempt Crown land includes national, state and wilderness parks, and reference areas. Exceptions to allow mining exist under Section 40 of the *National Parks Act 1975* which provides for the continuance of an exploration or mining licence current at the time the land is declared in one of those public land-use categories.

Exploration licence. A licence under the *Mineral Resources Development Act 1990*, issued by the Minister for Energy and Resources, entitling the holder to carry out exploration on the land covered by the licence, subject to satisfying the criteria for commencement of work.

Extant. Still existing.

Extraction. In the context of water, is where water is taken from rivers or streams for off-stream use or consumption.

Facies. The primary characteristic of a sedimentary rock.

Fault. A fracture in the Earth's crust accompanied by a displacement of one side of the fracture.

Fold belt. A series of rocks formed during a mountain building tectonic episode or orogeny.

Filter strip. Under the terms of the Code of Forest Practices for Timber Production, a narrow strip of ground retained either side of a drainage line or temporary stream. In the strip, trees may be felled subject to certain conditions and machinery entry is only permitted in certain circumstances.

Fire protection plan. Plans prepared within the context of the Code of Practice for Fire Management on Public Land. They define fire protection strategies adopted to achieve those objectives. Each Fire Protection Plan has four main strategies: wildfire prevention, wildfire preparedness, wildfire suppression and wildfire recovery.

First Step Decision. A decision announced by the Murray–Darling Basin Ministerial Council in November 2003 to address the decline in health of the River Murray system.

Fish ladder or fishway. A structure designed to enable fish to move over a physical barrier (dam or weir) in a waterway.

Flood. Flows that are high enough at their peak to overrun river banks or cause flow through high-level anabranches, floodrunners or to wetlands.

Flood channel. A natural channel in a floodplain, which carries flowing water only during a flood.

Floodplain. Flat land beside a river that is inundated when the river overflows its banks during a flood.

Flora and Fauna Guarantee (FFG) Action Statement. Documents prepared for selected species, ecological communities and potentially threatening processes listed under the *Flora and Fauna Guarantee Act 1988.*

Flow regimes. The spatial and temporal pattern of flows in the main river bed and the floodplain areas surrounding the river. Natural flows refer to a flood regime unaffected by any form of flow modification. Regulated flow refers to artificial control of dams, weirs, diversions or other structures or practices.

Fluvial. A geomorphic process whereby sediments are transported and deposited by flowing water.

Forest. Vegetation formation with the tallest stratum comprising trees which project a foliage cover for greater than 30 percent of the site (cf. woodland).

Forest management area (FMA) plan. A plan developed to address the full range of values and uses in state forest, including nature conservation and timber production. There are 14 forest management areas in Victoria, and a plan is produced for each FMA.

Forest structure. The main physical features of the forest—such as the density and height of vegetation layers (e.g. canopy, shrub layer, ground layer), and size and density of trees.

Fresh. A flow pulse in a river which is higher than the median flow at that time of the year. It may occur naturally or be the result of a decision to release water from a reservoir. A fresh can occur at any time of year. Also known as flush.

Fuel reduction burning (FRB). The use of low intensity fires as a management tool to remove the more flammable fuel from parts of forests and parks, with the purpose of reducing flame height, fire intensity and slower spreading patterns of any potential bushfire and making firefighting easier.

Geographic Information System (GIS). A system which holds spatially referenced data which can be classified, overlaid, analysed and presented in map, tabular or graphic form.

Geomorphology. The study of the arrangement and form of the Earth's crust and of the relationship between these physical features and the geologic structures beneath.

Geomorphological. Pertaining to the development of present landforms and the history of changes in the earth's structure as recorded by surface features.

Gigalitres. A measurement of water equivalent to one billion litres.

Glauconitic. Sediments containing a greenish micaceous mineral (glauconite).

Golden Triangle. Area of western and central Victoria encompassing the rich gold fields between Bendigo, Ballarat and Stawell.

Grey water. Household (including caravan and houseboat) water which has not been contaminated by toilet discharge and includes water from bathtubs, dishwashing machines, clothes washing machines and kitchen sinks.

Groundwater. Underground water filling the voids in rocks, often between mineral grains in sedimentary rocks. Water in the zone of saturation in the Earth's crust.

Group selection system. An uneven-aged silvicultural system, involving the felling of all trees in small patches (or groups) at intervals (generally every 10-15 years) over the rotation. The gaps created are scattered over the coupe. Gap size is usually no more than about two tree heights in diameter, so that seedfall from surrounding trees can be used to regenerate the gap. Deliberate seedbed preparation is generally required, involving soil disturbance or burning of slash.

Geographic Representation Units (GRU). Subdivisions created to help analyse the distribution of the reservation system across the region and the degree to which values are represented in that reserve system.

Gypsum/Gypseous. Mineral derived from evaporation of salty water ($CaSO_4.2H_2O$).

Habitat. The place or environment in which an organism naturally occurs.

Habitat links. Areas of often linear remnant or planted vegetation that connect two or more patches of vegetation. These links may be continuous or discontinuous strips and patches of vegetation. Often referred to as corridors.

Headwaters. The small streams on the higher ground of a catchment, which flow into a river.

Heavy mineral sands. Sediments that contain economic concentrations of heavy minerals such as ilmenite, rutile and zircon rich in the elements titanium and zirconium.

Heritage. All those things which we have inherited from previous generations and which we value. Heritage includes places, things (movable objects) and folklore (customs, songs and sayings).

Heritage River. Rivers or reaches of rivers designated under the *Heritage Rivers Act 1992*, managed primarily to protect their significant nature conservation, recreation, scenic or cultural heritage values.

Hinterland. The area within the sphere of influence of a large town, city, river or coastline.

Human settlement and patterns. Where and how people live and work in rural areas, towns and cities.

Hydraulic. Refers to the local dynamic aspects of flow, usually measured in terms of shear stress, water depth, flow velocity.

Hydrological system. Includes streams, wetlands, billabongs, floodplains, swamps, ground water recharge areas, ephemeral lakes, estuaries and the sea.

Hydrology. The science that deals with surface and groundwaters of the earth; their occurrence, circulation and distribution; their chemical and physical properties and their reaction with the environment.

Hydrological system. This includes streams, wetlands, billabongs, floodplains, swamps, groundwater recharge areas, ephemeral lakes, estuaries and the sea.

Igneous. Rock formed from crystallisation of molten magma either slowly at depth (granite) or rapidly at the surface (basalt, rhyolite).

Indigenous vegetation. Vegetation native to a particular location.

Industrial minerals. Minerals such as gypsum and clay that are largely used for construction and industrial purposes.

Informal reserve. A term used in the CAR reserve system to describe areas clearly identified in management plans suitable for and set aside for conservation purposes. See also 'dedicated reserves'.

Interpretation. Information, signage, nature trails and guided nature walks, aimed at providing insight and awareness of natural features, ecological systems, cultural heritage, and park management.

Introduced species. Species of plants or animals that are not native to Australia (also referred to as exotic or alien species).

Indigenous vegetation. Vegetation native to a specific location.

Inundation. To cover with water, usually by the process of flooding.

JANIS criteria. Criteria defined by the Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee for the establishment of the CAR system of forest reserves (see chapter 10).

Lacustrine. Pertaining to a lake; sediment formed at the base of a lake; organisms living or growing in a lake.

LCC – Land Conservation Council. VEAC's predecessor from 1971 to 1997. See also 'Environment Conservation Council (ECC)'.

Levee. A natural levee is a deposit of alluvium, which is raised above the general level of the banks of a stream and its floodplain. Man-made levees may be constructed along the course of a river or stream in order to contain flood waters.

Lignotuber. A woody swelling, partly or wholly underground at the base of the stem of many eucalypts. It is composed of food reserves and dormant shoots that can emerge for survival if the plant's aerial parts are destroyed.

Lithology. A physical characteristic of a rock formation or stratigraphic unit.

Lock. A rectangle chamber of concrete within a river with gates each end that enables boats to move from one water level to another.

Long-term sustainable yield. The theoretical rate of harvest that can be maintained in perpetuity; i.e. when the condition of the available forest is equal to the theoretical yield of the normal forest. It is a general goal for forest managers to work towards (cf sustainable yield).

Lunette. Crescent or semicircular shaped aeolian deposits of fine sediment located on the eastern (or lee) side of lake beds or playas in semi-arid areas.

Marls. A marine sediment consisting of calcareous mudstone.

Mature forest. Forest stands and/or individual trees where the tree crowns are well foliated and rounded. Trees have reached maximum height and crowns have reached full lateral development. Branch thickening can occur. The height and crown development of the trees has effectively ceased (compared with regrowth) but decline of the crown (loss of limbs, development of epicormic growth) has not yet significantly begun (as in the senescent or over-mature growth stage).

Meander. A curve in the course of a river, always present in a series.

Megalitre (ML). One million litres (one Olympic sized swimming pool is approximately 2 ML).

Merchantable. Used to describe trees suitable for processing into forest produce and for which a market exists.

Micaceous. Containing mica minerals.

Mineral sands. See 'Heavy mineral sands'.

Mining licence. A licence under the *Mineral Resources Development Act 1990*, issued by the Minister for Energy and Resources, entitling the holder to carry out exploration and mining on the land covered by the licence, subject to receiving an authority to commence work.

National Water Initiative. The Council of Australian Governments (29 August 2003) agreed to the establishment of a National Water Initiative to improve the security of water entitlements for ecosystem health and consumptive uses through expanding water trading practices, encouraging water conservation in cities, and improvements in irrigation practices.

Natural flow regime. The likely pattern of water flow before European settlement in Australia. Natural flow regime refers to the flow patterns without any regulation or water extraction.

Oceanic arc. A volcanic arc situated in an ocean setting. Indonesia is a modern example.

Old-growth forest. Forest that contains significant amounts of its oldest growth stage in the upper stratum—usually aging trees—and which has been not been disturbed or, only experienced disturbance the effect of which is now negligible.

Orogeny. A major mountain-building event.

Overmature. See 'senescent'.

Overwood. Trees left after harvesting that compete with regeneration for light, water and nutrients (may include trees retained for habitat or seed supply and unmerchantable trees).

Peri-urban. Low density development on the edge of urban areas. It is characterised by a mixture of rural and residential land uses and may be the location of commuters who live in a rural setting while travelling to work in the nearby urban centre.

Phytoplankton. Plant plankton, usually algae.

Planform. A bird's eye view of a river channel. In other words, the shape of a river from the air or as seen on a map.

Playa. A shallow, salty desert lake. May be predominantly dry and hold water only after prolonged or heavy rain.

Point bar. Deposit of sand or gravel on the inside of a meander or river bend.

POMA – Powerful Owl Management Area. Designated areas containing suitable habitat for powerful owls based on confirmed records of breeding sites, roosts and sightings.

Pool. A body of water in a river that is relatively deep and slow moving.

Pool-riffle morphology. A type of three dimensional stream bed morphology characterised by fairly regularly-spaced alternating pool and riffles. Not all streams have this morphology.

Porphyry. Igneous intrusive rock consisting of a fine grained matrix with larger crystals.

Potentially Threatening Process. A process that has the potential to pose a significant threat to flora or fauna and is listed under the *Flora and Fauna Guarantee Act 1988*. The Commonwealth equivalent is a Key Threatening Process.

Precautionary principle. The principle that the lack of scientific certainty should not be the reason to postpone preventative measures to avert threats of serious or irreversible damage.

Pre-1750 EVC. The extent of an ecological vegetation class (EVC) prior to the year 1750 as defined by existing vegetation supplemented by predictions and modelling of vegetation that has been cleared since European settlement.

Prior stream. The course of a former stream responsible for the nearby sediments that did not carry water other than local drainage. A low ridge built up from materials deposited by stream flow along a former stream channel.

Prospecting. The use of metal detectors, hand tools, pans or simple sluices to search for minerals, such as gold and gemstones.

Protected area. Park or reserve with the primary aim of biodiversity conservation.

Public land. Under the *Victorian Environmental Assessment Council Act 20001* public land refers to (a) any unalienated land of the Crown, including land temporarily or permanently reserved under the *Crown Land (Reserves) Act 1978*; (b) state forest within the meaning of the *Forests Act 1958*; (c) park, within the meaning of the *National Parks Act 1975*; (d) land under the ownership or control of Melbourne Parks and Waterways, established under the *Water Industry Act 1994*; (e) land vested in any public authority, other than—(i) a municipal council; or (ii) an Authority under the *Water Act 1989*, to the extent that the land vested in the Authority is within a sewerage district listed in column 3 of Schedule 12 of that Act.

Public land use categories. A classification of public lands into major land-use categories such as parks, nature conservation reserves, state forest and so forth. Each land-use category in essence defines the primary purpose of the land. For many of the land-use categories a range of additional purposes are also defined. Each land-use category is generally subject to particular legislation and management arrangements (see chapter 9).

Pugging. The compaction and rutting of soil through trampling by hard-hoofed animals, particularly during wet conditions, leading to reduced water infiltration into soils and damage to plants.

Rain rejection flows/floods. Water that is ordered but not used because rain subsequently falls. Currently this water is not debited on the water-user's account.

Ramsar convention. Lists of wetlands of international importance. To be placed on the register a wetland has to fulfil certain criteria such as being important to the survival of migratory birds or endangered animals and plant species.

Ramsar site. A wetland of international significance under the Ramsar Convention.

Reach. A relatively homogenous section of a river.

Recharge. Water that infiltrates through the soil surface to the watertable.

Regeneration (noun). The young regrowth of forest plants following disturbance of the forest such as timber harvesting or fire includes juvenile and sapling stages where the tree is very small and the crown exhibits apical dominance.

Regeneration (verb). The renewal of forest by natural or artificial means.

Regime. For water, the prevailing pattern of flows.

Regional Forest Agreement (RFA). An agreement between the Commonwealth and a State or Territory Government, for the long-term management and use of forests in a particular region.

Regional water authority. Statutory authority responsible for supplying water primarily to urban consumers and the disposal of waste-water from towns.

Regrowth. (a) a forest stand regenerated either naturally or by seeding following death or removal of the forest overstorey; (b) a growth stage of a forest stand or individual tree in which the tree is actively growing, has a well developed stem with crown and a narrow conical form of small branches, but is below the maximum height for the stand. Apical dominance is apparent in vigorous trees.

Regulated river/stream. Controlled flows within a river system resulting from the influence of a regulating structure such as weir or dam.

Regulator. Structural works that control water flow.

Residual logs. Produced as a by-product of sawlog harvesting and regrowth management operations. Comprises a log too small to meet sawlog or sleeper specifications or may meet sawlog specifications for size but with greater than 50 percent defect. Includes low quality logs suitable for conversion into sawn products or those unsuitable for sawing, such as firewood or pulpwood. Utilised for a variety of products where short lengths are suitable and the appearance and strength of the timber are less important. My be harvested under annual licence or tender from areas not required for production of commercial and domestic firewood.

Restricted Crown land. Land owned by the Crown upon which, under the *Mineral Resources Development Act 1990*, any exploration or mining requires the consent of the Minister for Environment; includes nature conservation reserves, regional parks and natural features reserves.

Retained trees. Trees retained on a coupe during harvesting operations to provide habitat for wildlife, or to grow on after thinning.

Riffle. A shallow area of a river in which water flows rapidly over stones or gravel.

Rill erosion. The development of numerous minute closely spaced channels resulting from the uneven removal of surface soil by running water.

Riparian. The area of land along the bank of a river or stream.

Riparian rights. The rights to water use possessed by a person owning land containing or bordering a water course or lake.

Riverine. Relating to a river.

Salinity. A measure of the total soluble salts in a soil. A saline soil is one with an accumulation of free salts at the soil surface and/or within the profile affecting plant growth and/or land use. It is generally attributed to changes in land use or natural changes in drainage or climate, which affects the movement of water through the landscape. Salinity levels of soil or water can be tested using Electrical Conductivity (EC). The concentration of various salts dissolved in a volume of water or soil.

Sediment load. The mass of sediment transported past a point in a river over a given time period.

Senescent. A growth stage of a forest stand or individual tree that is characterised by declining crown leaf area and crown diameter and irregular crown shape due to the loss of branches and epicormic growth. This term is interchangeable with overmature or veteran in timber-production terms, but from a nature conservation point-of-view the tree is regarded as a large old (habitat) tree.

Shales. Sedimentary rocks formed from muds and clays, usually with fine even layers.

Significant ecological asset (SEA). These assets are selected for their regional, national and international importance because of their ecological values, and the belief that they are at risk of ongoing environmental degradation because of changes in water flow regimes because of river regulation. The six significant environmental assets are: Barmah-Millewa Forest, Gunbower and Koondrook-Perricoota Forests, Hattah Lakes, Chowilla Floodplain, Murray Mouth, Coorong and Lower Lakes and the River Murray Channel.

Siltation. The process of deposition of material which can be clay, silt, or sand-sized material on the base of a river or lake.

Siltstones. Similar to mudstones but composed of slightly coarser grade of sediment.

Silviculture. The theory and practice of managing forest establishment, composition and growth, to achieve specified objectives (a harvesting and regeneration system).

Silvicultural system. A planned program of forest management that includes tending, harvesting and regeneration.

Site quality. A measure of the growth potential of a forest site (as determined by soils and climate). Often expressed in terms of the dominant height of trees at a particular age.

Snag. Large woody debris in rivers that impacts on human use of rivers. Provides habitat for plants and animals.

Source bordering dune. Sand and clay rich dunes formed on the downwind side of sandbars or wide river channels during dry or low water periods.

Southern 80. An annual high speed water-ski race held on the River Murray between Torrumbarry and Echuca.

Special area plan (SAP). A plan developed under the *Catchment and Land Protection Act 1994* that details specific conditions on land-use and land management practices. To date most Special Area Plans deal with land-use in declared water supply catchments.

Special Management Zone (in FMA plans). Delineates an area that is managed to maintain specified values, such as flora and fauna habitat or catchment values, while catering for timber production under certain conditions.

Special Protection Zone (in FMA plans). Delineates an area that is managed for the conservation of natural or cultural values and where timber harvesting is excluded. It forms part of a network designed to link and complement conservation reserves. An informal reserve.

Species. A group of similar organisms generally capable of interbreeding only with each other to produce fertile offspring. For clarity, the term 'species' is frequently used in this Discussion Paper when, technically, 'taxon' or 'taxa'(see below) would more accurate.

Stand. A group of trees in a forest that can be distinguished from other groups by their age, species composition and condition.

Stand condition. The health, age and size-class distribution and stocking of a forest stand.

Statistical Local Area. A subdivision of a municipality used by the Australian Bureau of Statistics for the purposes of collection and analysis of census data.

Stratification. Distinct layers of water in a dam or weir pool, formed when there is little movement to cause intermixing, usually in summer when deeper layers of water become cold and deoxygenated.

Stressed river. An evaluation approach used in the assessment of appropriate management strategies for water allocation and flow management in uncontrolled streams. A classification based on environmental and water-use criteria, hence a stressed river is one that has high levels of water diverted and is often associated with declining water quality and biodiversity.

Stocking. Density of any given forest stand, usually expressed in terms of the number of trees per hectare.

Surface water. Water on the surface of the land, for example in rivers, creeks, lakes and dams.

Sustainable yield. Rate of harvest of timber that can be maintained for a defined period. This figure may increase in the future if the condition of the forest is improved but should not decrease except in the case of a catastrophic event such as fire (cf long-term sustainable yield).

Swale. A long, narrow trough or depression, often between sand dunes or ridges. May be a marsh or swamp when the depression carries water.

Taxon (plural: taxa). The named classification unit to which individuals or sets of species are assigned, such as subspecies, species, genus or family.

Terrane. Sections of rock with different geological histories that come together as a single landmass, typically during orogenesis as fold belts.

Terrestrial. On land, pertaining to the earth and its dry land.

Timber production. Growing and harvesting of timber from native forests.

Thinning. The removal of a proportion of trees from a (usually even-aged) stand, with the aim of increasing the growth rate and/or health of the retained trees. No regeneration is required or implied.

Threatened community. An ecological association of plants and/or animals interacting within a common environment that is listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988* or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Threatened species. A term for a plant or animal generally listed under the *Flora and Fauna Guarantee Act 1988* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Species may be further categorised depending on the level of threat (e.g. critically endangered, endangered, vulnerable). Species may also be classed as near threatened when they are close to qualifying for a threatened category, or data deficient when it is believed a species should be in a threatened category but sufficient data to make an assessment is lacking (see Appendices 4 and 5).

Tributary. A creek or river flowing into a larger river.

Trigger. In relation to water, triggers relate to when a flow of a particular size and duration is likely to initiate part or all of an ecological response to the environmental flow.

Turbidity. A measure of the light scattering properties of water, indicating how much silt, algae and other material is suspended in water. Highly turbid water looks muddy.

Ultra-mafic (also ultrabasic). Igneous rocks that consist mostly of iron, magnesium and chromium minerals and virtually no quartz or feldspars.

Uneven-aged (forest or stand). Forest or stand which contains a continuum of age classes resulting from more or less continuous regeneration over a number of years.

Unrestricted Crown land. Land owned by the Crown that, under the *Mineral Resources Development Act 1990*, can generally be prospected, explored or mined, but over which conditions may apply.

Veteran tree. Formerly used to describe a tree more or less at the senescent stage of growth.

Visitor days. Accumulated number of visits to a site including overnight stays.

Volcanogenic. Sediment derived in part from volcanic material.

Wake boarding. A sport similar to water-skiing based on a down-sized board, similar to a surf board. The rider is towed behind a boat and attempts to do tricks such as jumps and flips using the wake of the boat.

Water entitlement. The volume of water authorised to be taken and used by an irrigator or water authority.

Water entitlements include bulk entitlements, environmental entitlements, water rights, sales water, surface water and groundwater licences.

Water right. Rights to water held by irrigators in an irrigation district.

Watertable. The upper surface of a groundwater body.

Weir. A structure that transverses the river to regulate water flow and provide a relatively constant pool level to facilitate pumping or gravity feeding for irrigation and water supply purposes.

Weir pool. The water held back by a weir, forming a still pool.

Wetland. The Ramsar Convention has adopted the following definition of wetlands: *areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water at the depth of water at low tide does not exceed six metres.* It includes the community of plants and animals that lives in it.

World Conservation Union (IUCN). The World Conservation Union was created in 1948. It is the world's largest conservation-related organisation and brings together 76 states, 111 government agencies as well as a large number of non-government organisations, and some 10,000 scientists and experts, from 181 countries. Through various programs it supports the conservation of natural heritage—for instance the work of the IUCN World Commission on Protected Areas aims to promote the establishment and effective management of a worldwide, representative network of terrestrial and marine protected areas.

Yorta Yorta Co-operative Management Agreement. A formal agreement between Yorta Yorta Nation Aboriginal Corporation and the State of Victoria relating to management of Crown land and waters over a total area of approximately 50,000 ha in northern Victoria.

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Yen, A.L., S.D. Hinkley, P.A. Horne, G.A. Milledge and T.R. New (1996). *Development of invertebrate indicators of remnant grassy-woodland ecosystems*. Unpublished report to the Australian Nature Conservation Agency Save the Bush Program.

APPENDIX 1: River Red Gum Forests Investigation Community Reference Group

River Red Gum Forests Investigation Government Contact Group	
Contact Person	**Organisation**
Ian Lobban	Victorian Farmers' Federation
Louise Anderson	Goulburn Valley Environment Group
Paul Madden	Victorian Association of Forest Industries
Euan Moore	Birds Australia
Faye Ashwin	Timber Communities Australia
Trevor Shard	Minerals Councils of Australia (Victorian Division)
Kelvin Trickey	Barmah Forest Cattlemen's Association
Stan Vale	Barmah Forest Preservation League
Rod Orr	Environment Victoria
Nick Roberts	Victorian National Parks Association
Nicholas Hunt	Tourism Alliance, Victoria
Steve Robertson	Federation of Victorian Walking Clubs (VicWalk)
Debbie Warne	Horse Riding Clubs Association of Victoria
Peter Ellard[1]	Australian Motorcycle Trail Riders Association
John Corbett	VRFish
Colin Wood	Sporting Shooters' Association of Victoria
Audrey Dickens[2]	Bush Users' Group Victoria
Ian Cook	Confederation of Australian Motor Sport, Victoria
Zac Powell	Four Wheel Drive Victoria
Cr Neville Goulding	Gannawarra Shire Council
Cr Tom Crouch	Mildura Shire Council
Cr David McKenzie	Moira Shire Council
Cr Neil Repacholi	Shire of Campaspe
Joe Blake	Friends of Nyah Vinifera Forest
Rachel Rogers	Country Fire Authority
Wayne Webster	Murray Lower Darling Rivers Indigenous Nations

[1] until 1 September 2006
[2] until 25 August 2006

APPENDIX 2: River Red Gum Forests Investigation Government Contact Group

River Red Gum Forests Investigation Government Contact Group	
Contact Person	**Organisation**
Mr Pat Groenhout	VicForests
Mr Graeme Davis	Parks Victoria
Ms Chris White	Tourism Victoria
Ms Sharon MacDonnell	VicRoads
Mr Trent Wallis	Mallee Catchment Management Authority
Mr Jon Leevers (Ms Emer Campbell)	North Central Catchment Management Authority
Mr Keith Ward	Goulburn-Broken Catchment Management Authority
Mr Geoff Robinson	North-East Catchment Management Authority
Mr Owen Russell	Lower Murray Urban & Rural Water Authority
Mr Nigel Binney	Grampians Wimmera Mallee Water Authority
Mr Pat Feehan	Goulburn-Murray Rural Water
Ms Sally-Anne Mason	Coliban Water
Mr Ken Ellis	Goulburn Valley Water
Mr Pat Feehan	Goulburn-Murray Water
Mr Aleksy Bogusiak	North East Water
Mr Brian Walsh	Regional Development Victoria, Department of Innovation, Industry & Regional Development
Mr Stewart Simmons	Aboriginal Affairs Victoria, Department for Victorian Communities
Dr Tim Cleary	Department of Primary Industries
Dr Ian Mansergh	Department of Sustainability & Environment
Ms Cathryn Pilioussis	Department of Sustainability & Environment
Mr Bernie Young	Department of Sustainability & Environment
Mr Mark Riley	Department of Sustainability & Environment
Dr Jane Doolan	Department of Sustainability & Environment
Mr Ian Miles	Department of Sustainability & Environment
Mr David Harvey	Department of Sustainability & Environment
Ms Joan Phillips*	Department of Sustainability & Environment
Mr Clive Smith	Department of Sustainability & Environment
Mr Mark O'Brien	Department of Sustainability & Environment
Ms Judy Goode	Department for Water, Land & Biodiversity (SA)
Ms Merridie Martin	Department of Environment & Heritage (SA)
Mr Michael Davis	Department of Infrastructure Planning & Natural Resources (NSW)
Mr Paul Packard (Michael Penny)	Department of Environment & Conservation (NSW)
Mr Mark Siebentritt	Murray-Darling Basin Commission (Cwth)
Ms Deb Callister	Department of Environment and Heritage (Cwth)

* until June 2006

APPENDIX 3: List of Submissions received in response to the Notice of Investigation

Organisation	Contact	Sub. No.
Arbuthnot Sawmills	Mr Paul Madden	271
Archard Laser & Hydraulics	The Manager	41
Australian Conservation Foundation	Dr Arlene Buchan	44
Australian Motorcycle Trail Riders Association	Mr Peter Ellard	3
Barham Koondrook Garden Club	Ms Lyn Smith	503
Barham Koondrook Historical Society	Ms Rhonda Frankling	544
Barham Progress Association Inc.	Ms Joy Eagle	15
Barmah Forest Cattlemen's Association Inc.	Mr Kelvin Trickey	364
Barmah Forest Preservation League	Mr Stan Vale	404
Benalla District Environment Group	Ms Christine Holmes	98
Bird Observers Club of Australia, Murray-Goulburn Branch	Mr Gary Deayton	339
Birds Australia, Victorian Regional Group	Mr Euan Moore	13
Bush Users Group, Indigo Region	Ms Win Morgan	384
Bush Users Group Victoria Inc.	Mr Bob Richardson	373
Central Murray Apiaries	Mr Peter Pigdon	14
Cohuna & District Progress Association Inc.	Mr Greg Peace	526
Cohuna Joinery & Building Supplies	Mr Alan Fletcher	177
Cohuna Trail Riding Club	Ms Audrey Dickins	81
Cohuna Uniting Church Shared Ministry Team	Ms Hazel Radley	541
Confederation of Australian Motor Sport, Victoria	Mr Gary Grant	523
Conservation Council of South Australia	Mr Peter Owen	200
Construction Material Processors' Association	Mr Grant Phillips	454
Daylesford Anglers Club	Mr Dale Whitehouse	524
Department of Infrastructure	Mr John Robinson	170
Ecosurveys Pty Ltd	Mr Rick Webster	95
Environment Victoria Inc.	Ms Sue Phillips	432
Federation of Victorian Walking Clubs (VicWalk) Inc.	Mr Steve Robertson	391
Field & Game Australia Inc.	Mr Rod Drew	456
Forest Action Trust	Ms Lauren Caulfield	428
Four Wheel Drive Victoria	Mr Barry Chare	460
Friends of Nyah Vinifera Forest Inc.	Mr John O'Bree	434
Friends of the Box-Ironbark Forests, Mount Alexander Region	Mr Bernard Slattery	340
Friends of the Earth	Mr Jonathon La Nauze	261
Gannawarra Shire Council, Kerang	Mr Des Bilske	525
Gondwana Canoe Hire Pty Ltd	Ms Lyn O'Brien	267
Goulburn Broken Catchment Management Authority	Mr Bill O'Kane	366
Goulburn Valley Environment Group	Dr Doug Robinson	199
Happy Horses Hoofcare	Ms Audrey Dickins	82
Institute of Foresters of Australia	Mr Ross Penny	398
J. & G. Coulter Pty Ltd	Ms Jeanette Coulter	389
Kerang & District Assembly of God Church Inc.	Ps Allan Jakobi	70
Kerang Environment Study Centre	Mr George Hardwick	537
Kingston Conservation & Environment Coalition Inc.	Mr Bill Hampel	310
Kyabram Field and Game	Mr Graham Jamison	399
Leitchville Bunyip Sporting Club	Mr L.J. Taylor	362
Mallee Catchment Management Authority	Mr Trent Wallis	435
Melbourne Bushwalkers Inc.	Mr Rod Novak	358

Organisation	Contact	Sub. No.
Mid Murray Landcare Network	Mr David Ellemor	57
Mid Northern Association of Angling Clubs Inc.	Mr Rob Loats	54
Mildura Rural City Council	Mr Phil Pearce	506
Minerals Council of Australia, Victorian Division	Mr Chris Fraser	314
Minister for Aboriginal Affairs	The Hon Mr Gavin Jennings MLC	79
Murrabit Advancement Association Inc.	Mr Stephen O'Donoghue	505
Murrabit Riding Club Inc.	Ms Jeanette Coulter	388
Murray Darling Association Inc.	Mr Adrian Wells	19
Murray Lower Darling Rivers Indigenous Nations	Mr Steven Ross	431
Murray River Horse Trails	Mr Graeme Padget & Ms Debbie Jackson	216
The Myer Foundation	Ms Christine Fraser	430
Nathalia Fire Brigades Group	Mr Phil Hawkey	85
National Association of Forest Industries		4711
National Parks Association of New South Wales	Ms Jacquie Kelly	421
Nature Conservation Council of NSW	Ms Madeline Hourihan	169
New South Wales Forest Products Association		4711
North Central Catchment Management Authority	Mr Gavin Hanlon	439
North-Eastern Apiarists' Association	Ms Elwyne Papworth	474
Plantations North East Incorporated	Mr Bernard Young	443
Prospectors & Miners Association of Victoria	Ms Rita Bentley	319
River Country Adventours	Mr Rob Asplin	74
River Redgum Furniture	Mr Dean Attwell & Mr Wayne Hall	370
Ryan & McNulty Sawmills	Mr Greg McNulty	313
Shepparton Adult Riding Club	Mr Chris Flynn	392
Shire of Campaspe	Mr Wayne Harvey	365
Sporting Shooters' Association of Australia (Victoria) Ltd	Mr Philip Brown	320
Sunraysia Bird Observers' Club	Ms Pauline Bartels	181
Surveyor-General Victoria	Mr David Boyle	24
Swan Hill Rural City Council	Cr Bruce Jones	348
The Timber Benders	Ms Sue Ewart	419
Timber Communities Australia	Mr Ray Hill	180
Timber Communities Australia, Central Murray Red Gum Branch	Ms Faye Ashwin	322
Timber Communities Australia, Victorian State Office	Ms Kersten Gentle	4711
Trust For Nature (Vic)	Dr Chris Williams	385
Victorian Association of Forest Industries	Mr Pat Wilson	4711
Victorian Farmers Federation, Nathalia Picola Branch	Mr Tom Tinkler	344
Victorian Farmers Federation, St James-Devenish Branch (incorporating Broken Boosey Landholders Group)	Ms Kathy Beattie	381
Victorian Forest Health Advisory Committee	Mr Ian Smith	451
Victorian National Parks Association	Mr Nick Roberts	311
Victorian Piscatorial Council Inc	Mr George Hardwick	217
Wangaratta Rural City Council	Ms Karen Jones	472
Wangaratta Urban Landcare Group	Ms Helen Curtis	16
Waterkeepers Australia	Mr Greg Hunt	120
Wildlife Profiles	Mr Peter Robertson	4
Yalca-Yielima Rural Fire Brigade	The Secretary	407
Yorta Yorta Nation Aboriginal Corporation; Council of Elders Yorta Yorta Nation	Ms Monica Morgan; Mr Henry Atkinson	450

[1] joint submission

Name	Sub. No.
Mr Ian Adams	436
Mr Leigh Ahern	134
M- Chris Allen	420
Mr Ron & Mrs Margaret Armstrong	130
Mrs M.E. Ash	547
Ms Lyndall Ash	208
Mr Roger Ashburner	466
Ms Faye Ashwin	455
Dr Wayne Atkinson	168
M- J. Augello	84
M- Neylan Aykut	445
Mr Max & Mrs Belinda Baker	520
Mr Jock & Mrs Lorna Bartram	176
Mr John Bat	78
Ms Beth Batt	350
Mr Matt Batten	467
M- M.L. Baxter	349
Mr Darren Beattie	542
Mr John Bentley	202
M- E. Bergmeier	299
Mr Geoff Berry	77
Ms Linda Bester	437
Mr David Beyer	441
Ms Julia Bielak	107
Ms Laura Billings	263
Ms Deanne Bird	111
Ms Rhiannon Bogaert	240
Ms Annie Bolitho	429
Mr Frank Bolton	6
Mrs Eleanor Bolza	39
Mr Greg & Mrs Kathleen Botterill	461
Mr Darcy Botterill	382
Ms Laura Botterill	383
Mr Mark Boulet	75
Mr John Bowen	94
Ms Cara Bramich	136
Ms Edwina Breitzke	30
Mr Owen & family Brew	336
Mr Darren & Ms Margie Briggs	63
Mr John Brissett	112
Mr William Broen	298
M- S.C. Brown	191
M- V. Brown	194
Mr Robert & Mrs Dorothy Brown	453
M- P.J. Brown	189
M- M.E. Brown	190
M- D. Brown	192
M- E.S. Brown	193
Mr Terry & Jerry Browning	380
Ms Ann Buik	55
Mr Tony Buiu	246
Ms Georgie Burns-Williamson	377

Name	Sub. No.
Mr Andrew Butcher	253
Ms Sophie Butcher	251
Ms Penny Byrne	368
Mrs Gwen Calder	521
Mr Bruce Calder	530
Mr Brad Caldwell	369
Ms Helen Caldwell	393
Mr Pierre Call	417
Mr John Cameron	26
Mr Douglas & Mrs Joan Campbell	376
Mr Anthony Carroll	214
Ms Lisa Carter	515
Mr John & Mrs Barbara Caven	329
M- J. Chalmers	534
Mr Luke Chamberlain	187
Mr Michael Chew	295
M- Childs	148
Mr Wayne Church	514
Ms Mary Cilli	418
Ms Barbary Clarke	390
Ms Nicole Cleary	236
Mr Craig & Mr John Cleave	546
Mr Steve Collett	491
Mrs E.M. Colman	528
Ms Elizabeth Cook	301
M- E. Coppings	414
Mr Walter Cordes	363
Ms Rleena Cordes	531
Mr David Corke	510
Ms Tarryn Corkery-Lavender	219
Miss Frances Corry	309
Ms Esther Costa	354
Ms Brigid Cowling	532
Ms Courtney Cox	37
Mr Don Crichton	131
M- M. Curtis	272
Mr Darryl Curwood	164
Mr Peter Dale	278
Ms Lesley Dalziel	315
Mr Geoffrey Davey	495
Mr Barry & Mrs Faye Davis	161
M- Chris Dawson	463
M- J.G. Dawson	233
M- Chic Dee	508
Ms Julia Dehm	88
Mr Jack Delaney	345
Mr Frank Di Mascolo	104
Mr James Donald	283
Ms Tanya Doran	139
Mr Malcolm Dow & Ms Elinor Knappert	197
Mr Jason Doyle	470
M- Duggan	154

Name	Sub. No.
M- Duggan	155
M- J.M. Duggan	144
Ms Jennifer Duke	241
Ms Lorna Dunn	10
Mr Neil Eagle	195
Ms Melissa Eastham	80
Mr John Eberbach	427
Mr Victor Eddy	101
Mr Rodney & Mrs Sandy Edwards	27
Mr Peter Ellard	317
Mr Michael & Ms Lara English	452
M- Falahey	185
Mr Robert Fallon	69
Dr Mike Faris	269
M- K.B. Farley	335
Ms Frances Farrall	488
Ms Denise Fenwick	287
Mr Rob Fisher	535
Dr James Fitzsimons	473
Mr J. & Mrs A. Flack	117
Mr Peter Flanagan	102
M- P.F. Flynn	529
Miss Trikkelle Flynn	337
Mr Owen Flynn	333
Mr Ray Foley	462
Mr Charles Foster	213
Mr Adrian Francis	265
Ms Catherine Fraser & Mr Robert Blake	446
M- G.F. & H.M. Frostick	361
Ms Tanya Galvin	42
Mr Miles Geldard	9
Mrs B.M. George	122
M- D. Gilpin	158
Ms Belinda Glass	401
Mr Anthony Glass	400
Mrs Fay & Mr George Godden	93
Mr Gerard Gomes	224
M- J. Goss	256
Cr Neville Goulding	65
Ms Angela Grace	221
Ms Ann Grant	62
Mr Keith Greenham	49
Mr William Hahucke	346
Mr George Hall	321
Ms June Halls	47
Ms Lexie Hancock	481
M- B. Hancock	416
Ms Kylie Hannel	492
Ms Denise Hanson	152
Mr Jim Happ	196
Mr Brendan Harding	110
Ms Celia Hardy-Smith	477
Mr Jim Harker	198
Ms Susan Harrington	211

Name	Sub. No.
Mr Ian Harris	328
M- G.C. Harrisen	302
Mr Barry & Mrs Heather Harvey	7
Mr James Hattam	326
Mr John Hay	173
Mr Julian Hay	125
Ms Ashley & Ms Linda Hazelman	215
Mr Jason & Mrs Lorelle Heap	447
Mr Gary & Mrs Carole Heap	448
Mr Soc Hedditch	91
Ms Julia Hempel	296
Mr Greg Henry	356
M- P. Hense	183
Mr Wayne Hester	119
Mrs Mavis Hester	126
Ms Jacqueline Hibbert	12
Mrs Hannah Hicks	83
Ms Juanita Hill	482
Mr Paul Hiraber	277
Mr Neville Holland	331
Ms Rebecca Holland	458
Ms Isobel Holland	243
Mr Keith & Mrs Jeanette Holland	343
Ms Mouci Holland	238
Mr Robert Hollingworth	109
Ms Annette Hollingworth	166
Ms Ann Holmes	497
Ms Christine Holmes	72
Mr Darren Howard	281
Mr Peter Hunter	201
M- Jeffrey	274
Mr Reg Johnson	59
Ms Katrina Joiner	5
Ms Antonia Jolic	239
Mr Carl Justin	288
Ms Effie Kene	61
Mr Andrew Kennedy	479
Ms Wilma Kennedy	413
Ms Amanda Keogh	282
Mr Stewart Kerr	115
Ms Lauren Kerr	500
Mr Barry Kidd	533
Mr Jim Killmister	522
Ms Lucy Klem	499
M- K.M. Kloe	300
Ms Dawn Kneen	374
Mr Roger Knight	518
Ms Joy Knight	175
M- Alex Knight	174
M- L. Koch	143
Ms Maree Kratzer	36
Ms Ana Kuzmanic	494
Mr Geoff Lacey	20
Ms Bervene Lake	538

Name	Sub. No.
Ms Melanie Lambert	444
M- N. Lane	285
Ms Jennifer Lang & Mr Paul Webb	45
Mr Stephen Lavender	38
Mr Shaun Lawlor	442
Ms Jan Laws	415
Mr Michael Lea-Whyte	188
M- N. Leoy	235
Mr Peter Lewis	347
Ms Rachel Liebhaber	469
Mr David Lilley	484
Ms Holly Livesey	284
Mr Len Lock	121
Mr Alan Lodge	476
Mr Stephen Lodge	459
Mr Graham Long	207
Ms Ruth Long	325
Ms Anne Low	22
Mr Les Lubke	424
Mr Geoff Lubke	179
Mr Ian Lubke	425
Mr Andrew Luke & Ms Helen Gargan	35
Mr Paul Madden	406
Mrs Lyn Madden	405
Ms Kaaren Manley	56
Mr Tim Mannion	132
Mr Niki Marijancevic	504
Mr Joe & Mrs Inge Marinac	330
Mr Peter Maroudas	291
Mr Dudley Marrows	527
M- M. Matan	290
Mr Ken Mawson	92
Mr Robert McBain	87
Mr James McCaw	29
Mr Cameron McDonald	378
Ms Pam & Ms Lyn McDonald	323
Mr Peter McDonald	449
Mr Ian McDonald	332
Ms Raelene McFarlane	286
M- S. McGrath	146
Mr Daniel McGrath	480
Ms Patricia McGrath	184
Mrs Eileen McKee	512
Ms Laura McKenzie	270
M- J. McLeish	318
Mr John & Ms Margot McNeil	396
Ms Margaret Mikulin	225
M- B. Miller	210
Mr Jeff Mills	105
Dr Lee-Ann Monk	379
Mr Max Moor	129
Ms Marlene Moor	342
Mrs L.M. Morris	203
Mr Michael Morrow	60

Name	Sub. No.
Mr Philip Moser	334
Mr Ian & Mrs Lois Mues	178
Ms Judith Muir	52
Ms Stella Mulder	140
Ms Maureen Murray	409
Ms Betty Murtagh	371
Mr Colin Myers	316
Mr Peter Newman	394
Ms Linda Nicholls	395
Ms Jackie Nicholson	167
Mrs W. Nikolovski	58
Mr Daniel Nitsche	501
Mr Rod Novak	206
Mr Ken O'Brien	516
Mr Martin O'Brien	360
Ms Joanna O'Brien	464
Ms Kylie O'Brien	275
M- J.M. O'Callaghan	145
M- W.F. O'Callaghan	156
Mr Harry & Mrs Margaret O'Connor	86
Mr Terry O'Donoghue	352
Ms Alison O'Gorman	279
Ms Margaret O'Neill	48
Mr Chris O'Neill	305
Mr Patrick O'Neill	171
Mr Grant Palmer	408
Ms Lucille Palmer	422
M- D.H. Panton	186
Mr Rodney Pascoe	517
Mr Wolf Passauer	2
Mr Ric Pawsey	66
Mr Leon & Mrs Brooke Peace	327
Mr Stanislaw & Ms Barbara Pelczynski & Pelczynska	108
Mr Michael Pellegrino	519
M- Miki Perkins	90
Ms Kiera Perrott	100
Mr John Pettigrew	308
Mr Eric Pilkington	25
M- J.M. & D.R. Plattfuss	351
Ms Ellenie Pond	498
Ms Jan Poolsinso	43
Ms Eva Popov	124
Mr Fabian Postiglioni	485
Ms Dorothy Powell	153
Mr Rod Power	545
Mr David Prest	223
Mr Anthony Price	135
Mr Bill Probst	11
Ms Sandra Pullman	507
Dr Frank Purcell	118
Mr Neville Quinlan	157
Mr Pat & Ms Michelle Quinn	50
Mr L. & Mrs H. Radley	540

Name	Sub. No.
Dr Victor Radywonik	357
Ms Sue Radywonik	402
Mr Tony Rae	234
Mr River Rain	324
Ms Jan Ramage	232
Mr Geoffrey Randall	513
Ms Gillian Rayner	312
Ms Melanie Read-Wishart	502
Mr Jack Rees	511
Mr David Reid	307
Ms Pauline Reilly	34
Mr Max Richards	18
Mr Peter Richardson & Ms Helen Harley	53
Mr David Riis	8
Mr David & Mrs Fay Rimmer	438
Mr Morgan Roberts	490
Mr Nick Roberts	106
Mr Ray Roberts	123
Mr Hugh Robertson	440
Mr Allan Robins	89
Mr Chris Robson	244
Ms Jane Robson	242
Mr Cameron Rodda	475
Mr Murray Ross	97
Mr Dave Roy	228
Ms Sharon Roy	229
Ms Karin Ruff	411
Ms Josephine Rumsey	151
Ms Holly Russ	539
Ms Jacqueline Russ	543
Mr Colin Russell	423
Ms Penni Russon	260
Mr Rick Ryan	76
Mr Terry Ryder	292
Ms Emma Salter	355
Mr Luke Sango	245
Ms Olympia Sarrunkolaou	231
Mr Erwin Sauerwein	1
M- K. Saxton	294
Ms Julie Schilin	412
Mrs Tania Schlemitz-Justin	289
Mr James Schrieber	262
Mr Brendan Scott	493
Mr Lee Seary	23
Ms Anne Selmas	293
Mr Ken & Mrs Ula Sheather	46
Mr Alan Shell	71
Mr David Simeveks	486
Mr Alex Sislov & Ms Rhonda Chrisanthou	28
Ms Lyndall Sleep	359
Mr Bruce Smith	338
Ms Zoe Smith	259
Ms Ellen Smith	237
Mr Colin Smith	172

Name	Sub. No.
M- R. Smith	303
Mr Terry Smith	182
Dr Peter Snider	128
Ms Tracee Spiby	403
Mr Peter Stafford	33
Mr Ross Staley	99
M- P. Starkey	147
Mr Jim Starkey	149
Ms Maya Statton	252
Mr Bob Steel	113
M- B. Stephens	487
M- R.R. Stephenson	165
Ms Hannah Stewart	230
Mr Keith Stockwell	17
Ms Marie-Claire Stoller	297
Mr Douglas & Mrs Lois Stone	341
M- P.R. Sullivan	304
Ms Jane Sultana	103
Mr Kevin Swan	249
Mr Robert Swan	509
Mr Trent Swan	250
Ms Amanda Swaney	32
Ms Jessica Sykes	127
Mr Howard Tankey	410
Ms Limia Tarr	73
Ms Angela Thelen	258
Mrs Joan Theyers	51
M- J.R. Thomas	137
Mr Geoff Thompson	67
M- T. Thomson	306
Ms Brooke Thomson	387
Mr Stuart Trickey	367
Mr Neil & Mrs Robyn Trickey	204
Mr Enoch Trickey	96
Mr Kelvin Trickey	205
Mr Paul Turnbull	433
Mr Rob Turner	468
Ms Maureen Turner	478
Mr Ron Turner	141
Mr John Turner	257
M- B. Turner	142
Ms Ann Turner	222
Mr Ken Turner	264
Mr Chris Tzaros	372
Ms Jean Vagg	138
Ms Linley Walker	114
Ms Tanya Walker	116
Ms Justine Ward	31
Mr Albert & Mrs Dolly Warild	465
Mrs Nancy & Mr Harry Weatherman	160
Mr John & Mrs Jan Webb	40
Mr Hugh Webb	536
Mr Shane Webster	496
Ms Raelene West	375

Name	Sub. No.
Mr James Westland	247
Mr James Wetter	220
Ms Bronte Wicker	226
Mr Nils Wiebkin	64
Mr Craig Williams	489
Ms Nicola Williams	386
Mr Philip Williamson	353
Miss Grace Willoughby	212
Miss Jenna Wilson	68
Mr James & Ms Shirley Wilson	397
Ms Ruth Wilson	483
Mr Douglas Wood	133
Ms Elizabeth Woodhouse	209
Ms Amanda Zame	280

Name incomplete or illegible:
21, 150, 159, 162, 163, 218, 227, 248, 254, 255, 266, 268, 273, 276, 426, 457.

APPENDIX 4: Flora Species Recorded in the River Red Gum Forests Study Area

As of September 2006, the Department of Sustainability and Environment's Flora Information System database contained records for the following taxa in the River Red Gum Forests study area. The Flora Information System has comprehensive coverage of all vascular plants, but not lower plants such as mosses, liverworts and algae.

LEGEND:

EPBC: status under Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, as at December 2004.

C Critically Endangered: A taxon is critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future.

E Endangered: A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in the near future.

V Vulnerable: A taxon is vulnerable when it is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future.

Vic: conservation status in Victoria, after DSE (2005a).

x Presumed Extinct in Victoria: not recorded from Victoria during the past 50 years despite field searches specifically for the plant, or, alternatively, intensive field searches (since 1950) at all previously known sites have failed to record the plant.

e Endangered in Victoria: at risk of disappearing from the wild state if present land use and other causal factors continue to operate.

v Vulnerable in Victoria: not presently endangered but likely to become so soon due to continued depletion; occurring mainly on sites likely to experience changes in land-use which would threaten the survival of the plant in the wild; or, taxa whose total population is so small that the likelihood of recovery from disturbance, including localised natural events such as drought, fire or landslip, is doubtful.

r Rare in Victoria: rare but not considered otherwise threatened - there are relatively few known populations or the taxon is restricted to a relatively small area.

k Poorly Known in Victoria: poorly known and suspected, but not definitely known, to belong to one of the above categories (x, e, v or r) within Victoria. At present, accurate distribution information is inadequate.

FFG: status under the Victorian *Flora and Fauna Guarantee Act 1988*, as at December 2004. For the most up-to-date listings under the Act, visit: http://www.dse.vic.gov.au

L – listed as threatened.

N – nominated for listing, awaiting recommendation.

X – rejected or ineligible for listing.

"Threatened and near-threatened species" refers to any taxon in this table with an "L" under FFG, or any category under "EPBC" or "Vic" (except rare or poorly known).

No.: The number of records of the taxon in the Flora Information System database as at September 2006.

* denotes species exotic to Victoria

\# denotes species indigenous to Victoria but not the study area

English Name	Scientific Name	EPBC	Vic	FFG	No.
Gymnosperms					
Black Cypress-pine	*Callitris endlicheri*				1
Cypress*	*Cupressus* spp.				4
Cypress-pine	*Callitris* spp.				1
Scrub Cypress-pine	*Callitris verrucosa*				2
Slender Cypress-pine	*Callitris gracilis* subsp. *murrayensis*				135
White Cypress-pine	*Callitris glaucophylla*				36
Aleppo Pine*	*Pinus halepensis*				1
Pine*	*Pinus* spp.				2
Radiata Pine*	*Pinus radiata*				2
Ferns and fern allies					
Bristly Cloak-fern	*Cheilanthes distans*				2
Common Maidenhair	*Adiantum aethiopicum*				2
Green Rock-fern	*Cheilanthes austrotenuifolia*				11
Narrow Rock-fern	*Cheilanthes sieberi* subsp. *sieberi*				22
Rock Fern	*Cheilanthes* spp.				3
Sickle Fern	*Pellaea falcata s.s.*				1
Mother Shield-fern	*Polystichum proliferum*				1
Blanket Fern	*Pleurosorus rutifolius s.s.*				3
Necklace Fern	*Asplenium flabellifolium*				2
Azolla	*Azolla* spp.				5
Ferny Azolla	*Azolla pinnata*				40
Pacific Azolla	*Azolla filiculoides*				154
Fishbone Water-fern	*Blechnum nudum*				1
Soft Water-fern	*Blechnum minus*				1
Strap Water-fern	*Blechnum patersonii* subsp. *patersonii*				1
Austral Bracken	*Pteridium esculentum*				12
Ruddy Ground-fern	*Hypolepis rugosula*				2
Soft Tree-fern	*Dicksonia antarctica*				1
Fan Fern	*Sticherus* spp.				1
Tasman Fan-fern	*Sticherus tener s.s.*		r		2
Common Filmy-fern	*Hymenophyllum cupressiforme*				1
Shiny Filmy-fern	*Hymenophyllum flabellatum*				1
Plain Quillwort	*Isoetes drummondii*				2
Quillwort	*Isoetes* spp.				3
Rock Quillwort	*Isoetes muelleri*				2
Screw Fern	*Lindsaea linearis*				1
Austral Pillwort	*Pilularia novae-hollandiae*				4
Common Nardoo	*Marsilea drummondii*				361
Nardoo	*Marsilea* spp.				22
Narrow-leaf Nardoo	*Marsilea costulifera*				102
Short-fruit Nardoo	*Marsilea hirsuta*				10
Adder's-tongue	*Ophioglossum* spp.				4
Austral Adder's-tongue	*Ophioglossum lusitanicum*				31
Austral Moonwort	*Botrychium australe*		v	L	1

English Name	Scientific Name	EPBC	Vic	FFG	No.
Upright Adder's-tongue	*Ophioglossum polyphyllum*		v		11
Salvinia*	*Salvinia molesta*				2
Common Ground-fern	*Calochlaena dubia*				1
Monocotyledons					
Agave*	*Agave* spp.				1
Century Plant*	*Agave americana*				1
Sagittaria*	*Sagittaria platyphylla*				84
Sagittaria*	*Sagittaria* spp.				1
Star Fruit	*Damasonium minus*				84
Water Plantain	*Alisma plantago-aquatica*				25
Water Plantain*	*Alisma lanceolata*				14
Darling Lily	*Crinum flaccidum*		v	L	9
Garland Lily	*Calostemma purpureum s.l.*		r		36
Garland Lily	*Calostemma purpureum s.s.*		r		2
Yellow Garland-lily	*Calostemma luteum*		v		1
Canary Island Date-palm*	*Phoenix canariensis*				11
Mexican Fan-palm*	*Washingtonia robusta*				2
Cushion Centrolepis	*Centrolepis cephaloformis* subsp. *cephaloformis*				1
Hairy Centrolepis	*Centrolepis strigosa* subsp. *strigosa*				1
Wiry Centrolepis	*Centrolepis polygyna*				1
Wandering Jew*	*Tradescantia fluminensis*				2
Annual Flat-sedge	*Cyperus nervulosus*		e	L	1
Awned Club-sedge*	*Isolepis hystrix*				10
Bearded Flat-sedge	*Cyperus squarrosus*		v		1
Bog Sedge	*Schoenus* spp.				4
Broad-fruit Club-sedge	*Isolepis cernua* var. *platycarpa*				10
Button Rush	*Lipocarpha microcephala*		v		27
Club Sedge	*Isolepis* spp.				17
Common Bog-sedge	*Schoenus apogon*				11
Common Grass-sedge	*Carex breviculmis*				7
Common Spike-sedge	*Eleocharis acuta*				435
Creeping Flat-sedge	*Cyperus lhotskyanus*				2
Curly Flat-sedge	*Cyperus rigidellus*		e	L	3
Curry Flat-sedge*	*Cyperus hamulosus*				2
Dark Flat-sedge	*Cyperus sanguinolentus*				4
Dense Flat-sedge*	*Cyperus congestus*				2
Desert Bog-sedge	*Schoenus subaphyllus*				2
Desert Saw-sedge	*Gahnia lanigera*				2
Divided Sedge*	*Carex divisa*				1
Downs Nutgrass	*Cyperus bifax*		v		9
Drain Flat-sedge*	*Cyperus eragrostis*				212
Dwarf Flat-sedge	*Cyperus pygmaeus*		v		9
False Fox-sedge*	*Carex otrubae*				2
Fen Sedge	*Carex gaudichaudiana*				33

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Flat Sedge	*Cyperus* spp.				19
Flat Spike-sedge	*Eleocharis plana*		v		5
Flat-sedge*	*Cyperus reflexus*				1
Flecked Flat-sedge	*Cyperus gunnii* subsp. *gunnii*				53
Floating Club-sedge	*Isolepis fluitans*				1
Fringe Sedge	*Fimbristylis* spp.				5
Globe Kyllinga	*Cyperus sphaeroideus*				2
Grassy Club-sedge	*Isolepis hookeriana*				22
Green-top Sedge	*Carex chlorantha*		k		1
Grey Spike-sedge	*Eleocharis macbarronii*		k		1
Inland Club-sedge	*Isolepis australiensis*		k		4
Knob Sedge	*Carex inversa*				226
Lax Flat-sedge	*Cyperus flaccidus*		v		5
Leafy Bog-sedge	*Schoenus maschalinus*				1
Little Club-sedge	*Isolepis marginata*				10
Marsh Club-sedge	*Bolboschoenus medianus*				41
Medusa Bog-sedge	*Schoenus latelaminatus*				4
Nodding Club-sedge	*Isolepis cernua* var. *cernua*				3
Nutgrass*	*Cyperus rotundus*				1
Pale Spike-sedge	*Eleocharis pallens*		k		47
Plains Sedge	*Carex bichenoviana*				66
Poong'ort	*Carex tereticaulis*				267
River Club-sedge	*Schoenoplectus tabernaemontani*				26
Salt Club-sedge	*Bolboschoenus caldwellii*				6
Sedge	*Cyperaceae* spp.				1
Sedge	*Carex* spp.				28
Sharp Club-sedge	*Schoenoplectus pungens*				1
Slender Club-sedge	*Isolepis congrua*		v	L	6
Slender Spike-sedge	*Eleocharis gracilis*				2
Small Spike-sedge	*Eleocharis pusilla*				240
Soft Bog-sedge	*Schoenus tesquorum*				1
Soft Twig-sedge	*Baumea rubiginosa* s.s.				2
Spike Sedge	*Eleocharis* spp.				47
Spiny Flat-sedge	*Cyperus gymnocaulos*				96
Sticky Sword-sedge	*Lepidosperma viscidum*				9
Summer Fringe-sedge	*Fimbristylis aestivalis*		k		12
Swamp Club-sedge	*Isolepis inundata*				3
Tall Club-sedge	*Bolboschoenus fluviatilis*		k		2
Tall Flat-sedge	*Cyperus exaltatus*				100
Tall Sedge	*Carex appressa*				42
Tall Spike-sedge	*Eleocharis sphacelata*				33
Tassel Sedge	*Carex fascicularis*				1
Thatch Saw-sedge	*Gahnia radula*				2
Tiny Flat-sedge*	*Cyperus tenellus*				6
Trim Flat-sedge	*Cyperus concinnus*		v		11

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Tuber Spike-sedge	*Eleocharis atricha*				4
Variable Flat-sedge	*Cyperus difformis*				30
Variable Sword-sedge	*Lepidosperma laterale*				4
Variable Sword-sedge	*Lepidosperma laterale* var. *laterale*				1
Veiled Fringe-sedge	*Fimbristylis velata*		r		8
Victorian Club-sedge	*Isolepis victoriensis*				10
Yelka	*Cyperus victoriensis*		k		3
Aloe*	*Aloe* spp.				1
Common Pipewort	*Eriocaulon scariosum*		r		1
African Love-grass*	*Eragrostis curvula*				7
American Crows-foot Grass*	*Eleusine tristachya*				1
Annual Beard-grass*	*Polypogon monspeliensis*				127
Annual Cat's-tail*	*Rostraria cristata*				96
Annual Fog*	*Holcus annuus*				5
Annual Meadow-grass*	*Poa annua*				68
Annual Veldt-grass*	*Ehrharta longiflora*				48
Arabian Grass*	*Schismus barbatus*				460
Arabian Grass*	*Schismus* spp.				3
Australian Salt-grass	*Distichlis distichophylla*				6
Australian Saltmarsh-grass	*Puccinellia stricta*				1
Australian Saltmarsh-grass	*Puccinellia stricta* var. *stricta*				4
Avellinia*	*Avellinia michelii*				4
Awnless Barnyard-grass*	*Echinochloa colona*				4
Balcarra Spear-Grass	*Austrostipa nitida*				68
Barb Grass*	*Parapholis* spp.				3
Barley Grass*	*Hordeum* spp.				31
Barley*	*Hordeum vulgare* s.l.				8
Barley-grass*	*Hordeum leporinum*				61
Barley-grass*	*Hordeum murinum* s.l.				443
Barnyard Grass*	*Echinochloa crus-galli*				34
Bearded Oat*	*Avena barbata*				173
Bent-grass	*Deyeuxia* spp.				1
Bent/Blown Grass	*Agrostis s.l.* spp.				20
Black-seed Panic*	*Panicum bisulcatum*				1
Bordered Panic	*Entolasia marginata*				1
Branched Panic*	*Panicum racemosum*				1
Bristle Grass	*Trisetum spicatum* subsp. *australiense*				2
Bristly Love-grass	*Eragrostis setifolia*		v		95
Bristly Wallaby-grass	*Austrodanthonia setacea*				501
Bristly Wallaby-grass	*Austrodanthonia setacea* var. *setacea*				35
Brome	*Bromus* spp.				102
Brown Beetle-grass	*Leptochloa fusca* subsp. *fusca*		r		9
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*				252
Brown-top Bent*	*Agrostis capillaris*				3
Brown-top Bent*	*Agrostis capillaris* var. *capillaris*				1

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Brush Wire-grass	*Aristida behriana*				55
Buffalo Grass*	*Stenotaphrum secundatum*				4
Bulbous Meadow-grass*	*Poa bulbosa*				18
Bulbous Meadow-grass*	*Poa bulbosa* var. *vivipara*				3
Bulbous Meadow-grass*	*Poa bulbosa* var. *bulbosa*				3
Canary Grass*	*Phalaris canariensis*				1
Canary Grass*	*Phalaris* spp.				14
Cane Grass	*Eragrostis australasica*		v		45
Cane Spear-grass	*Austrostipa breviglumis*		r		1
Cane Wire-grass	*Aristida ramosa*				4
Carpet Grass*	*Axonopus fissifolius*				4
Cat's Tail*	*Rostraria* spp.				1
Chilean Brome*	*Bromus lithobius*				2
Chilean Needle-grass*	*Nassella neesiana*				9
Close-headed Love-grass	*Eragrostis diandra*				52
Coast Barb-grass*	*Parapholis incurva*				162
Cocksfoot*	*Dactylis glomerata*				11
Common Barb-grass*	*Hainardia cylindrica*				2
Common Blown-grass	*Lachnagrostis filiformis*				523
Common Blown-grass	*Lachnagrostis filiformis* var. 1				95
Common Bottle-washers	*Enneapogon avenaceus*				31
Common Hedgehog-grass	*Echinopogon ovatus*				1
Common Love-grass	*Eragrostis brownii*				44
Common Reed	*Phragmites australis*				111
Common Swamp Wallaby-grass	*Amphibromus nervosus*				161
Common Tussock-grass	*Poa labillardierei*				108
Common Tussock-grass	*Poa labillardierei* var. *labillardierei*				28
Common Wallaby-grass	*Austrodanthonia caespitosa*				495
Common Wheat-grass	*Elymus scaber* var. *scaber*				134
Coolah Grass*	*Panicum coloratum*				15
Copper-awned Wallaby-grass	*Austrodanthonia fulva*				29
Corkscrew Spear-grass	*Austrostipa setacea*				2
Cotton Panic-grass	*Digitaria brownii*		k		2
Cottony Spear-grass	*Austrostipa drummondii*				8
Couch	*Cynodon dactylon*				306
Couch	*Cynodon* spp.				3
Couch*	*Cynodon dactylon* var. *dactylon*				40
Crested Dog's-tail*	*Cynosurus cristatus*				1
Crested Spear-grass	*Austrostipa blackii*				30
Dark Wire-grass	*Aristida calycina* var. *calycina*		r		1
Darnel*	*Lolium temulentum*				1
Delicate Hair-grass*	*Aira elegantissima*				42
Dense Spear-grass	*Austrostipa densiflora*				1
Desert Spear-grass	*Austrostipa eremophila*				19

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Desmazeria*	*Tribolium acutiflorum s.l.*				2
Desmazeria*	*Tribolium* spp.				1
Early Meadow-grass*	*Poa infirma*				1
Early Spring-grass	*Eriochloa pseudoacrotricha*				7
English Couch*	*Elytrigia repens*				7
False Brome*	*Brachypodium distachyon*				43
False Hair-grass*	*Pentaschistis airoides* subsp. *airoides*				375
Feather Spear-grass	*Austrostipa elegantissima*				66
Feather Windmill Grass*	*Chloris virgata*				1
Feathertop*	*Pennisetum villosum*				2
Fern Grass*	*Catapodium rigidum*				6
Fescue	*Festuca* spp.				1
Fescue*	*Vulpia* spp.				164
Fine-hairy Spear-grass	*Austrostipa puberula*		r		1
Fine-head Spear-grass	*Austrostipa oligostachya*				5
Finger Grass	*Dactyloctenium radulans*		r		5
Five-awned Spear-grass	*Pentapogon quadrifidus* var. *quadrifidus*				5
Flat-awned Spear-grass	*Austrostipa platychaeta*				4
Forde Poa	*Poa fordeana*				77
Fox Tail*	*Alopecurus* spp.				3
Fox-tail Fescue*	*Vulpia myuros* f. *megalura*				5
Golden-top*	*Lamarckia aurea*				75
Graceful Spear-grass	*Austrostipa acrociliata*				8
Grass	*Poaceae* spp.				13
Grass (naturalised)*	*Poaceae* spp. (naturalised)				6
Great Brome*	*Bromus diandrus*				261
Green Pigeon-grass*	*Setaria viridis*				1
Grey Tussock-grass	*Poa sieberiana*				14
Grey Tussock-grass	*Poa sieberiana* var. *hirtella*				5
Grey Tussock-grass	*Poa sieberiana* var. *sieberiana*				2
Hair Grass*	*Aira* spp.				73
Hairy Panic	*Panicum effusum*				17
Hare's-tail Grass*	*Lagurus ovatus*				4
Highland Bent*	*Agrostis capillaris* var. *aristata*				1
Hill Wallaby-grass	*Austrodanthonia eriantha*				34
Italian Millet*	*Setaria italica*				1
Italian Rye-grass*	*Lolium multiflorum*				6
Jericho Wire-grass	*Aristida jerichoensis* var. *subspinulifera*		e	L	2
Johnson Grass*	*Sorghum halepense*				6
Kangaroo Grass	*Themeda triandra*				48
Kentucky Blue-grass*	*Poa pratensis*				3
Kikuyu*	*Pennisetum clandestinum*				20
Kneed Spear-grass	*Austrostipa bigeniculata*				17
Kneed Wallaby-grass	*Austrodanthonia geniculata*				4
Knotted Barley-grass*	*Hordeum secalinum*				4

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Knotted Poa	*Poa drummondiana*		r		4
Knotty Spear-grass	*Austrostipa nodosa*				78
Knottybutt Grass	*Paspalidium constrictum*				55
Large Quaking-grass*	*Briza maxima*				44
Leafy Wallaby-grass	*Austrodanthonia bipartita s.l.*				33
Leafy Wallaby-grass	*Austrodanthonia bipartita s.s.*				8
Lesser Burr-grass*	*Cenchrus incertus*				2
Lesser Canary-grass*	*Phalaris minor*				78
Lesser Quaking-grass*	*Briza minor*				81
Liverseed Grass*	*Urochloa panicoides*				1
Lobed Wallaby-grass	*Austrodanthonia auriculata*				17
Long Grey-beard Grass	*Amphipogon caricinus* var. *caricinus*				5
Long-awn Spear-grass	*Austrostipa tenuifolia*		v		2
Long-hair Plume-grass	*Dichelachne crinita*				22
Long-leaf Wallaby-grass	*Notodanthonia longifolia*				2
Long-nosed Swamp Wallaby-grass	*Amphibromus macrorhinus*				6
Love Grass	*Eragrostis* spp.				21
Madrid Brome*	*Bromus madritensis*				13
Mallee Love-grass	*Eragrostis dielsii*				173
Mallee Tussock-grass	*Poa lowanensis*		r		1
Manna Grass*	*Glyceria declinata*				3
Marsh Fox-tail*	*Alopecurus geniculatus*				51
Mat Grass	*Hemarthria uncinata* var. *uncinata*				46
Meadow Brome*	*Bromus racemosus* subsp. *commutatus*				4
Mediterranean Barley-grass*	*Hordeum hystrix*				59
Mediterranean Brome*	*Bromus lanceolatus*				22
Mexican Love-grass*	*Eragrostis mexicana*				1
Native Couch	*Cynodon dactylon* var. *pulchellus*		k		33
Native Millet	*Panicum decompositum* var. *decompositum*				24
Needle Grass	*Triraphis mollis*		r		12
Nigger-heads	*Enneapogon nigricans*				6
Northern Barley-grass*	*Hordeum glaucum*				175
Oat Kangaroo-grass	*Themeda avenacea*		k		4
Oat*	*Avena sativa*				25
Oat*	*Avena* spp.				219
Orange Fox-tail*	*Alopecurus aequalis*				13
Pale Pigeon-grass*	*Setaria pumila* subsp. *pumila*				11
Pampas Grass*	*Cortaderia* spp.				1
Panic	*Panicum* spp.				7
Panic Grass	*Paspalidium* spp.				25
Panic Veldt-grass*	*Ehrharta erecta* var. *erecta*				12
Panic*	*Panicum gilvum*				18
Paradoxical Canary-grass*	*Phalaris paradoxa*				137
Paspalum*	*Paspalum dilatatum*				159

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Paspalum*	*Paspalum* spp.				8
Pepper Grass	*Panicum laevinode*		v		5
Perennial Beard-grass*	*X Agropogon littoralis*				1
Perennial Rye-grass*	*Lolium perenne*				194
Perennial Veldt-grass*	*Ehrharta calycina*				2
Pigeon Grass*	*Setaria* spp. (naturalised)				1
Plump Spear-grass	*Austrostipa aristiglumis*				114
Porcupine Grass	*Triodia scariosa*				24
Prairie Grass*	*Bromus catharticus*				52
Prairie Grass*	*Bromus catharticus* var. *catharticus*				12
Prickly Barnyard-grass*	*Echinochloa muricata* var. *microstachya*				2
Prickly Spear-grass	*Austrostipa pilata*		v		1
Purple Love-grass	*Eragrostis lacunaria*		v		90
Purplish Wallaby-grass	*Austrodanthonia tenuior*				3
Quicksilver Grass*	*Aira cupaniana*				42
Quizzical Spear-grass	*Austrostipa stuposa*				2
Rat's-tail Fescue*	*Vulpia myuros*				753
Rat's-tail Fescue*	*Vulpia myuros* f. *myuros*				78
Rat-tail Couch	*Sporobolus mitchellii*				497
Rat-tail Grass	*Sporobolus* spp.				6
Rat-tail Grass*	*Sporobolus africanus*				5
Red Brome*	*Bromus rubens*				766
Red Natal-grass*	*Melinis repens* subsp. *repens*				1
Red-leg Grass	*Bothriochloa macra*				18
Reed Bent-grass	*Deyeuxia quadriseta*				73
Reed Sweet-grass*	*Glyceria maxima*				3
Rhodes Grass*	*Chloris gayana*				8
Rice Millet*	*Piptatherum miliaceum*				3
Rigid Panic	*Whalleya proluta*				221
River Swamp Wallaby-grass	*Amphibromus fluitans*	V		X	178
Rough Dog's-tail*	*Cynosurus echinatus*				13
Rough Spear-grass	*Austrostipa scabra* subsp. *falcata*				471
Rough Spear-grass	*Austrostipa scabra*				203
Rough Spear-grass	*Austrostipa scabra* subsp. *scabra*				15
Rough-seed Wire-grass	*Aristida obscura*		e	L	2
Rye Beetle-grass	*Tripogon loliiformis*		r		12
Rye Grass*	*Lolium* spp.				82
Salt Couch	*Sporobolus virginicus*				4
Sand Brome	*Bromus arenarius*		r		18
Sand Wire-grass	*Aristida contorta*				11
Scaly Poa	*Poa fax*		r		1
Sea Barley-grass*	*Hordeum marinum*				282
Serrated Tussock*	*Nassella trichotoma*				2
Shiny Wallaby-grass	*Austrodanthonia induta*				5
Short Wallaby-grass	*Austrodanthonia carphoides*				14

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Short-awned Wheat-grass	*Elymus multiflorus*		k		10
Short-bristle Wallaby-grass	*Austrodanthonia setacea* var. *breviseta*		r		1
Short-crown Spear-grass	*Austrostipa curticoma*				2
Short-hair Plume-grass	*Dichelachne sciurea* spp. agg.				5
Siberian Wild-rye*	*Leymus multicaulis*				2
Sickle Love-grass	*Eragrostis falcata*		k		1
Silky Blue-grass	*Dichanthium sericeum* subsp. *sericeum*				8
Silky Browntop	*Eulalia aurea*				63
Silky Umbrella-grass	*Digitaria ammophila*		v		19
Silky-heads	*Cymbopogon obtectus*		e		2
Silvertop Wallaby-grass	*Joycea pallida*				6
Silvery Hair-grass*	*Aira caryophyllea*				38
Slender Barb-grass*	*Parapholis strigosa*				3
Slender Love-grass	*Eragrostis exigua*		e		7
Slender Panic	*Paspalidium gracile*		r		1
Slender Pigeon Grass*	*Setaria parviflora*				7
Slender Wallaby-grass	*Austrodanthonia racemosa* var. *racemosa*				21
Small Burr-grass	*Tragus australianus*		r		3
Small Hair-grass*	*Molineriella minuta*				5
Small-seed Plume-grass	*Dichelachne micrantha*				2
Smaller Stink-grass*	*Eragrostis minor*				1
Smooth Wallaby-grass	*Austrodanthonia laevis*				3
Soft Brome*	*Bromus hordeaceus* subsp. *hordeaceus*				228
Soft Love-grass*	*Eragrostis pilosa*				4
Soft Tussock-grass	*Poa morrisii*				2
Southern Cane-grass	*Eragrostis infecunda*				143
Southern Swamp Wallaby-grass	*Amphibromus neesii*				4
Spear Grass	*Austrostipa* spp.				301
Spear-grass	*Austrostipa trichophylla*		r		3
Spear-grass	*Austrostipa scabra* group				4
Spider Grass	*Enteropogon acicularis*				462
Spiny Burr-grass*	*Cenchrus longispinus*				11
Spiny Mud-grass	*Pseudoraphis spinescens*				132
Spurred Spear-grass	*Austrostipa gibbosa*				86
Squirrel-tail Fescue*	*Vulpia bromoides*				197
Sterile Brome*	*Bromus sterilis*				20
Sterile Oat*	*Avena sterilis*				3
Sterile Oat*	*Avena sterilis* subsp. *ludoviciana*				10
Sterile Oat*	*Avena sterilis* subsp. *sterilis*				2
Stiff Rye-grass*	*Lolium loliaceum*				4
Stink Grass*	*Eragrostis cilianensis*				21
Summer Grass	*Digitaria* spp.				1
Summer Grass*	*Digitaria sanguinalis*				10
Supple Spear-grass	*Austrostipa mollis*				9

English Name	Scientific Name	EPBC	Vic	FFG	No.
Swamp Millet	*Isachne globosa*				1
Swamp Wallaby-grass	*Amphibromus* spp.				30
Sweet Vernal-grass*	*Anthoxanthum odoratum*				3
Tall Cup-grass	*Eriochloa crebra*		k		1
Tall Fescue*	*Festuca arundinacea*				4
Tall Kerosene Grass	*Aristida holathera* var. *holathera*		v		6
Tall Spear-grass	*Austrostipa pubinodis*				2
Tall Wheat-grass*	*Lophopyrum ponticum*				12
Teff*	*Eragrostis tef*				1
Tiny Bent	*Agrostis australiensis*		r		1
Tiny Bristle-grass*	*Rostraria pumila*				40
Toowoomba Canary-grass*	*Phalaris aquatica*				117
Tussock Grass	*Poa australis* spp. agg.				2
Tussock Grass	*Poa* spp.				14
Two-row Barley*	*Hordeum distichon*				2
Umbrella Grass	*Digitaria divaricatissima*		v		4
Vasey Grass*	*Paspalum urvillei*				2
Veldt Grass*	*Ehrharta* spp.				1
Velvet Wallaby-grass	*Austrodanthonia pilosa*				7
Vernal Grass*	*Anthoxanthum* spp.				1
Wall Brome*	*Bromus tectorum*				5
Wall Fescue*	*Vulpia muralis*				118
Wallaby Grass	*Danthonia s.l.* spp.				112
Wallaby Grass	*Austrodanthonia* spp.				134
Wallaby Grass	*Rytidosperma* spp.				1
Warrego Summer-grass	*Paspalidium jubiflorum*				445
Water Couch*	*Paspalum distichum*				183
Weeping Grass	*Microlaena stipoides* var. *stipoides*				21
Weeping Love-grass	*Eragrostis parviflora*				23
Weeping Wallaby-grass	*Austrodanthonia penicillata*				1
Western Rat-tail Grass	*Sporobolus creber*		v		3
Wetland Wallaby-grass	*Notodanthonia semiannularis*				1
Wheat*	*Triticum aestivum*				8
Whisky Grass*	*Andropogon virginicus*				1
White-water Panic*	*Panicum obseptum*				3
Whorled Pigeon-grass*	*Setaria verticillata*				6
Wild Oat*	*Avena fatua*				177
Wimmera Rye-grass*	*Lolium rigidum*				445
Windmill Grass	*Chloris truncata*				188
Windmill Grass	*Chloris* spp.				3
Wire-grass	*Aristida* spp.				1
Witch Panic*	*Panicum hillmanii*				4
Yakka Grass	*Sporobolus caroli*		r		19
Yorkshire Fog*	*Holcus lanatus*				29
Canadian Pondweed*	*Elodea canadensis*				11

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Eel Grass	*Vallisneria americana* var. *americana*				41
Hydrilla	*Hydrilla verticillata*		r		1
Swamp Lily	*Ottelia ovalifolia* subsp. *ovalifolia*				13
Golden Weather-glass	*Hypoxis hygrometrica*				1
Hypoxis	*Hypoxis* spp.				7
Tiny Star	*Hypoxis glabella* var. *glabella*				34
Yellow Star	*Hypoxis glabella s.l.*				1
Yellow Star	*Hypoxis vaginata*				1
Blue Pigroot*	*Sisyrinchium iridifolium*				4
Bulbil Watsonia*	*Watsonia meriana* var. *bulbillifera*				2
Common Onion-grass*	*Romulea rosea* var. *australis s.s.*				9
Freesia*	*Freesia alba x Freesia leichtlinii*				2
One-leaf Cape-tulip*	*Moraea flaccida*				4
Onion Grass*	*Romulea rosea*				184
Onion Grass*	*Romulea* spp.				20
Pink Tritonia*	*Tritonia squalida*				1
Scour-weed*	*Sisyrinchium* sp. A				2
Small-flower Onion-grass*	*Romulea minutiflora*				222
Thread Iris*	*Moraea setifolia*				44
Tricolor Harlequin-flower*	*Sparaxis tricolor*				2
Two-leaf Cape-tulip*	*Moraea miniata*				1
Wild Gladiolus*	*Gladiolus undulatus*				2
Yellow Ixia*	*Ixia maculata*				2
Rush	*Juncus* sp. (sect genuini)				10
Austral Rush	*Juncus australis*				3
Billabong Rush	*Juncus usitatus*				34
Branching Rush	*Juncus prismatocarpus*				7
Broad-leaf Rush	*Juncus planifolius*				3
Broom Rush	*Juncus sarophorus*				8
Capitate Rush*	*Juncus capitatus*				10
Clustered Rush	*Juncus vaginatus*				2
Common Woodrush	*Luzula meridionalis* var. *densiflora*				6
Common Woodrush	*Luzula meridionalis* var. *flaccida*				2
Common Woodrush	*Luzula meridionalis*				5
Diffuse Rush	*Juncus remotiflorus*				15
Finger Rush	*Juncus subsecundus*				210
Folded Rush*	*Juncus imbricatus*				2
Giant Rush	*Juncus ingens*				94
Gold Rush	*Juncus flavidus*				196
Green Rush	*Juncus gregiflorus*				4
Hoary Rush	*Juncus radula*				32
Hollow Rush	*Juncus amabilis*				148
Joint-leaf Rush	*Juncus holoschoenus*				50
Jointed Rush*	*Juncus articulatus*				44
Pale Rush	*Juncus pallidus*				3

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Plains Rush	*Juncus semisolidus*				10
Rush	*Juncus* spp.				134
Sand Rush	*Juncus psammophilus*		r		5
Spiny Rush*	*Juncus acutus* subsp. *acutus*				99
String Rush*	*Juncus capillaceus*				1
Tall Rush	*Juncus procerus*				1
Toad Rush	*Juncus bufonius*				70
Tussock Rush	*Juncus aridicola*				96
Wiry Rush	*Juncus homalocaulis*				12
Common Water-ribbons	*Triglochin procera s.s.*				23
Dwarf Arrowgrass	*Triglochin nana*				8
Lilaea*	*Lilaea scilloides*				1
Northern Water-ribbons	*Triglochin multifructa*				51
Six-point Arrowgrass	*Triglochin hexagona*		v		2
Slender Water-ribbons	*Triglochin dubia*		r		6
Southern Water-ribbons	*Triglochin alcockiae*				1
Spurred Arrowgrass	*Triglochin calcitrapa s.l.*				75
Streaked Arrowgrass	*Triglochin striata*				5
Turret Arrowgrass	*Triglochin turrifera*				3
Water Ribbons	*Triglochin procera s.l.*				168
Water Ribbons	*Triglochin* spp.				3
Common Duckweed	*Lemna disperma*				23
Common Duckweed	*Lemna minor s.l.*				12
Duckweed	*Lemna* spp.				5
Thin Duckweed	*Landoltia punctata*				35
Tiny Duckweed	*Wolffia australiana*				3
Lily	*Liliaceae* spp. *(s.l.)*				5
Water Nymph	*Najas tenuifolia*		r		1
Austral Ladies' Tresses	*Spiranthes australis*				2
Bearded Greenhood	*Pterostylis plumosa s.l.*				1
Bird Orchid	*Chiloglottis* spp.				2
Bluebeard Orchid	*Pheladenia deformis*				1
Blunt Greenhood	*Pterostylis curta*				1
Broad-lip Leek-orchid	*Prasophyllum patens s.l.*				1
Brown-clubbed Spider-orchid	*Caladenia phaeoclavia*				1
Caladenia	*Caladenia* spp.				1
Common Onion-orchid	*Microtis unifolia*				16
Dwarf Greenhood	*Pterostylis nana*				2
Golden Cowslips	*Diuris behrii*		v		1
Golden Moths	*Diuris lanceolata s.l.*				1
Greenhood	*Pterostylis* spp.				1
Hood Orchid	*Caladenia cucullata*				2
Horned Orchid	*Orthoceras strictum*				3
Hybrid Sun-orchid	*Thelymitra X truncata s.s.*				2
Large Duck-orchid	*Caleana major*				2

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Large Tongue-orchid	*Cryptostylis subulata*				1
Leek Orchid	*Prasophyllum* spp.				3
Leopard Orchid	*Diuris pardina*				1
Mallee Spider-orchid	*Caladenia verrucosa*				3
Maroonhood	*Pterostylis pedunculata*				1
Mayfly Orchid	*Acianthus caudatus*				1
Midget Greenhood	*Pterostylis mutica*				3
Musk Hood-orchid	*Caladenia gracilis*				2
Nodding Greenhood	*Pterostylis nutans*				2
Onion Orchid	*Microtis* spp.				1
Parson's Bands	*Eriochilus cucullatus*				1
Pink Fingers	*Caladenia carnea s.s.*				2
Plain Sun-orchid	*Thelymitra nuda*				3
Purple Beard-orchid	*Calochilus robertsonii*				3
Purple Diuris	*Diuris punctata* var. *punctata*		v	L	6
Purple Hyacinth-orchid	*Dipodium punctatum s.s.*				1
Rabbit Ears	*Thelymitra antennifera*				1
Rosy Hyacinth-orchid	*Dipodium roseum s.s.*				1
Rustyhood	*Pterostylis biseta s.l.*				1
Salmon Sun-orchid	*Thelymitra rubra*				1
Scented Leek-orchid	*Prasophyllum odoratum s.l.*				1
Scented Sun-orchid	*Thelymitra megcalyptra*				1
Slender Onion-orchid	*Microtis parviflora*				3
Slender Sun-orchid	*Thelymitra pauciflora s.l.*				3
Small Gnat-orchid	*Cyrtostylis reniformis*				1
Small Snake-orchid	*Diuris pedunculata s.s.*	E	e		1
Spotted Sun-orchid	*Thelymitra ixioides s.l.*				1
Sun Orchid	*Thelymitra* spp.				3
Swan Greenhood	*Pterostylis cycnocephala*				2
Tall Greenhood	*Pterostylis longifolia s.l.*				1
Tiger Orchid	*Diuris sulphurea*				2
Wallflower Orchid	*Diuris orientis*				1
Wax-lip Orchid	*Glossodia major*				4
Wedge Diuris	*Diuris dendrobioides*		e	L	5
Western Leek-orchid	*Prasophyllum* sp. aff. *occidentale* C		e		1
Blunt Pondweed	*Potamogeton ochreatus*				6
Curly Pondweed	*Potamogeton crispus*				5
Fennel Pondweed	*Potamogeton pectinatus*				5
Floating Pondweed	*Potamogeton tricarinatus s.l.*				90
Furrowed Pondweed	*Potamogeton sulcatus*				1
Perfoliate Pondweed	*Potamogeton perfoliatus s.l.*		k		1
Pondweed	*Potamogeton* spp.				2
Broad-leaf Cumbungi	*Typha orientalis*				70
Bulrush	*Typha* spp.				48
Lesser Reed-mace*	*Typha latifolia*				13
Narrow-leaf Cumbungi	*Typha domingensis*				56
Austral Water-mat	*Lepilaena australis*				3
Small-fruit Water-mat	*Lepilaena bilocularis*				1
Water Mat	*Lepilaena* spp.				5
Desert Mat-rush	*Lomandra juncea*				1
Dwarf Mat-rush	*Lomandra nana*				2
Many-flowered Mat-rush	*Lomandra multiflora* subsp. *multiflora*				7
Mat-rush	*Lomandra* spp.				5
Pale Mat-rush	*Lomandra collina*				2
Scented Mat-rush	*Lomandra effusa*				62
Small Grass-tree	*Xanthorrhoea minor* subsp. *lutea*				3
Spiny-headed Mat-rush	*Lomandra longifolia*				4
Wattle Mat-rush	*Lomandra filiformis*				24
Wattle Mat-rush	*Lomandra filiformis* subsp. *coriacea*				1
Wattle Mat-rush	*Lomandra filiformis* subsp. *filiformis*				4
Woolly Mat-rush	*Lomandra leucocephala* subsp. *robusta*				6
Angled Onion*	*Allium triquetrum*				1
Fragrant False-garlic*	*Nothoscordum borbonicum*				1
Chocolate Lily	*Arthropodium strictum s.l.*				30
Chocolate Lily	*Dichopogon* spp.				14
Common Fringe-lily	*Thysanotus tuberosus*				3
Fringe Lily	*Thysanotus* spp.				1
Mallee Fringe-lily	*Thysanotus baueri*				47
Nodding Chocolate-lily	*Arthropodium fimbriatum*				66
Pale Vanilla-lily	*Arthropodium milleflorum s.l.*				3
Small Chocolate-lily	*Arthropodium* sp. 3 (aff. *strictum*)				7
Small Vanilla-lily	*Arthropodium minus*				103
Twining Fringe-lily	*Thysanotus patersonii*				7
Vanilla Lily	*Arthropodium* spp. *(s.s.)*				8
Asparagus Fern*	*Asparagus scandens*				1
Asparagus*	*Asparagus officinalis*				21
Bridal Creeper*	*Asparagus asparagoides*				41
Bulbine Lily	*Bulbine bulbosa*				93
Bulbine Lily	*Bulbine* spp.				1
Leek Lily	*Bulbine semibarbata*				431
Onion Weed*	*Asphodelus fistulosus*				154
Broad-leaf Early Nancy	*Wurmbea latifolia* subsp. *vanessae*				39
Common Early Nancy	*Wurmbea dioica*				97
Common Early Nancy	*Wurmbea dioica* subsp. *dioica*				7
Early Nancy	*Wurmbea* spp.				5
Milkmaids	*Burchardia umbellata*				8
Grape Hyacinth*	*Muscari armeniacum*				1
Arching Flax-lily	*Dianella* sp. aff. *longifolia* (Benambra)		v		1
Black-anther Flax-lily	*Dianella revoluta s.l.*				22
Black-anther Flax-lily	*Dianella revoluta* var. *revoluta s.l.*				17

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Day Lily*	*Hemerocallis* spp.				1
Flax Lily	*Dianella* spp.				3
Glaucous Flax-lily	*Dianella longifolia* var. *grandis s.l.*				1
Mallee Flax-lily	*Dianella* sp. aff. *revoluta* (Mallee)				1
Mallee Rush-lily	*Tricoryne tenella*				2
Nodding Blue-lily	*Stypandra glauca*				1
Pale Flax-lily	*Dianella longifolia s.l.*				43
Pale Flax-lily	*Dianella longifolia* var. *longifolia s.l.*				22
Pale Flax-lily	*Dianella* sp. aff. *longifolia* (Riverina)		v		54
Pale Grass-lily	*Caesia parviflora* var. *vittata*		k		1
Riverine Flax-lily	*Dianella porracea*		v		10
Sand Lily	*Corynotheca licrota*		r		8
Yellow Rush-lily	*Tricoryne elatior*				18
Large-fruit Tassel	*Ruppia megacarpa*				1
Many-fruit Tassel	*Ruppia polycarpa*				4
Tassel	*Ruppia* spp.				3
Dicotyledons					
Box-elder Maple*	*Acer negundo*				1
Maple*	*Acer* spp.				1
Sycamore Maple*	*Acer pseudoplatanus*				6
Angled Ice-plant*	*Mesembryanthemum aitonis*				2
Angled Pigface*	*Carpobrotus aequilaterus*				1
Annual Spinach	*Tetragonia moorei*		k		75
Common Ice-plant*	*Mesembryanthemum crystallinum*				83
Desert Spinach	*Tetragonia eremaea s.l.*				104
Desert Spinach	*Tetragonia eremaea s.s.*		k		31
Galenia*	*Galenia pubescens* var. *pubescens*				8
Hogweed*	*Zaleya galericulata* subsp. *australis*				2
Ice Plant*	*Mesembryanthemum* spp.				8
Inland Pigface	*Carpobrotus modestus*				11
Mallee Pigface	*Carpobrotus* aff. *rossii* (N.W. Victoria)		r		1
Native Spinach	*Tetragonia* spp.				6
Pigface	*Carpobrotus* spp.				1
Rounded Noon-flower	*Disphyma crassifolium* subsp. *clavellatum*				412
Sarcozona	*Sarcozona praecox*		r		151
Small Ice-plant*	*Mesembryanthemum nodiflorum*				341
Wiry Noon-flower*	*Psilocaulon granulicaule*				40
Alligator Weed*	*Alternanthera philoxeroides*				1
Common Joyweed	*Alternanthera nodiflora*		k		29
Crimson Tails	*Ptilotus sessilifolius* var. *sessilifolius*		k		9
Dwarf Amaranth	*Amaranthus macrocarpus* var. *macrocarpus*		v		8
Feather Heads	*Ptilotus macrocephalus*				24
Green Amaranth*	*Amaranthus viridis*				2
Hairy Tails	*Ptilotus erubescens*			L	37
Joyweed	*Alternanthera* spp.				35

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Khaki Weed*	*Alternanthera pungens*				9
Lamb Tails	*Ptilotus exaltatus* var. *semilanatus*				3
Lesser Joyweed	*Alternanthera denticulata s.l.*				291
Lesser Joyweed	*Alternanthera denticulata s.s.*				76
Long Tails	*Ptilotus polystachyus* var. *polystachyus*		e		16
Mulla Mulla	*Ptilotus exaltatus*				69
Pink Mulla-mulla	*Ptilotus exaltatus* var. *exaltatus*				2
Plains Joyweed	*Alternanthera* sp. *1* (Plains)		k		6
Pussy Tails	*Ptilotus spathulatus* f. *spathulatus*				58
Pussy Tails	*Ptilotus* spp.				3
Rabbit Tails	*Ptilotus seminudus*				8
Red-root Amaranth*	*Amaranthus retroflexus*				3
Rough-fruit Amaranth*	*Amaranthus muricatus*				6
Silver Tails	*Ptilotus obovatus* var. *obovatus*		e		1
Spleen Amaranth*	*Amaranthus hybridus*				4
Yellow Tails	*Ptilotus nobilis* var. *nobilis*		e		13
Pepper Tree*	*Schinus molle*				70
Blue Periwinkle*	*Vinca major*				10
Elderberry Panax	*Polyscias sambucifolia*				1
English Ivy*	*Hedera helix*				2
Broad-leaf Cotton-bush*	*Gomphocarpus cancellatus*				1
Doubah	*Marsdenia australis*		v		11
Purple Pentatrope	*Rhyncharrhena linearis*		v		9
Swan Plant*	*Gomphocarpus fruticosus* subsp. *fruticosus*				2
White Bladder-flower*	*Araujia sericifera*				2
Madeira Vine*	*Anredera cordifolia*				1
Austral Forget-me-not	*Myosotis australis*				4
Australian Hound's-tongue	*Cynoglossum australe*				32
Burr Stickseed	*Omphalolappula concava*				28
Common Fiddle-neck*	*Amsinckia intermedia*				6
Common Heliotrope	*Heliotropium europaeum*				90
Corn Gromwell*	*Buglossoides arvensis*				7
Creeping Heliotrope*	*Heliotropium supinum*				26
Fiddle Neck*	*Amsinckia* spp.				5
Forget-me-not	*Myosotis* spp.				1
Hairy Fiddle-neck*	*Amsinckia calycina*				5
Hairy Forget-me-not	*Plagiobothrys elachanthus*				29
Hairy Sheepweed*	*Neatostema apulum*				4
Heliotrope	*Heliotropium* spp.				6
Hound's Tongue	*Cynoglossum* spp.				1
Paterson's Curse*	*Echium plantagineum*				360
Rochelia	*Plagiobothrys* spp.				5
Rough Halgania	*Halgania cyanea*				6
Smooth Heliotrope	*Heliotropium curassavicum*				33
Sweet Hound's-tongue	*Cynoglossum suaveolens*				18

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Valley Popcorn Flower*	*Plagiobothrys canescens*				3
Viper's Bugloss*	*Echium vulgare*				1
White Rochelia	*Plagiobothrys plurisepalus*				9
Yellow-and-blue Forget-me-not*	*Myosotis discolor*				3
Blue Pincushion	*Brunonia australis*				3
Water-shield	*Brasenia schreberi*		v	L	5
Blind Prickly-pear*	*Opuntia puberula*				1
Common Prickly-pear*	*Opuntia stricta*				8
Devil's Rope*	*Cylindropuntia imbricata* var. *imbricata*				1
Drooping Prickly-pear*	*Opuntia monacantha*				2
Indian Fig*	*Opuntia ficus-indica*				3
Prickly Pear*	*Opuntia* spp.				18
Riverina Pear*	*Opuntia cardiosperma*				3
Wheel Cactus*	*Opuntia robusta*				8
Broad-leaf Desert Cassia	*Senna* form taxon *'coriacea'*				45
Desert Cassia	*Senna artemisioides* spp. *agg.*				34
Fine-leaf Desert Cassia	*Senna* form taxon *'filifolia'*				16
Honey Locust*	*Gleditsia triacanthos*				1
Narrow-leaf Desert Cassia	*Senna* form taxon *'zygophylla'*				8
Pepper-leaf Senna*	*Senna barclayana*				1
Woody Cassia	*Senna* form taxon *'petiolaris'*				42
Common Water-starwort*	*Callitriche stagnalis*				22
Matted Water-starwort	*Callitriche sonderi*				42
Thread Water-starwort*	*Callitriche hamulata*				19
Water Starwort	*Callitriche* spp.				5
Western Water-starwort	*Callitriche cyclocarpa*	V	v	L	10
Winged Water-starwort	*Callitriche umbonata*		r	X	1
Annual Bluebell	*Wahlenbergia gracilenta s.l.*				106
Bluebell	*Wahlenbergia* spp.				86
Branching Bluebell	*Wahlenbergia multicaulis*				11
Bronze Bluebell	*Wahlenbergia luteola*				26
Granite Bluebell	*Wahlenbergia graniticola s.l.*				3
Hairy Annual-bluebell	*Wahlenbergia gracilenta s.s.*				34
Hypsela	*Hypsela tridens*		k		5
Large-flowered Annual-bluebell	*Wahlenbergia victoriensis*				1
Mallee Annual-bluebell	*Wahlenbergia tumidifructa*		r		2
Matted Pratia	*Lobelia pedunculata s.l.*				3
Poison Lobelia	*Lobelia pratioides*				35
Poison Pratia	*Lobelia concolor*				251
River Bluebell	*Wahlenbergia fluminalis*				307
Rock Isotome	*Isotoma axillaris*				1
Sprawling Bluebell	*Wahlenbergia gracilis*				42
Swamp Isotome	*Isotoma fluviatilis* subsp. *australis*				22
Tall Bluebell	*Wahlenbergia stricta* subsp. *stricta*				8
Tufted Bluebell	*Wahlenbergia communis s.l.*				60
Tufted Bluebell	*Wahlenbergia communis s.s.*				5
Common Elder*	*Sambucus nigra*				1
Himalayan Honeysuckle*	*Leycesteria formosa*				1
Japanese Honeysuckle*	*Lonicera japonica*				1
Bocconi's Sand-spurrey*	*Spergularia bocconii*				1
Catchfly*	*Silene* spp.				36
Chalkwort*	*Gypsophila tubulosa*				15
Chickweed*	*Stellaria media*				36
Childling Pink*	*Petrorhagia nanteuilii*				2
Coast Sand-spurrey	*Spergularia media s.l.*				15
Common Mouse-ear Chickweed*	*Cerastium glomeratum s.l.*				64
Common Pearlwort*	*Sagina apetala*				9
Corn Spurrey*	*Spergula arvensis*				2
Corn Spurrey*	*Spergula* spp.				1
Cushion Knawel	*Scleranthus minusculus*				109
Erect Chickweed*	*Moenchia erecta*				9
Five-stamen Corn-spurrey*	*Spergula pentandra*				1
Forest Starwort	*Stellaria flaccida*				1
Four-leaved Allseed*	*Polycarpon tetraphyllum*				15
French Catchfly*	*Silene gallica*				63
Greater Sea-spurrey*	*Spergularia media s.s.*				1
Hairy Rupture-wort*	*Herniaria cinerea*				24
Knawel	*Scleranthus* spp.				2
Lesser Chickweed*	*Stellaria pallida*				39
Lesser Sand-spurrey*	*Spergularia diandra*				85
Lesser Sea-spurrey	*Spergularia marina s.s.*				4
Lesser Thyme-leaved Sandwort*	*Arenaria leptoclados*				2
Mallee Catchfly*	*Silene apetala* var. *apetala*				370
Matted Starwort	*Stellaria caespitosa*				50
Mediterranean Catchfly*	*Silene nocturna*				138
Mouse-ear Chickweed*	*Cerastium semidecandrum s.l.*				2
Mouse-ear Chickweed*	*Cerastium* spp.				3
Native Sea-spurrey	*Spergularia* sp. 1				1
Portuguese Catchfly*	*Silene longicaulis*				134
Rayless Starwort	*Stellaria multiflora*				2
Red Sand-spurrey*	*Spergularia rubra s.l.*				257
Red Sand-spurrey*	*Spergularia rubra s.s.*				63
Salt Sand-spurrey	*Spergularia marina s.l.*				1
Salt Sea-spurrey	*Spergularia* sp. 3				35
Sand Spurrey	*Spergularia* spp.				42
Sea Mouse-ear Chickweed*	*Cerastium diffusum*				1

English Name	Scientific Name	EPBC	Vic	FFG	No.
Spreading Knawel	*Scleranthus fasciculatus*		r		1
Starwort	*Stellaria* spp.				4
Sticky Mouse-ear Chickweed*	*Cerastium glomeratum s.s.*				12
Strapwort*	*Corrigiola litoralis*				4
Swamp Starwort	*Stellaria angustifolia*				154
Thread Starwort	*Stellaria filiformis s.l.*				2
Velvety Pink*	*Petrorhagia dubia*				56
Whitlow Wort*	*Paronychia brasiliana*				1
Belah	*Casuarina pauper*				21
Buloke	*Allocasuarina luehmannii*			L	174
Drooping Sheoak	*Allocasuarina verticillata*				8
Sheoak	*Casuarina* spp.				1
Slaty Sheoak	*Allocasuarina muelleriana* subsp. *muelleriana*				3
Swamp Sheoak	*Casuarina obesa*		e	L	10
Common Hornwort	*Ceratophyllum demersum*		k		8
Angular Saltbush	*Atriplex angulata*		e	L	1
Annual Seablite*	*Suaeda maritima* subsp. *maritima*				4
Austral Seablite	*Suaeda australis*				5
Babbagia	*Osteocarpum acropterum* var. *deminutum*				212
Baldoo	*Atriplex lindleyi* subsp. *conduplicata*		r		8
Beaded Glasswort	*Sarcocornia quinqueflora*				5
Beaded Glasswort	*Sarcocornia quinqueflora* subsp. *quinqueflora*				2
Berry Saltbush	*Atriplex semibaccata*				431
Berry Seablite*	*Suaeda baccifera*				61
Black Cotton-bush	*Maireana decalvans*				293
Black Roly-poly	*Sclerolaena muricata*				199
Black Roly-poly	*Sclerolaena muricata* var. *muricata*		k		15
Blackseed Glasswort	*Halosarcia pergranulata*				351
Blackseed Glasswort	*Halosarcia pergranulata* subsp. *pergranulata*				27
Blackseed Glasswort	*Halosarcia pergranulata* subsp. *divaricata*		v		8
Bladder Saltbush	*Atriplex vesicaria*				77
Bladder Saltbush	*Atriplex vesicaria* subsp. *macrocystidia*		k		8
Bladder Saltbush	*Atriplex vesicaria* subsp. *minor*		k		5
Bladder Saltbush	*Atriplex vesicaria* subsp. *variabilis*				1
Bluebush	*Maireana* spp.				46
Bluish Glasswort	*Halosarcia pruinosa*				17
Bonefruit	*Osteocarpum salsuginosum*				51
Bonefruit	*Osteocarpum* spp.				1
Bottle Bluebush	*Maireana excavata*				151
Brown-head Glasswort	*Halosarcia indica*				3
Brown-head Glasswort	*Halosarcia indica* subsp. *leiostachya*				4

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Burning Bush*	*Bassia scoparia* f. *trichophylla*				1
Chariot Wheels	*Maireana cheelii*	V	v		25
Chenopod	*Chenopodiaceae* spp.				6
Clammy Goosefoot	*Chenopodium pumilio*				68
Coast Bonefruit	*Threlkeldia diffusa*				1
Copperburr	*Sclerolaena* spp.				17
Coral Saltbush	*Atriplex papillata*		r		44
Corky Saltbush	*Atriplex lindleyi* subsp. *inflata*				136
Cottony Saltbush	*Chenopodium curvispicatum*				62
Crested Goosefoot	*Chenopodium cristatum*				53
Dark Roly-poly	*Sclerolaena muricata* var. *semiglabra*		k		16
Desert Glasswort	*Pachycornia triandra*		r		76
Dwarf Bluebush	*Maireana humillima*				104
Dwarf Old-man Saltbush	*Atriplex nummularia* subsp. *omissa*		r		3
Einadia	*Einadia* spp.				7
Erect Bluebush	*Maireana pentatropis*				26
Fat Hen*	*Chenopodium album*				44
Flat-top Saltbush	*Atriplex lindleyi*				284
Flat-top Saltbush	*Atriplex lindleyi* subsp. *lindleyi*		k		16
Frosted Goosefoot	*Chenopodium desertorum*				148
Frosted Goosefoot	*Chenopodium desertorum* subsp. *desertorum*		r		28
Frosted Goosefoot	*Chenopodium desertorum* subsp. *virosum*		k		39
Galvanized Burr	*Sclerolaena birchii*		k		1
Glasswort	*Halosarcia* spp.				15
Glasswort	*Sarcocornia* spp.				3
Glaucous Goosefoot	*Chenopodium glaucum*				13
Globular Pigweed	*Dysphania glomulifera spp. glomulifera*				18
Goat Head	*Malacocera tricornis*		r		115
Goosefoot	*Chenopodium* spp.				11
Green Copperburr	*Sclerolaena decurrens*		v		17
Grey Bluebush	*Maireana appressa*				64
Grey Copperburr	*Sclerolaena diacantha*				541
Grey Copperburr	*Sclerolaena diacantha* (erect shrubby form)				1
Grey Glasswort	*Halosarcia halocnemoides* subsp. *halocnemoides*				5
Grey Roly-poly	*Sclerolaena muricata* var. *villosa*				69
Hairy Bluebush	*Maireana pentagona*				404
Hairy-wing Bluebush	*Maireana trichoptera*				4
Hard-head Saltbush	*Dissocarpus paradoxus*				40
Hastate Orache*	*Atriplex prostrata*				94
Heathy Bluebush	*Maireana oppositifolia*		r		5
Hedge Saltbush	*Rhagodia spinescens*				376
Keeled Goosefoot	*Chenopodium carinatum*		v		2
Kidney Saltbush	*Atriplex stipitata*				19

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Lax Goosefoot	*Einadia trigonos* subsp. *trigonos*				5
Leafless Bluebush	*Maireana aphylla*		k		31
Limestone Copperburr	*Sclerolaena obliquicuspis*				91
Mallee Copperburr	*Sclerolaena parviflora*				5
Marsh Saltbush	*Atriplex paludosa* subsp. *paludosa*		r		1
Mat Saltbush	*Atriplex pumilio*				111
Mealy Saltbush	*Atriplex pseudocampanulata*		r		35
Mexican Tea*	*Chenopodium ambrosioides*				9
Native Orache	*Atriplex australasica*				3
Nitre Goosefoot	*Chenopodium nitrariaceum*				223
Nodding Saltbush	*Einadia nutans* subsp. *nutans*				878
Old-man Saltbush	*Atriplex nummularia*				94
Old-man Saltbush	*Atriplex nummularia* subsp. *nummularia*				5
Pearl Bluebush	*Maireana sedifolia*		r		9
Pointed Saltbush	*Atriplex acutibractea*		r		2
Pointed Saltbush	*Atriplex acutibractea* subsp. *karoniensis*		r		4
Pop Saltbush	*Atriplex holocarpa*		v	L	16
Poverty Bush	*Sclerolaena intricata*		v		11
Prickly Saltwort	*Salsola tragus*				186
Prickly Saltwort	*Salsola tragus* subsp. *tragus*				283
Radiant Bluebush	*Maireana radiata*				2
Red-stem Goosefoot*	*Chenopodium macrospermum*				1
Rohrlach's Bluebush	*Maireana rohrlachii*				38
Rosy Bluebush	*Maireana erioclada*				7
Ruby Saltbush	*Enchylaena tomentosa* var. *tomentosa*				1096
Sago Bush	*Maireana pyramidata*				119
Saloop	*Einadia hastata*				32
Salt Copperburr	*Sclerolaena ventricosa*		e	L	2
Saltbush	*Atriplex* spp.				86
Saltbush	*Rhagodia* spp.				5
Satiny Bluebush	*Maireana turbinata*				43
Seablite	*Suaeda* spp.				15
Shining Glasswort	*Halosarcia nitida*		r		2
Short-leaf Bluebush	*Maireana brevifolia*				256
Short-wing Saltbush	*Sclerochlamys brachyptera*				514
Silver Saltbush	*Atriplex rhagodioides*		v	L	15
Slender Glasswort	*Sclerostegia tenuis*				32
Slender-fruit Saltbush	*Atriplex leptocarpa*				530
Slit-wing Bluebush	*Maireana georgei*		v		1
Small Saltbush	*Atriplex eardleyae*				70
Small-leaf Bluebush	*Maireana microphylla*		e		13
Small-leaf Goosefoot	*Chenopodium desertorum* subsp. *microphyllum*				50
Soda Bush	*Neobassia proceriflora*		e		2
Sowbane*	*Chenopodium murale*				37

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Spear Orache*	*Atriplex patula*				3
Spear-fruit Copperburr	*Sclerolaena patenticuspis*		v		7
Spiny Goosefoot	*Rhagodia ulicina*		r		1
Spiny-fruit Saltbush	*Atriplex spinibractea*		e		23
Sprawling Saltbush	*Atriplex suberecta*				79
Spreading Saltbush	*Atriplex limbata*		v	L	12
Star Bluebush	*Stelligera endecaspinis*				221
Starry Goosefoot	*Scleroblitum atriplicinum*				40
Stinking Goosefoot*	*Chenopodium vulvaria*				1
Streaked Copperburr	*Sclerolaena tricuspis*				332
Tangled Copperburr	*Sclerolaena divaricata*		k		36
Three-wing Bluebush	*Maireana triptera*		r		6
Turnip Copperburr	*Sclerolaena napiformis*	E	e	L	17
Twin-flower Saltbush	*Dissocarpus biflorus* var. *biflorus*		r		48
Two-spined Copperburr	*Sclerolaena uniflora*		r		1
Wingless Bluebush	*Maireana enchylaenoides*				227
Woolly Copperburr	*Sclerolaena lanicuspis*		e		2
Woolly-fruit Bluebush	*Eriochiton sclerolaenoides*				20
African Boneseed*	*Chrysanthemoides monilifera* subsp. *monilifera*				1
Alpine Buttons	*Leptorhynchos squamatus* subsp. *alpinus*		r		1
Angianthus	*Angianthus* spp.				1
Annual Buttons	*Leptorhynchos orientalis*		e	L	15
Annual Cudweed	*Euchiton sphaericus*				170
Annual Everlasting	*Chrysocephalum* sp. 2				3
Annual Fireweed	*Senecio glomeratus*				16
Annual New Holland Daisy	*Vittadinia cervicularis*				45
Annual New Holland Daisy	*Vittadinia cervicularis* var. *cervicularis*				15
Annual New Holland Daisy	*Vittadinia cervicularis* var. *subcervicularis*				43
Artichoke Thistle*	*Cynara cardunculus*				14
Aster-weed*	*Aster subulatus*				284
Austral Bear's-ear	*Cymbonotus preissianus*				25
Azure Daisy-bush	*Olearia rudis*				5
Basalt Podolepis	*Podolepis* sp. 1		e		2
Bathurst Burr*	*Xanthium spinosum*				110
Bear's-ear	*Cymbonotus lawsonianus*		r		33
Bear's-ear	*Cymbonotus* spp.				1
Beauty Buttons	*Leptorhynchos tetrachaetus*				19
Billabong Daisy	*Brachyscome* aff. *gracilis* (Kings Billabong)		v	L	8
Billy Buttons	*Craspedia* spp.				17
Billy Buttons	*Pycnosorus* spp.				1
Blanket Leaf	*Bedfordia arborescens*				1
Blue Burr-daisy	*Calotis cuneifolia*		r		32
Blue Sow-thistle*	*Sonchus asper* subsp. *glaucescens*				6
Blunt Everlasting	*Argentipallium obtusifolium*				1

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Branching Groundsel	*Senecio cunninghamii* var. *cunninghamii*		r		45
Bristly Hawksbeard*	*Crepis setosa*				2
Broad-leaf Millotia	*Millotia myosotidifolia*				15
Burr Daisy	*Calotis* spp.				13
Bush Minuria	*Minuria cunninghamii*		r		32
Button Everlasting	*Helichrysum scorpioides*				2
Button Immortelle	*Leptorhynchos waitzia*		v		2
Buttons	*Leptorhynchos* spp.				11
Californian Burr*	*Xanthium orientale*				1
Calomba Daisy*	*Oncosiphon suffruticosum*				1
Canadian Fleabane*	*Conyza canadensis s.l.*				2
Cape Weed*	*Arctotheca calendula*				376
Carpet Burrweed*	*Soliva stolonifera*				5
Cassinia	*Cassinia* spp.				1
Cat's Ear*	*Hypochoeris* spp.				49
Chamomile Sunray	*Rhodanthe anthemoides*				3
Chicory*	*Cichorium intybus*				30
Clammy Sow-thistle*	*Sonchus tenerrimus*				14
Clay Sunray	*Rhodanthe stuartiana*				13
Club-hair New Holland Daisy	*Vittadinia condyloides*		r		24
Club-moss Daisy-bush	*Olearia lepidophylla*				3
Clustered Everlasting	*Chrysocephalum semipapposum*				11
Clustered/Creeping Cudweed	*Euchiton collinus s.l.*				2
Coarse Bottle-daisy	*Lagenophora huegelii*				4
Cockleburr*	*Xanthium* spp.				6
Common Billy-buttons	*Craspedia glauca* spp. agg.				30
Common Bottle-daisy	*Lagenophora stipitata*				1
Common Bow-flower	*Millotia muelleri*				24
Common Cassinia	*Cassinia aculeata*				6
Common Cotula	*Cotula australis*				128
Common Cudweed	*Euchiton involucratus s.l.*				22
Common Everlasting	*Chrysocephalum apiculatum s.l.*				110
Common Everlasting	*Chrysocephalum apiculatum s.s.*				8
Common Sneezeweed	*Centipeda cunninghamii*				372
Common Sow-thistle*	*Sonchus oleraceus*				968
Common Sunflower*	*Helianthus annuus*				3
Common Sunray	*Triptilodiscus pygmaeus*				112
Common White Sunray	*Rhodanthe floribunda*		e		3
Compact Sneezeweed	*Centipeda crateriformis* subsp. *compacta*		r		1
Composite	*Asteraceae* spp.				6
Cotton Fireweed	*Senecio quadridentatus*				214
Cotton Sneezeweed	*Centipeda nidiformis*		r		13
Cotula	*Cotula* spp.				13
Creeping Cotula	*Leptinella reptans s.l.*				1
Creeping Cudweed	*Euchiton collinus s.s.*				27

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Creeping Knapweed*	*Acroptilon repens*				72
Cretan Hedypnois*	*Hedypnois cretica*				64
Crownbeard*	*Verbesina encelioides* subsp. *encelioides*				9
Cudweed	*Euchiton* spp.				6
Cudweed	*Gnaphalium* spp.				6
Cut-leaf Burr-daisy	*Calotis anthemoides*				33
Cut-leaf Daisy	*Brachyscome multifida*				3
Daisy	*Brachyscome* spp.				31
Dandelion	*Taraxacum* spp.				17
Delicate Podolepis	*Podolepis tepperi*				1
Desert Sneezeweed	*Centipeda thespidioides s.l.*		r		16
Desert Sneezeweed	*Centipeda thespidioides s.s.*		r		1
Dissected Fireweed	*Senecio bathurstianus*				1
Dissected New Holland Daisy	*Vittadinia dissecta s.l.*				169
Dissected New Holland Daisy	*Vittadinia dissecta* var. *hirta*				25
Dissected New Holland Daisy	*Vittadinia dissecta s.s.*				2
Dookie Daisy	*Brachyscome gracilis*		v	L	10
Downy Daisy	*Brachyscome debilis s.l.*				1
Drooping Cassinia	*Cassinia arcuata*				105
Drumsticks	*Pycnosorus globosus*				100
Dwarf Beauty-heads	*Blennospora drummondii*				1
Dwarf Cup-flower	*Gnephosis tenuissima*		r		6
Dwarf Daisy	*Brachyscome goniocarpa*				7
Dwarf Jo-jo*	*Soliva anthemifolia*				15
Dwarf Marigold*	*Schkuhria pinnata* var. *abrotanoides*				1
Elatine Sneezeweed	*Centipeda elatinoides*				1
Everlasting	*Helichrysum* spp.				1
False Hawkbit*	*Urospermum picroides*				1
False Sow-thistle*	*Reichardia tingitana*				176
Ferny Cotula*	*Cotula bipinnata*				258
Field Daisy	*Brachyscome decipiens*				1
Field Marigold*	*Calendula arvensis*				1
Fireweed Groundsel	*Senecio linearifolius*				1
Flannel Cudweed	*Actinobole uliginosum*				255
Flatweed*	*Hypochoeris radicata*				253
Flaxleaf Fleabane*	*Conyza bonariensis*				94
Fleabane*	*Conyza* spp.				17
Floodplain Fireweed	*Senecio glandulosus*		r		3
Fringed Daisy-bush	*Olearia ciliata*				1
Furrowed New Holland Daisy	*Vittadinia sulcata*		k		1
Fuzzy New Holland Daisy	*Vittadinia cuneata*				241
Fuzzy New Holland Daisy	*Vittadinia cuneata* var. *morrisii*		r		3
Fuzzy New Holland Daisy	*Vittadinia cuneata* var. *cuneata*				23
Fuzzy New Holland Daisy	*Vittadinia cuneata* var. *hirsuta*		r		3
Garden Dandelion*	*Taraxacum* Sect. *erythrosperma*				3

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Garden Dandelion*	*Taraxacum* Sect. *hamata*				1
Garden Dandelion*	*Taraxacum officinale* spp. agg.				10
Gazania*	*Gazania linearis*				4
Golden Billy-buttons	*Pycnosorus chrysanthes*				27
Golden Everlasting	*Xerochrysum bracteatum*				72
Golden Sunray	*Hyalosperma glutinosum* subsp. *glutinosum*				11
Golden Thistle*	*Scolymus hispanicus*				3
Grass Cushion	*Isoetopsis graminifolia*				248
Grass Daisy	*Brachyscome graminea*				2
Grey Billy-buttons	*Craspedia canens*		e	L	1
Grey Everlasting	*Ozothamnus obcordatus*				4
Grey Podolepis	*Podolepis canescens*		r		3
Grey Wrinklewort	*Rutidosis helichrysoides*		x		1
Groundheads	*Chthonocephalus pseudevax*				18
Groundsel	*Senecio* spp.				12
Hairy Angianthus	*Angianthus tomentosus*				11
Hairy Burr-daisy	*Calotis hispidula*				511
Hairy Hawkbit*	*Leontodon taraxacoides* subsp. *taraxacoides*				128
Hairy Solenogyne	*Solenogyne gunnii*				3
Hard-head Daisy	*Brachyscome lineariloba*				609
Hawksbeard*	*Crepis* spp.				1
Hoary Sunray	*Leucochrysum albicans*				10
Indian Cudweed	*Gnaphalium polycaulon*				43
Indian Weed	*Sigesbeckia orientalis* subsp. *orientalis*				12
Inland Daisy	*Brachyscome trachycarpa*		v		2
Jersey Cudweed	*Pseudognaphalium luteoalbum*				227
Jo Jo*	*Soliva sessilis*				5
Knapweed*	*Centaurea* spp.				1
Large-fruited Millotia	*Millotia macrocarpa*		r		5
Lemon Beauty-heads	*Calocephalus citreus*				91
Lesser Mantle	*Eriochlamys* sp. 1		v		1
Lettuce*	*Lactuca* spp.				9
Lobe-seed Daisy	*Brachyscome dentata*				29
Malta Thistle*	*Centaurea melitensis*				135
Mantisalca*	*Mantisalca salmantica*				1
Mantle	*Eriochlamys* spp.				9
Mayweed Sunray	*Hyalosperma praecox*				28
Milkwort Sunray	*Rhodanthe polygalifolia*		r		3
Milky Beauty-heads	*Calocephalus lacteus*				2
Millotia	*Millotia* spp.				4
Minnie Daisy	*Minuria leptophylla*				45
Moss Sunray	*Hyalosperma demissum*				7
Mountain Burr-daisy	*Calotis pubescens*		x		1
Mueller Daisy	*Brachyscome muelleroides*	V	e	L	6
Mueller Daisy-bush	*Olearia muelleri*				10

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Murray Groundsel	*Senecio murrayanus*		x		1
Musk Sunray	*Rhodanthe moschata*				14
Narrow-leaf New Holland Daisy	*Vittadinia muelleri*				2
Native Picris	*Picris angustifolia*				23
Native Sow-thistle	*Sonchus hydrophilus*				5
New Holland Daisy	*Vittadinia* spp.				279
Noogoora Burr species a ggregate*	*Xanthium strumarium* spp. agg.				59
Noogoora Burr*	*Xanthium occidentale*				1
Nut Heads	*Epaltes* spp.				1
Orange Immortelle	*Waitzia acuminata* var. *acuminata*				3
Orange Sunray	*Hyalosperma semisterile*				33
Ox-tongue*	*Helminthotheca echioides*				297
Pale Beauty-heads	*Calocephalus sonderi*				346
Pale Everlasting	*Helichrysum rutidolepis s.l.*				13
Pale Everlasting	*Helichrysum rutidolepis s.s.*				11
Pale Plover-daisy	*Leiocarpa leptolepis*		e	L	15
Pale Swamp Everlasting	*Helichrysum* aff. *rutidolepis* (Lowland Swamps)		v		41
Panicled Knapweed*	*Centaurea paniculata*				1
Paper Sunray	*Rhodanthe corymbiflora*				245
Picris	*Picris* spp.				3
Pimelea Daisy-bush	*Olearia pimeleoides*				57
Plains Billy-buttons	*Craspedia haplorrhiza*		k		5
Plains Everlasting	*Chrysocephalum* sp. 1				1
Plover Daisy	*Leiocarpa* spp.				16
Poached-eggs Daisy	*Polycalymma stuartii*				316
Podolepis	*Podolepis* spp.				3
Poverty Weed*	*Iva axillaris* subsp. *robustior*				6
Prickly Cudweed	*Stuartina hamata*		r		1
Prickly Lettuce*	*Lactuca serriola*				342
Purple Cudweed*	*Gamochaeta purpurea s.l.*				34
Pygmy Sunray	*Rhodanthe pygmaea*				123
Rasp Daisy-bush	*Olearia picridifolia*		v		1
Rayless Daisy	*Brachyscome perpusilla*				8
Reader's Daisy	*Brachyscome readeri*		r		9
Riverina Groundsel	*Senecio productus* subsp. *productus*		v		1
Rough Burr-daisy	*Calotis scabiosifolia*				79
Rough Burr-daisy	*Calotis scabiosifolia* var. *integrifolia*				1
Rough Burr-daisy	*Calotis scabiosifolia* var. *scabiosifolia*				24
Rough Fireweed	*Senecio hispidulus s.l.*				2
Rough Sow-thistle*	*Sonchus asper s.l.*				271
Rough Sow-thistle*	*Sonchus asper* subsp. *asper*				10
Rough Sow-thistle*	*Sonchus asper s.s.*				1

English Name	Scientific Name	EPBC	Vic	FFG	No.
Saffron Thistle*	*Carthamus lanatus*				136
Salsify*	*Tragopogon porrifolius*				7
Satin Everlasting	*Helichrysum leucopsideum*				14
Scaly Buttons	*Leptorhynchos squamatus*				119
Scaly Buttons	*Leptorhynchos squamatus* subsp. *squamatus*				6
Scorzonera*	*Scorzonera laciniata*				77
Scorzonera*	*Scorzonera laciniata* var. *calcitrapifolia*				11
Scorzonera*	*Scorzonera laciniata* var. *laciniata*				1
Scorzonera*	*Scorzonera* spp.				13
Scotch Thistle*	*Onopordum acanthium* subsp. *acanthium*				24
Shiny Cassinia	*Cassinia longifolia*				6
Shiny Daisy-bush	*Olearia passerinoides*				3
Shiny Everlasting	*Xerochrysum viscosum*				9
Showy Podolepis	*Podolepis jaceoides s.s.*				6
Showy/Basalt Podolepis	*Podolepis jaceoides s.l.*				7
Shrubby Fireweed	*Senecio minimus*				1
Silky Cudweed*	*Gamochaeta calviceps*				9
Skeleton Weed*	*Chondrilla juncea*				203
Slender Fireweed	*Senecio tenuiflorus* spp. agg.				17
Slender Groundsel	*Senecio glossanthus s.l.*				484
Slender Sunray	*Rhodanthe stricta*		e	L	4
Slender Thistle*	*Carduus pycnocephalus*				65
Slender Thistle*	*Carduus* spp.				2
Small Elachanth	*Elachanthus pusillus*		r		4
Small Fleabane*	*Conyza parva*				7
Small Swamp-daisy	*Allittia uliginosa*				1
Smooth Cat's-ear*	*Hypochoeris glabra*				946
Smooth Elachanth	*Elachanthus glaber*		r		6
Smooth Fleabane*	*Conyza bilbaoana*				12
Smooth Hawksbeard*	*Crepis capillaris*				1
Smooth Minuria	*Minuria integerrima*		r		55
Smooth Solenogyne	*Solenogyne dominii*				43
Sneezeweed	*Centipeda* spp.				8
Soft Billy-buttons	*Pycnosorus pleiocephalus*				22
Soft Millotia	*Millotia tenuifolia* var. *tenuifolia*				4
Soft Sunray	*Leucochrysum molle*		v		1
Soldier Thistle*	*Picnomon acarna*				1
Solenogyne	*Solenogyne* spp.				2
Sow Thistle	*Sonchus* spp.				36
Spear Thistle*	*Cirsium vulgare*				474
Spiked Cudweed*	*Gamochaeta purpurea s.s.*				7
Spiked Cudweed*	*Gamochaeta americana*				8
Spiked Daisy-bush	*Olearia subspicata*		v		1
Splendid Daisy-bush	*Olearia magniflora*				1
Spoon Cudweed	*Stuartina muelleri*				30
Spreading Angianthus	*Angianthus brachypappus*		v		6
Spreading Nut-heads	*Sphaeromorphaea australis*				52
Spreading Sneezeweed	*Centipeda minima s.l.*				84
Spreading Sneezeweed	*Centipeda minima* subsp. *minima s.s.*				24
Squat Picris	*Picris squarrosa*		r		18
St Barnaby's Thistle*	*Centaurea solstitialis*				6
Stalked Plover-daisy	*Leiocarpa websteri*				29
Star Cudweed	*Euchiton involucratus s.s.*				38
Star Thistle*	*Centaurea calcitrapa*				12
Stemless Thistle*	*Onopordum acaulon*				34
Sticky Long-heads	*Podotheca angustifolia*				15
Sticky New Holland Daisy	*Vittadinia australasica* var. *australasica*				1
Sticky New Holland Daisy	*Vittadinia australasica* var. *oricola*		k		1
Stiff Cup-flower	*Pogonolepis muelleriana*				209
Stiff Groundsel	*Senecio behrianus*	E	e	L	16
Stinking Hawksbeard*	*Crepis foetida* subsp. *foetida*				6
Stinking Roger*	*Tagetes minuta*				3
Stinkwort*	*Dittrichia graveolens*				163
Stony Fireweed	*Senecio phelleus*				3
Sunray	*Hyalosperma* spp.				17
Swamp Billy-buttons	*Craspedia paludicola*				127
Tall Daisy	*Brachyscome diversifolia*				4
Tall Fireweed	*Senecio runcinifolius*				171
Tall Fleabane*	*Conyza sumatrensis*				101
Tall Nut-heads	*Epaltes cunninghamii*		v		8
Tall Sneezeweed	*Centipeda pleiocephala*		x		1
Tangled Burr-daisy	*Calotis erinacea*				138
Thistle*	*Carthamus* spp.				1
Thistle*	*Cirsium* spp.				1
Tiny Bow-flower	*Millotia perpusilla*				33
Tiny Cudweed	*Gnaphalium indutum*				11
Toothed Groundsel	*Senecio platylepis*		r		5
Trifid Burr-marigold*	*Bidens tripartita*				1
Tripteris*	*Osteospermum clandestinum*				40
Tufted Burr-daisy	*Calotis scapigera*				106
Variable Billy-buttons	*Craspedia variabilis*				6
Variable Daisy	*Brachyscome ciliaris*				143
Variable Daisy	*Brachyscome ciliaris* var. *brachyglottis*				1
Variable Daisy	*Brachyscome ciliaris* var. *ciliaris*				2
Variable Daisy	*Brachyscome ciliaris* var. *lanuginosa*				3
Variable Daisy	*Brachyscome ciliaris* var. *subintegrifolia*				2
Variable Groundsel	*Senecio pinnatifolius*				125
Variegated Thistle*	*Silybum marianum*				91
Water Buttons*	*Cotula coronopifolia*				68

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White Cudweed*	*Vellereophyton dealbatum*				4
Willow-leaf Lettuce*	*Lactuca saligna*				82
Winged New Holland Daisy	*Vittadinia pterochaeta*		v		10
Winged Slender-thistle*	*Carduus tenuiflorus*				63
Wires-and-wool	*Lemooria burkittii*		x		1
Wiry Buttons	*Leptorhynchos tenuifolius*				1
Wiry Podolepis	*Podolepis capillaris*				46
Woodland Swamp-daisy	*Brachyscome basaltica* var. *gracilis*				155
Woolly Buttons	*Leiocarpa panaetioides*				61
Woolly Mantle	*Eriochlamys behrii s.l.*		r		66
Woolly Minuria	*Minuria denticulata*		r		8
Woolly New Holland Daisy	*Vittadinia gracilis*				262
Woolly-heads	*Myriocephalus rhizocephalus*				68
Yam Daisy	*Microseris scapigera* spp. agg.				15
Yam Daisy	*Microseris* sp. 3				9
Yam Daisy	*Microseris* spp.				4
Yellow Burr-daisy	*Calotis lappulacea*		r		1
Yellow Hawkweed*	*Tolpis barbata*				5
Yellow Twin-heads	*Eclipta platyglossa*				159
Yellow-tongue Daisy	*Brachyscome chrysoglossa*		v	L	7
Bindweed	*Convolvulus* spp.				4
Blushing Bindweed	*Convolvulus angustissimus*				1
Blushing Bindweed	*Convolvulus angustissimus* subsp. *angustissimus*				1
Common Bindweed*	*Convolvulus arvensis*				22
Desert Bindweed	*Convolvulus clementii*		v		1
Grass Bindweed	*Convolvulus remotus*				59
Kidney-weed	*Dichondra repens*				77
Large Bindweed	*Calystegia sepium* subsp. *roseata*				3
Pink Bindweed	*Convolvulus erubescens* spp. agg.				243
Rosinweed	*Cressa australis*				182
Round-leaf Wilsonia	*Wilsonia rotundifolia*				4
Silky Wilsonia	*Wilsonia humilis*				2
Wilsonia	*Wilsonia* spp.				1
Wimmera Bindweed	*Convolvulus wimmerensis*				2
Australian Stonecrop	*Crassula tetramera*				7
Crassula	*Crassula* spp.				55
Dense Crassula	*Crassula colorata*				884
Dense Crassula	*Crassula colorata* var. *colorata*				1
Dense Crassula	*Crassula colorata* var. *acuminata*				7
Large-fruit Crassula	*Crassula exserta*				5
Pig's Ear*	*Cotyledon orbiculata*				1
Purple Crassula	*Crassula peduncularis*				27
Sieber Crassula	*Crassula sieberiana s.l.*				613
Spreading Crassula	*Crassula decumbens* var. *decumbens*				156

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Stalked Crassula	*Crassula closiana*				1
Swamp Crassula	*Crassula helmsii*				40
Water Crassula*	*Crassula natans* var. *minus*				7
Annual Bitter-cress	*Cardamine paucijuga s.l.*				86
Annual Bitter-cress	*Cardamine paucijuga s.s.*		v		1
Argentine Cress*	*Lepidium bonariense*				12
Basalt Peppercress	*Lepidium hyssopifolium*	E	e	L	2
Bitter Cress	*Cardamine spp.*				9
Bitter Cress	*Rorippa spp.*				9
Bundled Peppercress	*Lepidium fasciculatum*		k		26
Cabbage*	*Brassica oleracea*				1
Common Bitter-cress*	*Cardamine hirsuta s.s.*				1
Common Peppercress*	*Lepidium africanum*				251
Crucifer	*Brassicaceae* spp.				5
Dwarf Bitter-cress	*Rorippa eustylis*		r		20
Earth Cress	*Geococcus pusillus*				10
Fat Spectacles	*Menkea crassa*		e	L	1
Flax-leaf Alyssum*	*Alyssum linifolium*				16
Giant Mustard*	*Rapistrum rugosum*				11
Hedge Mustard*	*Sisymbrium officinale*				7
Hoary Cress*	*Lepidium draba*				11
Indian Hedge-mustard*	*Sisymbrium orientale*				27
Jagged Bitter-cress	*Rorippa laciniata*				61
Lesser Swine-cress*	*Lepidium didymum*				8
London Rocket*	*Sisymbrium irio*				96
Marsh Yellow-cress*	*Rorippa palustris*				41
May Smocks	*Harmsiodoxa blennodioides*				79
Mediterranean Turnip*	*Brassica tournefortii*				628
Mustard*	*Sisymbrium* spp.				13
Narrow Thread-petal	*Stenopetalum lineare*				18
Native Peppercress	*Lepidium pseudohyssopifolium*		k		41
Oval Purse	*Hymenolobus procumbens*				2
Pea Thread-petal	*Stenopetalum sphaerocarpum*				2
Peppercress	*Lepidium* spp.				76
Purple-vein Rocket*	*Eruca vesicaria* subsp. *sativa*				1
Riverina Bitter-cress	*Cardamine moirensis*		r		10
Sand Cress	*Pachymitus cardaminoides*				18
Sand Rocket*	*Diplotaxis tenuifolia*				1
Shepherd's Purse*	*Capsella bursa-pastoris*				43
Short Cress	*Harmsiodoxa brevipes* var. *brevipes*				44
Shrubby Cress	*Arabidella trisecta*				2
Slender Bitter-cress	*Cardamine tenuifolia*		k		3
Smooth Mustard*	*Sisymbrium erysimoides*				151
Spectacles	*Menkea* spp.				1
Turnip*	*Brassica* spp.				2

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Twiggy Turnip*	*Brassica fruticulosa*				7
Veined Peppercress	*Lepidium phlebopetalum*		e		4
Wall Rocket*	*Diplotaxis muralis*				5
Ward's Weed*	*Carrichtera annua*				18
Warty Peppercress	*Lepidium papillosum*		k		75
Watercress*	*Nasturtium officinale*				1
Western Bitter-cress	*Cardamine lineariloba*		v		3
Wild Radish*	*Raphanus raphanistrum*				8
Winged Peppercress	*Lepidium monoplocoides*	E	e	L	32
Camel Melon*	*Citrullus lanatus*				11
Colocynth*	*Citrullus colocynthis*				1
Mallee Cucumber	*Mukia micrantha*		r		6
Paddy Melon*	*Cucumis myriocarpus* subsp. *leptodermis*				36
Squirting Cucumber*	*Ecballium elaterium*				1
Dodder	*Cuscuta* spp.				4
Field Dodder*	*Cuscuta campestris*				16
Golden Dodder	*Cuscuta tasmanica*				15
Inland Dodder	*Cuscuta victoriana*		x		1
Grey Guinea-flower	*Hibbertia obtusifolia*				5
Hoary Guinea-flower	*Hibbertia crinita*				1
Juniper Guinea-flower	*Hibbertia calycina*				2
Silky Guinea-flower	*Hibbertia sericea s.l.*				2
Spiky Guinea-flower	*Hibbertia exutiacies*				2
Twiggy Guinea-flower	*Hibbertia virgata*				1
Upright Guinea-flower	*Hibbertia stricta s.l.*				1
Flycatcher	*Drosera indica*		v		1
Pale Sundew	*Drosera peltata* subsp. *peltata*				6
Pale Sundew	*Drosera peltata*				4
Scarlet Sundew	*Drosera glanduligera*				6
Scented Sundew	*Drosera whittakeri* subsp. *aberrans*				1
Sundew	*Drosera* spp.				2
Tall Sundew	*Drosera peltata* subsp. *auriculata*				8
Small Water-fire	*Bergia trimera*		v		2
Waterwort	*Elatine gratioloides*				41
Common Beard-heath	*Leucopogon virgatus* var. *brevifolius*		r		1
Cranberry Heath	*Astroloma humifusum*				2
Crimson Berry	*Leptecophylla juniperina* subsp. *oxycedrus*		v		1
Daphne Heath	*Brachyloma daphnoides*				7
Flame Heath	*Astroloma conostephioides*				1
Heart-leaf Beard-heath	*Leucopogon cordifolius*				2
Honey-pots	*Acrotriche serrulata*				3
Ruddy Beard-heath	*Leucopogon rufus*				1
Urn Heath	*Melichrus urceolatus*				5
Coast Bitter-bush	*Adriana quadripartita*		v		1
Dark Turpentine Bush	*Beyeria opaca*				1

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Desert Spurge	*Euphorbia tannensis* subsp. *eremophila*		e	L	1
Eyebane*	*Chamaesyce maculata*				1
Flat Spurge	*Chamaesyce drummondii*				483
Lagoon Spurge	*Phyllanthus lacunarius*		v		10
Mallee Bitter-bush	*Adriana urticoides* var. *hookeri*				8
Petty Spurge*	*Euphorbia peplus*				13
Plains Spurge	*Euphorbia planiticola*		e	L	3
Sandhill Spurge	*Phyllanthus lacunellus*		r		8
Small Poranthera	*Poranthera microphylla s.l.*				4
Spurge	*Euphorbia* spp.				13
Terracina Spurge*	*Euphorbia terracina*				6
English Oak*	*Quercus robur*				2
Bristly Sea-heath	*Frankenia serpyllifolia*		r		22
Hoary Sea-heath	*Frankenia crispa*		r		1
Leafy Sea-heath	*Frankenia foliosa*		r		1
Sea Heath	*Frankenia* spp.				6
Small-leaf Sea-heath	*Frankenia sessilis*		r		1
Bastard's Fumitory*	*Fumaria bastardii*				14
Dense-flower Fumitory*	*Fumaria densiflora*				4
Fumitory*	*Fumaria officinalis* spp. agg.				3
Fumitory*	*Fumaria* spp.				6
Indian Fumitory*	*Fumaria indica*				1
Persian Poppy*	*Hypecoum pendulum*				3
Ramping Fumitory*	*Fumaria capreolata*				6
Small-flower Fumitory*	*Fumaria parviflora* var. *parviflora*				3
Wall Fumitory*	*Fumaria muralis* subsp. *muralis*				6
Centaury*	*Centaurium* spp.				10
Common Centaury*	*Centaurium erythraea*				11
Slender Centaury*	*Centaurium tenuiflorum*				90
Slender Cicendia*	*Cicendia filiformis*				1
Spiked Centaury	*Centaurium spicatum*				28
Square Cicendia*	*Cicendia quadrangularis*				37
Austral Crane's-bill	*Geranium solanderi s.l.*				30
Austral Stork's-bill	*Pelargonium australe*				3
Big Heron's-bill*	*Erodium botrys*				139
Blue Heron's-bill	*Erodium crinitum*				168
Common Heron's-bill*	*Erodium cicutarium*				132
Crane's Bill	*Geranium* spp.				8
Cut-leaf Crane's-bill*	*Geranium dissectum*				3
Dove's Foot*	*Geranium molle* var. *molle*				5
Grassland Crane's-bill	*Geranium retrorsum s.l.*				42
Grassland Crane's-bill	*Geranium retrorsum s.s.*				4
Hairy-pit Heron's-bill*	*Erodium brachycarpum*				5
Heron's Bill	*Erodium* spp.				74
Magenta Stork's-bill	*Pelargonium rodneyanum*				1

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Musky Heron's-bill*	*Erodium moschatum*				30
Naked Crane's-bill	*Geranium* sp. 5				6
Stork's Bill	*Pelargonium* spp.				1
Variable Crane's-bill	*Geranium* sp. 2				12
Bent Goodenia	*Goodenia geniculata*				1
Black's Goodenia	*Goodenia blackiana*				1
Blue Dampiera	*Dampiera stricta*				1
Cut-leaf Goodenia	*Goodenia pinnatifida*				76
Goodenia	*Goodenia* spp.				87
Grassland Velleia	*Velleia arguta*		r		5
Grooved Dampiera	*Dampiera lanceolata* var. *lanceolata*				4
Ivy Goodenia	*Goodenia hederacea*				1
Ivy Goodenia	*Goodenia hederacea* subsp. *hederacea*				1
Lanky Goodenia	*Goodenia elongata*				12
Pale Goodenia	*Goodenia glauca*				178
Prickly Fan-flower	*Scaevola spinescens*				7
Sandhill Goodenia	*Goodenia willisiana*				11
Silky Goodenia	*Goodenia fascicularis*				73
Skeleton Fan-flower	*Scaevola depauperata*		e		3
Slender Goodenia	*Goodenia gracilis*				86
Small-flower Goodenia	*Goodenia pusilliflora*				215
Spreading Goodenia	*Goodenia heteromera*				59
Spur Velleia	*Velleia paradoxa*				19
Sticky Goodenia	*Goodenia varia*				4
Stiff Goodenia	*Goodenia lunata*		v		1
Swamp Goodenia	*Goodenia humilis*				6
Velleia	*Velleia* spp.				2
Velvet Dampiera	*Dampiera marifolia*				1
Bell-fruit Tree	*Codonocarpus cotinifolius*				1
Wheel Fruit	*Gyrostemon australasicus*				2
Amphibious Water-milfoil	*Myriophyllum simulans*				5
Bluish Raspwort	*Haloragis glauca* f. *glauca*		k		56
Clustered Water-milfoil	*Myriophyllum glomeratum*				1
Coarse Water-milfoil	*Myriophyllum caput-medusae*				17
Common Raspwort	*Gonocarpus tetragynus*				21
Creeping Raspwort	*Gonocarpus micranthus* subsp. *micranthus*				1
Golden Pennants	*Glischrocaryon behrii*				2
Hooded Water-milfoil	*Myriophyllum muelleri*				1
Lake Water-milfoil	*Myriophyllum salsugineum*				10
Mat Water-milfoil	*Myriophyllum pedunculatum*				1
Parrot's Feather*	*Myriophyllum aquaticum*				1
Raspwort	*Gonocarpus* spp.				1
Raspwort	*Haloragis* spp.				18
Red Water-milfoil	*Myriophyllum verrucosum*				36
Ridged Water-milfoil	*Myriophyllum porcatum*	V	v	L	2

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Robust Water-milfoil	*Myriophyllum papillosum*				89
Rough Raspwort	*Haloragis aspera*				106
Shade Raspwort	*Gonocarpus humilis*				1
Tall Raspwort	*Gonocarpus elatus*				6
Toothed Raspwort	*Haloragis odontocarpa*				4
Toothed Raspwort	*Haloragis odontocarpa* f. *pterocarpa*				2
Upright Water-milfoil	*Myriophyllum crispatum*				155
Varied Raspwort	*Haloragis heterophylla*				31
Varied Water-milfoil	*Myriophyllum variifolium*				9
Water-milfoil	*Myriophyllum* spp.				56
Small St John's Wort	*Hypericum gramineum*				53
St John's Wort	*Hypericum* spp.				1
St John's Wort*	*Hypericum perforatum* subsp. *veronense*				75
Austral Bugle	*Ajuga australis*				101
Australian Gipsywort	*Lycopus australis*				4
Creeping mint	*Mentha satureoides*				53
Dead Nettle*	*Lamium amplexicaule*				8
Dwarf Skullcap	*Scutellaria humilis*				1
Forest Mint	*Mentha laxiflora*				10
Germander	*Teucrium* spp.				30
Grey Germander	*Teucrium racemosum s.l.*				155
Grey Germander	*Teucrium racemosum s.s.*				25
Horehound*	*Marrubium vulgare*				242
Mint	*Mentha* spp.				3
Pennyroyal*	*Mentha pulegium*				51
River Mint	*Mentha australis*				38
Sage	*Salvia* spp.				1
Scarlet Mint-bush	*Prostanthera aspalathoides*				1
Scurfy Germander	*Teucrium albicaule*		k		6
Self-heal*	*Prunella vulgaris*				3
Slender Mint	*Mentha diemenica*				25
Snowy Mint-bush	*Prostanthera nivea* var. *nivea*		r		1
Stagger Weed*	*Stachys arvensis*				6
Stiff Westringia	*Westringia rigida*				4
Topped Lavender*	*Lavandula stoechas* subsp. *stoechas*				1
Victorian Christmas-bush	*Prostanthera lasianthos*				1
Wild Sage*	*Salvia verbenaca*				153
Wild Sage*	*Salvia verbenaca* var. *vernalis*				4
Coarse Dodder-laurel	*Cassytha melantha*				4
Bladderwort	*Utricularia* spp.				3
Fairies' Aprons	*Utricularia dichotoma s.l.*				1
Single Bladderwort	*Utricularia uniflora*		k		1
Yellow Bladderwort	*Utricularia australis*				10
White Cedar*	*Melia azedarach*				2
Native Flax	*Linum marginale*				54

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Flax-leaf Logania	*Logania linifolia*				1
Box Mistletoe	*Amyema miquelii*				128
Buloke Mistletoe	*Amyema linophylla* subsp. *orientale*		v		25
Creeping Mistletoe	*Muellerina eucalyptoides*				21
Drooping Mistletoe	*Amyema pendula*				13
Fleshy Mistletoe	*Amyema miraculosa* subsp. *boormanii*				15
Grey Mistletoe	*Amyema quandang* var. *quandang*				6
Harlequin Mistletoe	*Lysiana exocarpi*				13
Mistletoe	*Amyema* spp.				9
Wire-leaf Mistletoe	*Amyema preissii*				7
Jerry-jerry	*Ammannia multiflora*		v		7
Purple Loosestrife	*Lythrum salicaria*				21
Small Loosestrife	*Lythrum hyssopifolia*				260
Alkali Sida*	*Malvella leprosa*				22
Australian Hollyhock	*Malva australiana s.l.*				12
Australian Hollyhock	*Malva australiana s.s.*				8
Bladder Ketmia*	*Hibiscus trionum* var. *trionum*				3
Chingma Lantern*	*Abutilon theophrasti*				12
Desert Lantern	*Abutilon otocarpum*		v		17
Dwarf Lantern-flower	*Abutilon fraseri*		e	L	10
Dwarf Mallow*	*Malva neglecta*				1
Hemp Bush	*Gynatrix pulchella s.s.*				1
Low Hibiscus	*Hibiscus brachysiphonius*		e	L	9
Mallow	*Malva* spp.				12
Mallow of Nice*	*Malva nicaeensis*				20
Narrow-leaf Sida	*Sida trichopoda*				99
Paddy's Lucerne*	*Sida rhombifolia*				2
Pin Sida	*Sida fibulifera*		v		30
Pink Pavonia*	*Pavonia hastata*				2
Red-flower Mallow*	*Modiola caroliniana*				45
Sand Sida	*Sida ammophila*		v		34
Sida	*Sida* spp.				25
Small-flower Mallow*	*Malva parviflora*				80
Straggly Lantern-bush	*Abutilon oxycarpum*		e	L	7
Thorny Lawrencia	*Lawrencia squamata*				13
Twiggy Sida	*Sida intricata*		v		43
Variable Sida	*Sida corrugata*				431
Variable Sida (grey-leaf form)	*Sida* aff. *corrugata (grey-leaf Boort form)*		e		1
Running Marsh-flower	*Villarsia reniformis*				1
Wavy Marshwort	*Nymphoides crenata*		v	N	28
Ausfeld's Wattle	*Acacia ausfeldii*		v	X	4
Bent-leaf Wattle	*Acacia flexifolia*		r		1
Black Wattle	*Acacia mearnsii*				3
Blackwood	*Acacia melanoxylon*				10
Box-leaf Wattle	*Acacia buxifolia* subsp. *buxifolia*				1

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Bramble Wattle	*Acacia victoriae*		r		3
Cootamundra Wattle*	*Acacia baileyana*				6
Currawang	*Acacia doratoxylon*		r		2
Deane's Wattle	*Acacia deanei* subsp. *paucijuga*		r		3
Drooping Wattle	*Acacia difformis*				2
Dwarf Myall	*Acacia ancistrophylla* var. *lissophylla*		v		1
Dwarf Nealie	*Acacia wilhelmiana*				9
Early Black-wattle*	*Acacia decurrens*				4
Eumong	*Acacia stenophylla*				153
Flinders Range Wattle*	*Acacia iteaphylla*				2
Gold-dust Wattle	*Acacia acinacea s.l.*				79
Gold-dust Wattle	*Acacia acinacea s.s.*				55
Golden Wattle	*Acacia pycnantha*				27
Golden Wreath Wattle*	*Acacia saligna*				9
Grey Mulga	*Acacia brachybotrya*				19
Hakea Wattle	*Acacia hakeoides*				8
Hall's Wattle	*Acacia halliana*				5
Hard-leaf Wattle	*Acacia sclerophylla* var. *sclerophylla*				4
Harrow Wattle	*Acacia acanthoclada* subsp. *acanthoclada*				1
Hedge Wattle	*Acacia paradoxa*				9
Hickory Wattle	*Acacia penninervis* var. *penninervis*		r		1
Juniper Wattle	*Acacia ulicifolia*				2
Lightwood	*Acacia implexa*				37
Mallee Wattle	*Acacia montana*				14
Manna Wattle	*Acacia microcarpa s.l.*				1
Manna Wattle	*Acacia microcarpa s.s.*				2
Mesquite*	*Prosopis* spp.				2
Nealie	*Acacia loderi*		v		11
Nealie	*Acacia rigens*				15
Ovens Wattle	*Acacia pravissima*				5
Pale Hickory-wattle	*Acacia sporadica*		v		1
Ploughshare Wattle	*Acacia gunnii*				1
Red-stem Wattle	*Acacia rubida*				2
Silver Wattle	*Acacia dealbata*				212
Small Cooba	*Acacia ligulata*				59
Spine Bush	*Acacia nyssophylla*				1
Spiny Wattle	*Acacia spinescens*				2
Spreading Wattle	*Acacia genistifolia*				3
Spur-wing Wattle	*Acacia triptera*		r		10
Sticky Hop Wattle*	*Acacia dodonaeifolia*				1
Streaked Wattle	*Acacia lineata*		r		1
Thin-leaf Wattle	*Acacia aculeatissima*				1
Three-nerve Wattle	*Acacia trineura*		v		1
Umbrella Wattle	*Acacia oswaldii*				102
Varnish Wattle	*Acacia verniciflua*				6

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Velvet Mesquite*	*Prosopis velutina*				4
Wait-a-while	*Acacia colletioides*		r		7
Wallowa	*Acacia euthycarpa*				1
Wallowa	*Acacia euthycarpa* subsp. *euthycarpa*				2
Wattle	*Acacia* spp.				11
Wedderburn Wattle	*Acacia euthycarpa* subsp. *oblanceolata*		v		3
Weeping Myall	*Acacia pendula*		e	L	7
Western Silver Wattle	*Acacia decora*		v		4
Willow Wattle	*Acacia salicina*				37
Yarran	*Acacia melvillei*		v		28
Yarran Wattle	*Acacia omalophylla*		e	L	5
Hairy Carpet-weed	*Glinus lotoides*				20
Indian Chickweed	*Mollugo verticillata*		k		2
Slender Carpet-weed	*Glinus oppositifolius*				9
Fig*	*Ficus carica*				1
Osage Orange*	*Maclura pomifera*				8
Berrigan	*Eremophila longifolia*				54
Bignonia Emu-bush	*Eremophila bignoniiflora*		v	L	9
Common Boobialla#	*Myoporum insulare*				3
Common Emu-bush	*Eremophila glabra*				14
Creeping Myoporum	*Myoporum parvifolium*				10
Emu Bush	*Eremophila* spp.				1
Myoporum	*Myoporum* spp.				2
Narrow-leaf Emu-bush	*Eremophila sturtii*		e	L	2
Spotted Emu-bush	*Eremophila maculata* var. *maculata*		r		10
Spreading Emu-bush	*Eremophila divaricata* subsp. *divaricata*		r		75
Sugarwood	*Myoporum platycarpum*				39
Sugarwood	*Myoporum platycarpum* subsp. *platycarpum*				2
Sugarwood	*Myoporum platycarpum* subsp. *perbellum*				2
Turkey Bush	*Eremophila deserti*				5
Twiggy Emu-bush	*Eremophila polyclada*		v		8
Waterbush	*Myoporum montanum*		r		24
Black Box	*Eucalyptus largiflorens*				714
Black Mallee-box	*Eucalyptus porosa*				1
Black Sallee	*Eucalyptus stellulata*				1
Blakely's Red-gum	*Eucalyptus blakelyi*				11
Brittle Gum	*Eucalyptus mannifera* subsp. *mannifera*				1
Broad-leaf Peppermint	*Eucalyptus dives*				1
Broom Baeckea	*Babingtonia behrii*				1
Broombush	*Melaleuca uncinata*				2
Bull Mallee	*Eucalyptus behriana*				8
Bundy	*Eucalyptus goniocalyx s.l.*				3
Bundy	*Eucalyptus goniocalyx s.s.*				2
Burgan	*Kunzea ericoides* spp. agg.				5

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But But	*Eucalyptus bridgesiana s.l.*				4
Common Fringe-myrtle	*Calytrix tetragona*				12
Creamy Honey-myrtle	*Melaleuca acuminata* subsp. *acuminata*				1
Desert Baeckea	*Baeckea crassifolia*				1
Dumosa Mallee	*Eucalyptus dumosa*				39
Eucalypt	*Eucalyptus* spp.				8
Eucalypt*	*Eucalyptus* spp. (naturalised)				1
Eurabbie	*Eucalyptus globulus* subsp. *bicostata*				1
Green Mallee	*Eucalyptus viridis*				1
Green-leaf Mallee	*Eucalyptus phenax*		r		1
Grey Box	*Eucalyptus microcarpa*				185
Grey Mallee	*Eucalyptus socialis* subsp. *socialis*				33
Gum-barked Coolibah	*Eucalyptus intertexta*		k		1
Heath-myrtle	*Micromyrtus ciliata*				12
Honey-myrtle	*Melaleuca* spp.				6
Lemon Bottlebrush	*Callistemon pallidus*				3
Lemon-scented Gum*	*Corymbia citriodora* subsp. *citriodora*				1
Mallee Tea-tree	*Leptospermum coriaceum*				9
Moonah	*Melaleuca lanceolata* subsp. *lanceolata*				65
Mountain Swamp-gum	*Eucalyptus camphora* subsp. *humeana*				1
Mugga	*Eucalyptus sideroxylon s.s.*		r		1
Nodding Baeckea	*Euryomyrtus ramosissima* subsp. *prostrata*		r		2
Oil Mallee	*Eucalyptus oleosa* subsp. *oleosa*				19
Peppermint Box	*Eucalyptus odorata s.l.*				1
Prickly Bottlebrush	*Callistemon brachyandrus*		r		34
Prickly Paperbark*	*Melaleuca styphelioides* var. *styphelioides*				2
Prickly Tea-tree	*Leptospermum continentale*				1
Quambatook Mallee-box	*Eucalyptus* aff. *porosa* (Quambatook)		e		1
Red Box	*Eucalyptus polyanthemos*				9
Red Box	*Eucalyptus polyanthemos* subsp. *vestita*				13
Red Ironbark	*Eucalyptus tricarpa* subsp. *tricarpa*				2
Red Mallee	*Eucalyptus calycogona*				2
Red Mallee	*Eucalyptus calycogona* subsp. *trachybasis*				3
Red Stringybark	*Eucalyptus macrorhyncha*				6
River Bottlebrush	*Callistemon sieberi*				34
River Red-gum	*Eucalyptus camaldulensis*			N	733
River Tea-tree	*Leptospermum obovatum*				11
Rough-barked Honey-myrtle	*Melaleuca parvistaminea*				9
Salt Paperbark	*Melaleuca halmaturorum* subsp. *halmaturorum*		v	L	2
Scarlet Bottlebrush	*Callistemon rugulosus*				2
Silver Bundy	*Eucalyptus nortonii*				2
Silver Tea-tree	*Leptospermum multicaule*		v		1
Slender-leaf Mallee	*Eucalyptus leptophylla*				6
Sugar Gum*	*Eucalyptus cladocalyx*				14

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Swamp Paperbark	*Melaleuca ericifolia*				1
Totem-poles	*Melaleuca decussata*				1
Violet Kunzea	*Kunzea parvifolia*				1
Waxy Yellow-gum	*Eucalyptus leucoxylon* subsp. *pruinosa*				1
White Box	*Eucalyptus albens*				12
Yellow Box	*Eucalyptus melliodora*				92
Yellow Gum	*Eucalyptus leucoxylon*				12
Yellow Mallee	*Eucalyptus costata* subsp. *murrayana*				22
Yorrell	*Eucalyptus gracilis*				10
Tah-vine	*Boerhavia dominii*				57
Waterlily*	*Nymphaea* spp.				2
Ash*	*Fraxinus* spp.				2
Common Olive*	*Olea europaea* subsp. *europaea*				3
Desert Ash*	*Fraxinus angustifolia*				21
Desert Jasmine	*Jasminum didymum* subsp. *lineare*		v		8
European Privet*	*Ligustrum vulgare*				1
Large-leaf Privet*	*Ligustrum lucidum*				3
Olive*	*Olea europaea*				16
Privet*	*Ligustrum* spp.				1
Clove-strip	*Ludwigia peploides* subsp. *montevidensis*				124
Common Evening-primrose*	*Oenothera stricta* subsp. *stricta*				9
Glandular Willow-herb*	*Epilobium ciliatum*				15
Grey Willow-herb	*Epilobium billardierianum* subsp. *cinereum*				49
Hairy Willow-herb	*Epilobium hirtigerum*				79
Marsh Ludwigia*	*Ludwigia palustris*				24
Robust Willow-herb	*Epilobium billardierianum* subsp. *hydrophilum*				1
Showy Willow-herb	*Epilobium pallidiflorum*				1
Smooth Willow-herb	*Epilobium billardierianum* subsp. *billardierianum*				1
Variable Willow-herb	*Epilobium billardierianum*				54
Variable Willow-herb	*Epilobium billardierianum* subsp. *intermedium*				18
Willow Herb	*Epilobium* spp.				24
Australian Broomrape	*Orobanche cernua* var. *australiana*		v		5
Lesser Broomrape*	*Orobanche minor*				4
Creeping Wood-sorrel*	*Oxalis corniculata s.s.*				2
Grassland Wood-sorrel	*Oxalis perennans*				514
Shady Wood-sorrel	*Oxalis exilis*				22
Soursob*	*Oxalis pes-caprae*				55
Stout-rooted Wood-sorrel	*Oxalis radicosa*				3
Wood Sorrel	*Oxalis* spp.				39
Wood Sorrel*	*Oxalis* spp. (naturalised)				10
Yellow Wood-sorrel	*Oxalis corniculata s.l.*				47
Bristle Poppy*	*Papaver aculeatum*				2

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Long-headed Poppy*	*Papaver dubium*				1
Opium Poppy*	*Papaver somniferum*				3
Rough Poppy*	*Papaver hybridum*				1
Angular Pea*	*Lathyrus angulatus*				5
Annual White Clover*	*Trifolium michelianum* var. *michelianum*				1
Arrowleaf Clover*	*Trifolium vesiculosum* var. *vesiculosum*				2
Austral Indigo	*Indigofera australis*				3
Austral Trefoil	*Lotus australis* var. *australis*		k		8
Barrel Medic*	*Medicago truncatula*				78
Bird's-foot Trefoil*	*Lotus corniculatus*				5
Bird's-foot Trefoil*	*Lotus corniculatus* var. *corniculatus*				2
Birdsfoot Clover*	*Trifolium ornithopodioides*				32
Bitter-pea	*Daviesia* spp.				1
Bokhara Clover*	*Melilotus albus*				6
Broom Bitter-pea	*Daviesia genistifolia s.s.*		r		1
Broughton Pea	*Swainsona procumbens*				105
Burr Medic*	*Medicago polymorpha*				388
Bush-pea	*Pultenaea* spp.				1
Button Medic*	*Medicago orbicularis*				2
Cactus Bossiaea	*Bossiaea walkeri*		e		5
Camel Thorn*	*Alhagi maurorum*				8
Chinese Lespedeza	*Lespedeza juncea* subsp. *sericea*		r		2
Clover*	*Trifolium* spp.				128
Cluster Clover*	*Trifolium glomeratum*				267
Common Eutaxia	*Eutaxia microphylla*				14
Common Eutaxia	*Eutaxia microphylla* var. *microphylla*				12
Common Golden-tip	*Goodia lotifolia* var. *lotifolia*				27
Common Hovea	*Hovea heterophylla*				3
Common Vetch*	*Vicia sativa*				52
Common Vetch*	*Vicia sativa* subsp. *sativa*				4
Common Wedge-pea	*Gompholobium huegelii*				3
Cut-leaf Medic*	*Medicago laciniata* var. *laciniata*				32
Downy Swainson-pea	*Swainsona swainsonioides*		e	L	19
Drooping-flower Clover*	*Trifolium cernuum*				30
Dwarf Swainson-pea	*Swainsona phacoides*		e	L	50
Flat Templetonia	*Templetonia sulcata*				4
Flax-leaf Broom*	*Genista linifolia*				1
Glycine	*Glycine* spp.				3
Gorse Bitter-pea	*Daviesia ulicifolia*				2
Gorse Bitter-pea	*Daviesia ulicifolia* subsp. *ruscifolia*				1
Gorse Bitter-pea	*Daviesia ulicifolia* subsp. *ulicifolia*				3
Gorse*	*Ulex europaeus*				6
Greater Bird's-foot Trefoil*	*Lotus uliginosus*				3
Grey Bush-pea	*Pultenaea spinosa*				9
Grey Parrot-pea	*Dillwynia cinerascens s.l.*				37

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Grey Parrot-pea	*Dillwynia cinerascens s.s.*				7
Grey Scurf-pea	*Cullen discolor*		e	L	2
Hairy Bird's-foot Trefoil*	*Lotus subbiflorus*				6
Hairy Darling-pea	*Swainsona greyana*		e	L	21
Handsome Flat-pea	*Platylobium formosum*				2
Hare's-foot Clover*	*Trifolium arvense* var. *arvense*				193
Hoary Scurf-pea	*Cullen cinereum*		e	L	15
Hop Bitter-pea	*Daviesia latifolia*				6
Hop Clover*	*Trifolium campestre* var. *campestre*				122
Kneed Swainson-pea	*Swainsona reticulata*		v	L	5
Knotted Clover*	*Trifolium striatum*				63
Leafy Templetonia	*Templetonia stenophylla*				3
Liquorice*	*Glycyrrhiza glabra*				1
Little Medic*	*Medicago minima*				664
Locust Tree*	*Robinia pseudoacacia*				1
Lucerne*	*Medicago sativa* subsp. *sativa*				35
Mallee Bitter-pea	*Daviesia arenaria*				3
Matted Bossiaea	*Bossiaea buxifolia*				1
Medic*	*Medicago* spp.				104
Melilot*	*Melilotus* spp.				1
Montpellier Broom*	*Genista monspessulana*				16
Mountain Beauty	*Hovea asperifolia* subsp. *asperifolia*				1
Mountain Mirbelia	*Mirbelia oxylobioides*				2
Mountain Swainson-pea	*Swainsona recta*	E	e	L	8
Narrow-leaf Bitter-pea	*Daviesia leptophylla*				1
Narrow-leaf Clover*	*Trifolium angustifolium* var. *angustifolium*				205
Narrow-leaf Vetch*	*Vicia sativa* subsp. *nigra*				8
Native Scurf-pea	*Cullen australasicum*		e	L	1
Parrot Pea	*Dillwynia* spp.				1
Prickly Parrot-pea	*Dillwynia juniperina*				1
Purple Coral-pea	*Hardenbergia violacea*				7
Red Bird's-foot Trefoil	*Lotus cruentus*				24
Red Clover*	*Trifolium pratense*				2
Red Swainson-pea	*Swainsona plagiotropis*	V	e	L	116
Round Templetonia	*Templetonia egena*		v		9
Rusty Bush-pea	*Pultenaea hispidula*				1
Scurf Pea	*Cullen* spp.				4
Shaftal Clover*	*Trifolium resupinatum*				16
Shaftal Clover*	*Trifolium resupinatum* var. *majus*				1
Showy Parrot-pea	*Dillwynia sericea*				8
Silky Bush-pea	*Pultenaea prostrata*				1
Silky Glycine	*Glycine canescens*		e	L	17
Silky Swainson-pea	*Swainsona sericea*		v	L	64
Slender Bird's-foot Trefoil*	*Lotus angustissimus*				2
Slender Darling-pea	*Swainsona murrayana*	V	e	L	46

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Slender Tick-trefoil	*Desmodium varians*		k		2
Slender Vetch*	*Vicia tetrasperma*				4
Small Scurf-pea	*Cullen parvum*		e	L	42
Small-leaf Bush-pea	*Pultenaea foliolosa*		r		8
Small-leaf Parrot-pea	*Dillwynia phylicoides*				2
Small-leaf Swainson-pea	*Swainsona microphylla*		r		95
Smooth Parrot-pea	*Dillwynia glaberrima*				1
Soft Bush-pea	*Pultenaea mollis*				2
Southern Liquorice	*Glycyrrhiza acanthocarpa*				116
Southern Swainson-pea	*Swainsona behriana*		r		14
Southern Tick-trefoil	*Desmodium gunnii*				1
Spiny Bitter-pea	*Daviesia benthamii* subsp. *humilis*				1
Spotted Medic*	*Medicago arabica*				15
Spreading Eutaxia	*Eutaxia microphylla* var. *diffusa*				12
Spreading Scurf-pea	*Cullen patens*		e	L	7
Spurred Vetch*	*Vicia monantha*				2
Strawberry Clover*	*Trifolium fragiferum* var. *fragiferum*				54
Subterranean Clover*	*Trifolium subterraneum*				121
Suckling Clover*	*Trifolium dubium*				43
Suffocated Clover*	*Trifolium suffocatum*				2
Swainson Pea	*Swainsona* spp.				8
Sweet Fenugreek	*Trigonella suavissima*		r		13
Sweet Melilot*	*Melilotus indicus*				54
Three-flower Vetch*	*Vicia monantha* subsp. *triflora*				2
Tiny Vetch*	*Vicia hirsuta*				37
Tough Scurf-pea	*Cullen tenax*		e	L	28
Tree Lucerne*	*Chamaecytisus palmensis*				3
Trefoil	*Lotus* spp.				2
Trefoil*	*Lotus* spp. (naturalised)				1
Twiggy Bush-pea	*Pultenaea largiflorens*				3
Twining Glycine	*Glycine clandestina*				9
Variable Glycine	*Glycine tabacina s.l.*				12
Variable Glycine	*Glycine tabacina s.s.*				13
Variable Swainson-pea	*Swainsona oroboides s.l.*				31
Vetch*	*Vicia* spp.				2
Violet Swainson-pea	*Swainsona adenophylla*		e	L	1
White Clover*	*Trifolium repens* var. *repens*				67
Woolly Clover*	*Trifolium tomentosum* var. *tomentosum*				103
Woolly Scurf-pea	*Cullen pallidum*		e	L	55
Yellow Pea-bush	*Sesbania cannabina* var. *cannabina*		v		2
Tamarisk*	*Tamarix ramosissima*				5
Tamarisk*	*Tamarix* spp.				2
Red-ink Weed*	*Phytolacca octandra*				3
Blue Finger-flower	*Cheiranthera cyanea* var. *cyanea*				3
Common Apple-berry	*Billardiera scandens s.l.*				1

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Hairy Bursaria	*Bursaria spinosa* subsp. *lasiophylla*				1
Sweet Apple-berry	*Billardiera cymosa s.l.*				2
Sweet Bursaria	*Bursaria spinosa* subsp. *spinosa*				29
Sweet Pittosporum#	*Pittosporum undulatum*				1
Weeping Pittosporum	*Pittosporum angustifolium*				181
Buck's-horn Plantain*	*Plantago coronopus*				33
Buck's-horn Plantain*	*Plantago coronopus* subsp. *coronopus*				2
Clay Plantain	*Plantago cunninghamii*				59
Crowned Plantain	*Plantago turrifera*				211
Dark Plantain	*Plantago drummondii*				100
Greater Plantain*	*Plantago major*				3
Hairy Plantain	*Plantago hispida*				10
Narrow Plantain	*Plantago gaudichaudii*				47
Plantain	*Plantago* spp.				51
Ribwort*	*Plantago lanceolata*				142
Variable Plantain	*Plantago varia*				14
Notch-leaf Sea-lavender*	*Limonium sinuatum*				9
Riviera Sea-lavender*	*Limonium companyonis*				3
Sea Lavender	*Limonium* spp.				2
Winged Sea-lavender*	*Limonium lobatum*				38
Californian Stinkweed*	*Navarretia squarrosa*				1
Broom Milkwort	*Comesperma scoparium*		r		1
Dwarf Milkwort	*Polygala japonica*		v		1
Milkwort	*Polygala* spp.				1
Broad-leaf Dock*	*Rumex obtusifolius* subsp. *obtusifolius*				9
Clustered Dock*	*Rumex conglomeratus*				94
Creeping Knotweed	*Persicaria prostrata*				138
Curled Dock*	*Rumex crispus*				198
Dock	*Rumex* spp.				67
Dock (naturalised)*	*Rumex* spp. (naturalised)				14
Dock*	*Acetosa* spp.				5
Fiddle Dock*	*Rumex pulcher* subsp. *pulcher*				12
Glistening Dock	*Rumex crystallinus s.l.*				38
Glistening Dock	*Rumex crystallinus s.s.*		v		2
Hairy Knotweed	*Persicaria subsessilis*				3
Hogweed	*Polygonum* spp.				8
Hogweed*	*Polygonum aviculare s.s.*				23
Knotweed	*Persicaria* spp.				5
Lignum	*Muehlenbeckia* spp.				5
Mud Dock	*Rumex bidens*				1
Narrow-leaf Dock	*Rumex tenax*				82
Pale Knotweed	*Persicaria lapathifolia*				57
Prostrate Knotweed*	*Polygonum aviculare s.l.*				139
Redshank*	*Persicaria maculosa*				1
Sheep Sorrel*	*Acetosella vulgaris*				41

English Name	Scientific Name	EPBC	Vic	FFG	No.
Slender Dock	*Rumex brownii*				349
Slender Knotweed	*Persicaria decipiens*				81
Small Knotweed	*Polygonum plebeium*				44
Spiny Emex*	*Emex australis*				12
Spiny Lignum	*Muehlenbeckia horrida* subsp. *horrida*		r		148
Spotted Knotweed	*Persicaria praetermissa*				4
Tangled Lignum	*Muehlenbeckia florulenta*				584
Tongue Dock	*Rumex stenoglottis*		k		1
Tree Hogweed*	*Polygonum bellardii*				3
Twiggy Lignum	*Muehlenbeckia diclina*				5
Velvet Knotweed	*Persicaria attenuata*		k		5
Water Pepper	*Persicaria hydropiper*				80
Wireweed*	*Polygonum arenastrum*				7
Wiry Dock	*Rumex dumosus*				27
Common Purslane	*Portulaca oleracea*				9
Miner's Lettuce*	*Claytonia perfoliata*				1
Pigmy Purslane	*Calandrinia granulifera*				22
Pink Purslane	*Calandrinia calyptrata*				5
Purple Purslane*	*Calandrinia menziesii*				1
Purslane	*Calandrinia* spp.				2
Small Purslane	*Calandrinia eremaea*				564
Strap Purslane	*Calandrinia corrigioloides*		r		10
Twining Purslane	*Calandrinia volubilis*		r		28
White Purslane	*Neopaxia australasica*				10
Chaffweed*	*Anagallis minima*				1
Pimpernel*	*Anagallis arvensis*				86
Bushy Needlewood	*Hakea sericea s.l.*				1
Cat's Claw Grevillea	*Grevillea alpina*				4
Comb Grevillea	*Grevillea huegelii*				16
Desert Grevillea	*Grevillea pterosperma*				3
Desert Hakea	*Hakea mitchellii*				2
Grevillea	*Grevillea* spp.				1
Hairy Geebung	*Persoonia rigida*				4
Holly Grevillea	*Grevillea aquifolium*				1
Hooked Needlewood	*Hakea tephrosperma*				82
Kosciuszko Grevillea	*Grevillea victoriae* subsp. *nivalis*		e		4
Rosemary Grevillea	*Grevillea rosmarinifolia*				3
Rusty Grevillea*	*Grevillea floribunda* subsp. *floribunda*				1
Silky Oak*	*Grevillea robusta*				4
Silver Banksia	*Banksia marginata*				2
Silver Needlewood	*Hakea leucoptera* subsp. *leucoptera*				33
Small-fruit Hakea	*Hakea microcarpa*				1
Tree Hakea	*Hakea eriantha*				1
Woolly Grevillea	*Grevillea lanigera*				2
Annual Buttercup	*Ranunculus sessiliflorus*				34

English Name	Scientific Name	EPBC	Vic	FFG	No.
Annual Buttercup	*Ranunculus sessiliflorus* var. *sessiliflorus*				3
Australian Buttercup	*Ranunculus lappaceus*				71
Buttercup	*Ranunculus* spp.				50
Celery Buttercup*	*Ranunculus sceleratus* subsp. *sceleratus*				76
Creeping Buttercup*	*Ranunculus repens*				5
Ferny Small-flower Buttercup	*Ranunculus pumilio*				71
Ferny Small-flower Buttercup	*Ranunculus pumilio* var. *politus*		k		4
Ferny Small-flower Buttercup	*Ranunculus pumilio* var. *pumilio*				50
Inland Buttercup	*Ranunculus pentandrus* var. *platycarpus*				48
Large Annual Buttercup*	*Ranunculus trilobus*				8
Mountain Clematis	*Clematis aristata*				1
Mousetail	*Myosurus minimus* var. *australis*				55
River Buttercup	*Ranunculus inundatus*				88
Sharp Buttercup*	*Ranunculus muricatus*				48
Small River Buttercup	*Ranunculus amphitrichus*				1
Small-flower Buttercup*	*Ranunculus parviflorus*				2
Small-leaved Clematis	*Clematis microphylla*				35
Swamp Buttercup	*Ranunculus undosus*		v		34
Water Fennel*	*Batrachium trichophyllum*				3
Weld*	*Reseda luteola*				10
Bitter Cryptandra	*Cryptandra amara s.s.*				2
Dusty Miller	*Spyridium parvifolium*				1
Hazel Pomaderris	*Pomaderris aspera*				1
Heath Spyridium	*Spyridium eriocephalum* var. *eriocephalum*				3
Inland Pomaderris	*Pomaderris paniculosa* subsp. *paniculosa*		v		6
Narrow-leaf Pomaderris	*Pomaderris angustifolia*				1
Prickly Cryptandra	*Cryptandra tomentosa*				3
Scurfy Pomaderris	*Pomaderris paniculosa*				1
Silky Cryptandra	*Cryptandra propinqua*				1
Trident Spyridium	*Stenanthemum notiale* subsp. *notiale*		x		1
Velvet Spyridium	*Spyridium subochreatum* var. *subochreatum*				1
White Cryptandra	*Stenanthemum leucophractum*				2
Apple*	*Malus pumila*				9
Australian Piert	*Aphanes australiana*				9
Australian Sheep's Burr	*Acaena ovina*				1
Bidgee-widgee	*Acaena novae-zelandiae*				8
Blackberry*	*Rubus cissburiensis*				19
Blackberry*	*Rubus fruticosus* spp. agg.				99
Blackberry*	*Rubus polyanthemus*				1
Blackberry*	*Rubus anglocandicans*				15
Blackberry*	*Rubus erythrops*				1
Blackberry*	*Rubus ulmifolius*				13
Bramble	*Rubus* spp.				148
Cherry Plum*	*Prunus cerasifera*				9

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Dog Rose*	*Rosa canina*				2
Firethorn*	*Pyracantha* spp.				3
Hairy Sheep's Burr	*Acaena agnipila*				2
Hawthorn*	*Crataegus monogyna*				15
Large-leaf Cotoneaster*	*Cotoneaster glaucophyllus* var. *serotinus*				2
Orange Firethorn*	*Pyracantha angustifolia*				2
Parsley Piert*	*Aphanes arvensis*				18
Piert	*Aphanes* spp.				7
Prunus*	*Prunus* spp.				4
Purple-leaf Cherry-plum*	*Prunus cerasifera* 'Nigra'				1
Rose*	*Rosa* spp.				2
Sheep's Burr	*Acaena echinata*				4
Sheep's Burr	*Acaena* spp.				1
Small-leaf Bramble	*Rubus parvifolius*				6
Sweet Briar*	*Rosa rubiginosa*				697
Velvet Cotoneaster*	*Cotoneaster pannosus*				2
Wine Raspberry*	*Rubus phoenicolasius*				1
Bedstraw	*Galium* spp.				2
Cleavers*	*Galium aparine*				40
Common Woodruff	*Asperula conferta*				163
Field Madder*	*Sherardia arvensis*				4
Mountain Woodruff	*Asperula gunnii*				1
Native Madder	*Synaptantha tilleacea* var. *tilleacea*		v		1
Prickly Currant-bush	*Coprosma quadrifida*				1
Prickly Woodruff	*Asperula scoparia*				24
Reflexed Bedstraw	*Galium binifolium*				1
Rough Bedstraw	*Galium gaudichaudii*				7
Slender Bedstraw*	*Galium divaricatum*				4
Small Goosegrass*	*Galium murale*				20
Twiggy Stinkweed	*Opercularia turpis*				1
Twin-leaf Bedstraw	*Asperula gemella*		r		59
Variable Stinkweed	*Opercularia varia*				1
Water Woodruff	*Asperula subsimplex*				9
Wimmera Woodruff	*Asperula wimmerana*		r		1
Woodruff	*Asperula* spp.				24
Common Correa	*Correa reflexa* var. *reflexa*				1
Desert Phebalium	*Phebalium bullatum*				1
Dwarf Boronia	*Boronia nana*				2
Dwarf Boronia	*Boronia nana* var. *hyssopifolia*				1
Dwarf Boronia	*Boronia nana* var. *nana*				1
Fairy Wax-flower	*Philotheca verrucosa*				2
Grampians Correa	*Correa reflexa* var. *angustifolia*		r		1
Rock Correa	*Correa glabra* var. *glabra*				5
Wilga	*Geijera parviflora*		e	L	102
Yellow-wood	*Acronychia oblongifolia*		r	N	2

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Basket Willow*	*Salix X rubens*				36
Black Willow*	*Salix nigra*				4
Crack Willow*	*Salix fragilis*				6
Grey Sallow*	*Salix cinerea*				4
Lombardy Poplar*	*Populus nigra* 'Italica'				1
Poplar*	*Populus* spp.				2
Purple Osier*	*Salix purpurea*				2
Weeping Willow*	*Salix babylonica s.l.*				30
Weeping Willow*	*Salix babylonica s.s.*				21
White Poplar*	*Populus alba*				1
White Willow*	*Salix alba*				4
Willow*	*Salix* spp.				6
Bitter Quandong	*Santalum murrayanum*				1
Broom Ballart	*Exocarpos sparteus*				4
Cherry Ballart	*Exocarpos cupressiformis*				16
Leafless Ballart	*Exocarpos aphyllus*				49
Northern Sandalwood	*Santalum lanceolatum*		e	L	8
Pale-fruit Ballart	*Exocarpos strictus*				166
Sandalwood	*Santalum* spp.				1
Sweet Quandong	*Santalum acuminatum*				6
Cattle Bush	*Alectryon oleifolius* subsp. *canescens*				63
Hop Bush	*Dodonaea* spp.				6
Slender Hop-bush	*Dodonaea viscosa* subsp. *angustissima*				233
Small Hop-bush	*Dodonaea bursariifolia*				1
Sticky Hop-bush	*Dodonaea viscosa*				16
Wedge-leaf Hop-bush	*Dodonaea viscosa* subsp. *cuneata*				11
Austral Brooklime	*Gratiola peruviana*				5
Austral Mudwort	*Limosella australis*				25
Blue Rod	*Morgania glabra* spp. agg.				62
Blue Rod	*Stemodia florulenta*				72
Blue Water-speedwell*	*Veronica anagallis-aquatica*				1
Brooklime	*Gratiola* spp.				1
Creeping Monkey-flower	*Mimulus repens*				9
Dwarf Brooklime	*Gratiola pumilo*		r		3
Glandular Brooklime	*Gratiola pubescens*				15
Great Mullein*	*Verbascum thapsus* subsp. *thapsus*				5
Hairy Toadflax*	*Kickxia elatine*				21
Large Mudwort	*Limosella curdieana*				13
Lesser Snapdragon*	*Misopates orontium*				1
Monkey Flower	*Mimulus* spp.				4
Moth Mullein*	*Verbascum blattaria*				3
Mud Mat	*Glossostigma* spp.				2
Mudwort	*Limosella* spp.				3
Pelisser's Toad-flax*	*Linaria pelisseriana*				2
Persian Speedwell*	*Veronica persica*				3

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Pink Water-speedwell*	*Veronica catenata*				2
Red Bartsia*	*Parentucellia latifolia*				41
Slender Monkey-flower	*Mimulus gracilis*				31
Slender Speedwell	*Veronica gracilis*				7
Small Monkey-flower	*Mimulus prostratus*		r		3
Small Mud-mat	*Glossostigma elatinoides*				25
Smooth Blue-rod	*Stemodia glabella s.s.*		k		1
Speedwell	*Veronica* spp.				10
Speedwell*	*Veronica* spp. (naturalised)				3
Thread Speedwell	*Veronica* sp. 2				1
Toadflax*	*Kickxia* spp.				1
Trailing Speedwell	*Veronica plebeia*				1
Twiggy Mullein*	*Verbascum virgatum*				29
Twining Toadflax*	*Kickxia elatine* subsp. *crinita*				10
Wall Speedwell*	*Veronica arvensis*				1
Wandering Speedwell*	*Veronica peregrina*				78
Woolly Toadflax*	*Kickxia elatine* subsp. *elatine*				1
Tree of Heaven*	*Ailanthus altissima*				8
African Box-thorn*	*Lycium ferocissimum*				354
Australian Box-thorn	*Lycium australe*				16
Black Nightshade*	*Solanum nigrum* sensu *Willis (1972)*				153
Black Nightshade*	*Solanum nigrum s.s.*				17
Box Thorn	*Lycium* spp.				5
Buffalo Burr*	*Solanum rostratum*				1
Chinese Box-thorn*	*Lycium barbarum*				2
Common Thorn-apple*	*Datura stramonium*				10
Cut-leaf Nightshade*	*Solanum triflorum*				1
Glossy Nightshade*	*Solanum americanum*				1
Green Poison-berry*	*Cestrum parqui*				2
Green-berry Nightshade	*Solanum opacum*				4
Hairy Nightshade	*Solanum eremophilum*		k		2
Hairy Thorn-apple*	*Datura wrightii*				1
Kangaroo Apple	*Solanum aviculare*				2
Lagoon Nightshade	*Solanum lacunarium*		v		31
Large Kangaroo Apple	*Solanum laciniatum*				3
Long-spine Thorn-apple*	*Datura ferox*				3
Madeira Winter-cherry*	*Solanum pseudocapsicum*				13
Narrawa Burr	*Solanum cinereum*		k		1
Nightshade	*Solanum* spp.				23
Oondoroo	*Solanum simile*				6
Pampas Lily-of-the-Valley*	*Salpichroa origanifolia*				1
Quena	*Solanum esuriale*				225
Recurved Thorn-apple*	*Datura inoxia*				11
Silver-leaf Nightshade*	*Solanum elaeagnifolium*				40
Small-flower Tobacco	*Nicotiana goodspeedii*		r		2

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Small-leaf Ray-flower	*Cyphanthera myosotidea*				2
Sticky Ground-cherry*	*Physalis viscosa*				23
Thorn Apple*	*Datura* spp.				4
Tobacco	*Nicotiana* spp.				2
Tree Tobacco*	*Nicotiana glauca*				32
Velvet Tobacco	*Nicotiana velutina*				110
Wild Tobacco Tree*	*Solanum mauritianum*				3
Creamy Stackhousia	*Stackhousia monogyna*				26
Plains Stackhousia	*Stackhousia* sp. 1				2
Kurrajong	*Brachychiton populneus* subsp. *populneus*				17
Grass Triggerplant	*Stylidium graminifolium s.l.*				4
Hairy Stylewort	*Levenhookia dubia*				20
Stylewort	*Levenhookia* spp.				1
Annual Rice-flower	*Pimelea trichostachya*				10
Common Rice-flower	*Pimelea humilis*				6
Curved Rice-flower	*Pimelea curviflora s.l.*				8
Curved Rice-flower	*Pimelea curviflora s.s.*				10
Curved Rice-flower	*Pimelea curviflora* var. 1				2
Forked Rice-flower	*Pimelea hewardiana*		r		1
Gaunt Rice-flower	*Pimelea stricta*				3
Mallee Rice-flower	*Pimelea microcephala* subsp. *microcephala*				12
Rice Flower	*Pimelea* spp.				5
Silky Rice-flower	*Pimelea micrantha*				8
Slender Rice-flower	*Pimelea linifolia*				4
Slender Rice-flower	*Pimelea linifolia* subsp. *linifolia*				1
Smooth Rice-flower	*Pimelea glauca*				5
Spiny Rice-flower	*Pimelea spinescens*		e	L	4
Spiny Rice-flower	*Pimelea spinescens* subsp. *spinescens*	C	v		11
Glandular Pink-bells	*Tetratheca labillardierei*				1
Pink-bells	*Tetratheca ciliata*				4
Common Elm*	*Ulmus* aff. *procera*				1
Elm*	*Ulmus* spp.				3
Australian Carrot	*Daucus glochidiatus*				402
Australian Lilaeopsis	*Lilaeopsis polyantha*				5
Bishop's Weed*	*Ammi majus*				2
Blue Devil	*Eryngium ovinum*				115
Carrot*	*Daucus carota*				1
Celery*	*Apium graveolens*				2
Centella	*Centella cordifolia*				33
Centella	*Centella* spp.				1
Dwarf Trachymene	*Trachymene pilosa*				1
Eryngium	*Eryngium* spp.				3
Fennel*	*Foeniculum vulgare*				49
Hemlock*	*Conium maculatum*				3
Long Eryngium	*Eryngium paludosum*		v		32

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Pennywort	*Hydrocotyle* spp.				6
Prickfoot	*Eryngium vesiculosum*				7
Purple Trachymene	*Trachymene cyanopetala*				6
Shining Pennywort	*Hydrocotyle sibthorpioides*				34
Slender Celery*	*Ciclospermum leptophyllum*				1
Slender Pennywort	*Hydrocotyle tripartita*				1
Stinking Pennywort	*Hydrocotyle laxiflora*				8
Trefoil Pennywort	*Hydrocotyle medicaginoides*				1
Water Dropwort*	*Oenanthe pimpinelloides*				1
Yellow Pennywort	*Hydrocotyle foveolata*				2
Scrub Nettle	*Urtica incisa*				1
Shade Pellitory	*Parietaria debilis s.l.*				13
Shade Pellitory	*Parietaria debilis s.s.*				2
Small Nettle*	*Urtica urens*				83
Italian Corn-salad*	*Valerianella eriocarpa*				1
Common Verbena	*Verbena officinalis s.l.*				44
Common Verbena*	*Verbena officinalis s.s.*				8
Fog-fruit*	*Phyla canescens*				178
Purple-top Verbena*	*Verbena bonariensis s.l.*				19
Purple-top Verbena*	*Verbena bonariensis* var. *bonariensis s.s.*				3
Trailing Verbena*	*Verbena supina*				21
Verbena	*Verbena* spp.				9
Floodplain Violet	*Viola betonicifolia* subsp. *novaguineensis*		r		1
Showy Violet	*Viola betonicifolia*				18
Shrub Violet	*Hybanthus floribundus* subsp. *floribundus*				1
Tree Violet	*Melicytus dentatus s.l.*				6
Caltrop	*Tribulus* spp.				1
Caltrop	*Tribulus terrestris*				32
Climbing Twin-leaf	*Zygophyllum eremaeum*				14
Coast Twin-leaf	*Zygophyllum billardierei*		r		1
Dwarf Twin-leaf	*Zygophyllum ovatum*				5
Nitre-bush	*Nitraria billardierei*				126
Notched Twin-leaf	*Zygophyllum crenatum*				13
Pale Twin-leaf	*Zygophyllum glaucum*				31
Pointed Twin-leaf	*Zygophyllum apiculatum*				55
Rabbit-ears Twin-leaf	*Zygophyllum compressum*		v		1
Sand Twin-leaf	*Zygophyllum ammophilum*				122
Scrambling Twin-leaf	*Zygophyllum angustifolium*		r		3
Shrubby Twin-leaf *aurantiacum*	*Zygophyllum aurantiacum* subsp.			11	
Twin-leaf	*Zygophyllum* spp.				5
Violet Twin-leaf	*Zygophyllum iodocarpum*				11
White Twin-leaf	*Zygophyllum simile*		r		7
Mosses					
Apple Moss	*Philonotis scabrifolia*				1

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Common Apple-moss	*Bartramia ithyphylla*				2
Common Breutelia	*Breutelia affinis*				2
Feather Moss	*Rhynchostegium tenuifolium*				1
Acorn-fruited Thread-moss	*Bryum pachytheca* var. *pachytheca*				9
Broody Bryum	*Bryum dichotomum*				1
Desert Thread-moss	*Bryum eremaeum*				1
Sand Thread-moss	*Rosulabryum campylothecium*				5
Silver Moss	*Bryum argenteum*				7
Earth Moss	*Bryobartramia novae-valesiae*				1
Earth Moss	*Pleuridium nervosum*				3
Earth Moss	*Ephemerum cristatum*				3
Curly Pocket-moss	*Fissidens megalotis*				10
Fountain Pocket-moss	*Fissidens berteroi*				1
Portuguese Pocket-moss	*Fissidens curvatus*				1
Common Cord-moss	*Funaria hygrometrica*				3
Cord Moss	*Entosthodon subnudus* var. *gracilis*				2
Cord Moss	*Entosthodon apophysatus*				3
Cord Moss	*Funaria microstoma*				1
Earth Moss	*Physcomitrella patens* subsp. *readeri*				2
Pineapple Moss	*Gigaspermum repens*				8
Blunt-beak Grimmia	*Grimmia pulvinata* var. *africana*				4
Salt and Pepper	*Grimmia laevigata*				2
Green Hoar-moss	*Hedwigidium integrifolium*				1
Festoon Moss	*Papillaria crocea*				1
Feathered Neckera	*Neckera pennata*				1
Common Bristle-moss	*Orthotrichum tasmanicum* var. *tasmanicum*				1
Common Zygodon	*Zygodon intermedius*				1
Juniper Haircap	*Polytrichum juniperinum*				1
Aloe Moss	*Aloina sullivaniana*				3
Ball Moss	*Phascum robustum* var. *crassinervium*				1
Ball Moss	*Phascum robustum* var. *robustum*				1
Beard Moss	*Barbula crinita*				7
Beard Moss	*Didymodon torquatus*				10
Common Beard-moss	*Barbula calycina*				4
Common Twine-moss	*Triquetrella papillata*				8
Common Wall-moss	*Tortula muralis*				1
Crisp Moss	*Trichostomopsis australasiae*				1
Earth Moss	*Pterygoneurum ovatum*				2
Green-tufted Stubble-moss	*Weissia controversa*				5
Gypsum Moss	*Crossidium geheebii*				1
Pottia	*Pottia drummondii*				1
Pottia	*Pottia starckeana*				1
Pottia	*Pottia truncata*				2
Pottia	*Tetrapterum cylindricum*				2
Pygmy Moss	*Acaulon chrysacanthum*				5
Pygmy Moss	*Acaulon granulosum*				1
Pygmy Moss	*Acaulon leucochaete*				3
Screw Moss	*Tortula papillosa*				6
Screw Moss	*Tortula antarctica*				7
Triangular Pygmy-moss	*Acaulon triquetrum*				7
Twine Moss	*Triquetrella* spp.				1
Bronze Signal-moss	*Sematophyllum homomallum*				2
Dung Moss	*Tayloria octoblepharum*				1
Golden Weft-moss	*Thuidiopsis furfurosa*				1
Weft Moss	*Thuidiopsis* spp.				1
Dwarf Swan-neck Moss	*Campylopus pyriformis*				2
Heath Star Moss	*Campylopus introflexus*				9
Liverworts					
Forked Veilwort	*Metzgeria furcata*				1
Chalk Crystalwort	*Riccia albida*				1
Crystalwort	*Riccia* spp.				1
Fringed Heartwort	*Ricciocarpos natans*				5
Algae					
Stonewort	*Characeae* spp.				2

The table below lists flora species mentioned in the text, but not in the main list of species recorded in the study area

English Name	Scientific Name
Hairpin Banksia	*Banksia ericifolia*
Alpine Ash	*Eucalyptus delegatensis*
Shining Gum	*Eucalyptus nitens*
Blue Gum	*Eucalyptus globulus*
Flooded Gum	*Eucalyptus grandis*
Mountain Ash	*Eucalyptus regnans*
Messmate	*Eucalyptus obliqua*

APPENDIX 5: Fauna Species Recorded in the River Red Gum Forests Study Area

As of September 2006, the Department of Sustainability and Environment (DSE) Atlas of Victorian Wildlife and Aquatic Fauna databases contained records for the following taxa in River Red Gum Forests study area. These two databases provide coverage of vertebrate fauna and threatened invertebrate fauna but are still improving their coverage of other invertebrates. Chapter 5 describes key points relating to species diversity and threatened species.

LEGEND:

EPBC: status under Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, as at December 2004.

EN Endangered: A taxon is endangered when it is not critically endangered but is facing a very high risk of extinction in the wild in the near future.

VU Vulnerable: A taxon is vulnerable when it is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future.

Vic: conservation status in Victoria, after DSE (2003a).

EX Extinct: when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. Records of several extinct species that were formerly found in the study area are not in the DSE databases—they are listed in a separate table following the main table.

RX Regionally Extinct: As for Extinct but within a defined region that does not encompass the entire geographic range of the taxon—in this case Victoria. A taxon is presumed Regionally Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout the region have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. Records of several regionally extinct species that were formerly found in the study area are not in the DSE databases—they are listed in a separate table following the main table.

CR Critically Endangered: A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Species Survival Commission 2001), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

EN Endangered in Victoria: when the best available evidence indicates that the taxon meets any of the criteria A to E for Endangered (see Species Survival Commission 2001), and it is therefore considered to be facing a very high risk of extinction in the wild.

VU Vulnerable in Victoria: when the best available evidence indicates that the taxon meets any of the criteria A to E for Vulnerable (see Species Survival Commission 2001), and it is therefore considered to be facing a high risk of extinction in the wild.

NT Near Threatened: A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered, Vulnerable now, but is close to qualifying for, or is likely to qualify for a threatened category in the near future.

DD Data Deficient: A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate.

FFG: status under the Victorian *Flora and Fauna Guarantee Act 1988*, as at December 2004. For the most up-to-date listings under the Act, visit: http://www.dse.vic.gov.au

L – listed as threatened.

"Threatened and near-threatened species" refers to any taxon in this table with an "L" under FFG, or any category under "EPBC" or "Vic" (except Data Deficient species).

No.: The number of records of the taxon in the Atlas of Victorian Wildlife and the Aquatic Fauna databases as at September 2006.

* denotes species exotic to Victoria
^ denotes species listed under the JAMBA agreement
# denotes spedies listed under the CAMBA agreement

(see chapter 5 for details of these agreements)

English Name	Scientific Name	EPBC	Vic	FFG	No.
Birds					
Emu	*Dromaius novaehollandiae*				90
Malleefowl	*Leipoa ocellata*	VU	EN	L	13
Stubble Quail	*Coturnix pectoralis*				121
Brown Quail	*Coturnix ypsilophora*		NT		42
King Quail	*Coturnix chinensis*		CR	L	1
Magpie Goose	*Anseranas semipalmata*		VU		8
Plumed Whistling-Duck	*Dendrocygna eytoni*				64
Blue-billed Duck	*Oxyura australis*		EN	L	274
Musk Duck	*Biziura lobata*		VU		644
Freckled Duck	*Stictonetta naevosa*		EN	L	219
Black Swan	*Cygnus atratus*				2014
Cape Barren Goose	*Cereopsis novaehollandiae*		NT		1
Australian Shelduck	*Tadorna tadornoides*				1921
Australian Wood Duck	*Chenonetta jubata*				1526
Cotton Pygmy-goose	*Nettapus coromandelianus*				3
Mallard*	*Anas platyrhynchos*				14
Pacific Black Duck	*Anas superciliosa*				2931
Australasian Shoveler	*Anas rhynchotis*		VU		698
Grey Teal	*Anas gracilis*				2575
Chestnut Teal	*Anas castanea*				486
Garganey^#	*Anas querquedula*				2
Pink-eared Duck	*Malacorhynchus membranaceus*				551
Hardhead	*Aythya australis*		VU		668
Australasian Grebe	*Tachybaptus novaehollandiae*				869
Hoary-headed Grebe	*Poliocephalus poliocephalus*				795
Great Crested Grebe	*Podiceps cristatus*				271
Wilson's Storm-Petrel^	*Oceanites oceanicus*				1
Darter	*Anhinga melanogaster*				569
Little Pied Cormorant	*Phalacrocorax melanoleucos*				1342
Pied Cormorant	*Phalacrocorax varius*		NT		194
Little Black Cormorant	*Phalacrocorax sulcirostris*				773
Great Cormorant	*Phalacrocorax carbo*				818
Australian Pelican	*Pelecanus conspicillatus*				1149
White-faced Heron	*Egretta novaehollandiae*				1846
Little Egret	*Egretta garzetta*		EN	L	68
White-necked Heron	*Ardea pacifica*				617
Great Egret^#	*Ardea alba*		VU	L	771
Intermediate Egret	*Ardea intermedia*		CR	L	165
Cattle Egret^#	*Ardea ibis*				50
Nankeen Night Heron	*Nycticorax caledonicus*		NT		249
Little Bittern	*Ixobrychus minutus*		EN	L	13
Australasian Bittern	*Botaurus poiciloptilus*		EN	L	23
Glossy Ibis#	*Plegadis falcinellus*		NT		63
Australian White Ibis	*Threskiornis molucca*				1587
Straw-necked Ibis	*Threskiornis spinicollis*				1235
Royal Spoonbill	*Platalea regia*		VU		400
Yellow-billed Spoonbill	*Platalea flavipes*				913

English Name	Scientific Name	EPBC	Vic	FFG	No.
Osprey	*Pandion haliaetus*				1
Black-shouldered Kite	*Elanus axillaris*				198
Letter-winged Kite	*Elanus scriptus*				1
Square-tailed Kite	*Lophoictinia isura*		VU	L	11
Black-breasted Buzzard	*Hamirostra melanosternon*				6
Black Kite	*Milvus migrans*				447
Whistling Kite	*Haliastur sphenurus*				874
White-bellied Sea-Eagle#	*Haliaeetus leucogaster*		VU	L	170
Spotted Harrier	*Circus assimilis*		NT		42
Swamp Harrier	*Circus approximans*				401
Brown Goshawk	*Accipiter fasciatus*				209
Grey Goshawk	*Accipiter novaehollandiae*		VU		8
Collared Sparrowhawk	*Accipiter cirrhocephalus*				90
Wedge-tailed Eagle	*Aquila audax*				339
Little Eagle	*Hieraaetus morphnoides*				281
Brown Falcon	*Falco berigora*				572
Australian Hobby	*Falco longipennis*				161
Grey Falcon	*Falco hypoleucos*		EN	L	12
Black Falcon	*Falco subniger*		VU		41
Peregrine Falcon	*Falco peregrinus*				150
Nankeen Kestrel	*Falco cenchroides*				517
Brolga	*Grus rubicunda*		VU	L	130
Buff-banded Rail	*Gallirallus philippensis*				25
Lewin's Rail	*Rallus pectoralis*		VU	L	2
Baillon's Crake	*Porzana pusilla*		VU	L	18
Australian Spotted Crake	*Porzana fluminea*				73
Spotless Crake	*Porzana tabuensis*				21
Purple Swamphen	*Porphyrio porphyrio*				771
Dusky Moorhen	*Gallinula tenebrosa*				752
Black-tailed Native-hen	*Gallinula ventralis*				316
Eurasian Coot	*Fulica atra*				1251
Australian Bustard	*Ardeotis australis*		CR	L	6
Little Button-quail	*Turnix velox*		NT		30
Red-chested Button-quail	*Turnix pyrrhothorax*		VU	L	11
Painted Button-quail	*Turnix varia*				70
Plains-wanderer	*Pedionomus torquatus*	VU	CR	L	63
Latham's Snipe^#	*Gallinago hardwickii*		NT		58
Black-tailed Godwit^#	*Limosa limosa*		VU		17
Bar-tailed Godwit^#	*Limosa lapponica*				5
Eastern Curlew^#	*Numenius madagascariensis*		NT		3
Marsh Sandpiper^#	*Tringa stagnatilis*				125
Common Greenshank^#	*Tringa nebularia*				165
Wood Sandpiper^#	*Tringa glareola*		VU		22
Common Sandpiper^#	*Actitis hypoleucos*		VU		6
Ruddy Turnstone^#	*Arenaria interpres*				13
Great Knot^#	*Calidris tenuirostris*		EN	L	8
Red Knot^#	*Calidris canutus*		NT		5
Sanderling^#	*Calidris alba*		NT		1

English Name	Scientific Name	EPBC	Vic	FFG	No.
Red-necked Stint^#	*Calidris ruficollis*				135
Long-toed Stint^#	*Calidris subminuta*				3
Pectoral Sandpiper^	*Calidris melanotos*		NT		5
Sharp-tailed Sandpiper^#	*Calidris acuminata*				189
Curlew Sandpiper^#	*Calidris ferruginea*				67
Ruff^#	*Philomachus pugnax*				3
Red-necked Phalarope^#	*Phalaropus lobatus*				2
Painted Snipe#	*Rostratula benghalensis*	VU	CR	L	5
Bush Stone-curlew	*Burhinus grallarius*		EN	L	124
Black-winged Stilt	*Himantopus himantopus*				566
Banded Stilt	*Cladorhynchus leucocephalus*				133
Red-necked Avocet	*Recurvirostra novaehollandiae*				257
Pacific Golden Plover^#	*Pluvialis fulva*		NT		8
Red-capped Plover	*Charadrius ruficapillus*				302
Double-banded Plover	*Charadrius bicinctus*				24
Greater Sand Plover^#	*Charadrius leschenaultii*		VU		1
Oriental Plover^	*Charadrius veredus*				2
Black-fronted Dotterel	*Elseyornis melanops*				557
Red-kneed Dotterel	*Erythrogonys cinctus*				283
Banded Lapwing	*Vanellus tricolor*				82
Masked Lapwing	*Vanellus miles*				1617
Oriental Pratincole^#	*Glareola maldivarum*				1
Australian Pratincole	*Stiltia isabella*		NT		11
Silver Gull	*Larus novaehollandiae*				778
Gull-billed Tern	*Sterna nilotica*		EN	L	23
Caspian Tern^#	*Sterna caspia*		NT	L	172
Whiskered Tern	*Chlidonias hybridus*		NT		208
White-winged Black Tern^#	*Chlidonias leucopterus*		NT		8
Rock Dove*	*Columba livia*				100
Spotted Turtle-Dove*	*Streptopelia chinensis*				26
Brown Cuckoo-Dove	*Macropygia amboinensis*				2
Common Bronzewing	*Phaps chalcoptera*				518
Crested Pigeon	*Ocyphaps lophotes*				1641
Diamond Dove	*Geopelia cuneata*		NT	L	20
Peaceful Dove	*Geopelia striata*				768
Bar-shouldered Dove	*Geopelia humeralis*				1
Glossy Black-Cockatoo	*Calyptorhynchus lathami*		VU	L	1
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*				5
Gang-gang Cockatoo	*Callocephalon fimbriatum*				74
Galah	*Cacatua roseicapilla*				3503
Long-billed Corella	*Cacatua tenuirostris*				324
Little Corella	*Cacatua sanguinea*				305
Major Mitchell's Cockatoo	*Cacatua leadbeateri*		VU	L	55
Sulphur-crested Cockatoo	*Cacatua galerita*				1952
Cockatiel	*Nymphicus hollandicus*				275
Rainbow Lorikeet	*Trichoglossus haematodus*				14
Musk Lorikeet	*Glossopsitta concinna*				129
Little Lorikeet	*Glossopsitta pusilla*				85

English Name	Scientific Name	EPBC	Vic	FFG	No.
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*				19
Australian King-Parrot	*Alisterus scapularis*				112
Superb Parrot	*Polytelis swainsonii*	VU	EN	L	269
Regent Parrot	*Polytelis anthopeplus*	VU	VU	L	274
Crimson Rosella	*Platycercus elegans*				1587
Yellow Rosella	*Platycercus elegans flaveolus*				3
Eastern Rosella	*Platycercus eximius*				1368
Australian Ringneck	*Barnardius zonarius*				289
Blue Bonnet	*Northiella haematogaster*				113
Swift Parrot	*Lathamus discolor*	EN	EN	L	51
Red-rumped Parrot	*Psephotus haematonotus*				2182
Mulga Parrot	*Psephotus varius*				121
Budgerigar	*Melopsittacus undulatus*				91
Blue-winged Parrot	*Neophema chrysostoma*				29
Elegant Parrot	*Neophema elegans*		VU		2
Turquoise Parrot	*Neophema pulchella*		NT	L	42
Pallid Cuckoo	*Cuculus pallidus*				249
Brush Cuckoo	*Cacomantis variolosus*				3
Fan-tailed Cuckoo	*Cacomantis flabelliformis*				115
Black-eared Cuckoo	*Chrysococcyx osculans*		NT		27
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*				367
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*				74
Common Koel	*Eudynamys scolopacea*				3
Powerful Owl	*Ninox strenua*		VU	L	21
Barking Owl	*Ninox connivens*		EN	L	51
Southern Boobook	*Ninox novaeseelandiae*				328
Masked Owl	*Tyto novaehollandiae*		EN	L	3
Barn Owl	*Tyto alba*				78
Tawny Frogmouth	*Podargus strigoides*				155
White-throated Nightjar	*Eurostopodus mystacalis*				2
Spotted Nightjar	*Eurostopodus argus*				7
Australian Owlet-nightjar	*Aegotheles cristatus*				106
White-throated Needletail^#	*Hirundapus caudacutus*				34
Fork-tailed Swift^#	*Apus pacificus*				32
Azure Kingfisher	*Alcedo azurea*		NT		101
Laughing Kookaburra	*Dacelo novaeguineae*				1896
Red-backed Kingfisher	*Todiramphus pyrrhopygia*		NT		22
Sacred Kingfisher	*Todiramphus sanctus*				940
Rainbow Bee-eater	*Merops ornatus*				647
Dollarbird	*Eurystomus orientalis*				135
Superb Lyrebird	*Menura novaehollandiae*				5
White-throated Treecreeper	*Cormobates leucophaeus*				1140
White-browed Treecreeper	*Climacteris affinis*		VU	L	7
Red-browed Treecreeper	*Climacteris erythrops*				4
Brown Treecreeper	*Climacteris picumnus*		NT		2268
Superb Fairy-wren	*Malurus cyaneus*				2481
Splendid Fairy-wren	*Malurus splendens*				164
Variegated Fairy-wren	*Malurus lamberti*				188

English Name	Scientific Name	EPBC	Vic	FFG	No.
White-winged Fairy-wren	*Malurus leucopterus*				230
Mallee Emu-wren	*Stipiturus mallee*	VU	VU	L	3
Striated Grasswren	*Amytornis striatus*		NT		1
Spotted Pardalote	*Pardalotus punctatus*				638
Striated Pardalote	*Pardalotus striatus*				2684
White-browed Scrubwren	*Sericornis frontalis*				238
Shy Heathwren	*Hylacola cauta*				38
Rufous Fieldwren	*Calamanthus campestris*		NT		2
Redthroat	*Pyrrholaemus brunneus*		EN	L	2
Speckled Warbler	*Chthonicola sagittata*		VU	L	32
Weebill	*Smicrornis brevirostris*				1347
Western Gerygone	*Gerygone fusca*				385
White-throated Gerygone	*Gerygone olivacea*				39
Brown Thornbill	*Acanthiza pusilla*				195
Inland Thornbill	*Acanthiza apicalis*				44
Chestnut-rumped Thornbill	*Acanthiza uropygialis*				402
Buff-rumped Thornbill	*Acanthiza reguloides*				412
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*				1371
Yellow Thornbill	*Acanthiza nana*				807
Striated Thornbill	*Acanthiza lineata*				249
Southern Whiteface	*Aphelocephala leucopsis*				341
Red Wattlebird	*Anthochaera carunculata*				684
Little Wattlebird	*Anthochaera chrysoptera*				9
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*				444
Striped Honeyeater	*Plectorhyncha lanceolata*				120
Noisy Friarbird	*Philemon corniculatus*				580
Little Friarbird	*Philemon citreogularis*				909
Regent Honeyeater	*Xanthomyza phrygia*	EN	CR	L	47
Blue-faced Honeyeater	*Entomyzon cyanotis*				243
Bell Miner	*Manorina melanophrys*				2
Noisy Miner	*Manorina melanocephala*				1542
Yellow-throated Miner	*Manorina flavigula*				169
Yellow-faced Honeyeater	*Lichenostomus chrysops*				101
Singing Honeyeater	*Lichenostomus virescens*				471
White-eared Honeyeater	*Lichenostomus leucotis*				137
Yellow-tufted Honeyeater	*Lichenostomus melanops*				127
Purple-gaped Honeyeater	*Lichenostomus cratitius*		VU		1
Yellow-plumed Honeyeater	*Lichenostomus ornatus*				252
Grey-fronted Honeyeater	*Lichenostomus plumulus*		VU		5
Fuscous Honeyeater	*Lichenostomus fuscus*				182
White-plumed Honeyeater	*Lichenostomus penicillatus*				3676
Black-chinned Honeyeater	*Melithreptus gularis*		NT		216
Brown-headed Honeyeater	*Melithreptus brevirostris*				458
White-naped Honeyeater	*Melithreptus lunatus*				103
Brown Honeyeater	*Lichmera indistincta*				2
Painted Honeyeater	*Grantiella picta*		VU	L	23
Crescent Honeyeater	*Phylidonyris pyrrhoptera*				5
New Holland Honeyeater	*Phylidonyris novaehollandiae*				54

English Name	Scientific Name	EPBC	Vic	FFG	No.
White-fronted Honeyeater	*Phylidonyris albifrons*				66
Tawny-crowned Honeyeater	*Phylidonyris melanops*				7
Eastern Spinebill	*Acanthorhynchus tenuirostris*				119
Black Honeyeater	*Certhionyx niger*				34
Pied Honeyeater	*Certhionyx variegatus*				18
Crimson Chat	*Epthianura tricolor*				32
Orange Chat	*Epthianura aurifrons*				51
White-fronted Chat	*Epthianura albifrons*				373
Jacky Winter	*Microeca fascinans*				776
Scarlet Robin	*Petroica multicolor*				139
Red-capped Robin	*Petroica goodenovii*				664
Flame Robin	*Petroica phoenicea*				183
Rose Robin	*Petroica rosea*				6
Pink Robin	*Petroica rodinogaster*				5
Hooded Robin	*Melanodryas cucullata*		NT	L	260
Eastern Yellow Robin	*Eopsaltria australis*				193
Southern Scrub-robin	*Drymodes brunneopygia*				16
Grey-crowned Babbler	*Pomatostomus temporalis*		EN	L	508
White-browed Babbler	*Pomatostomus superciliosus*				382
Chestnut-crowned Babbler	*Pomatostomus ruficeps*				63
Eastern Whipbird	*Psophodes olivaceus*				11
Chestnut Quail-thrush	*Cinclosoma castanotus*		NT		20
Varied Sittella	*Daphoenositta chrysoptera*				223
Crested Shrike-tit	*Falcunculus frontatus*				528
Crested Bellbird	*Oreoica gutturalis*		NT	L	149
Olive Whistler	*Pachycephala olivacea*				1
Gilbert’s Whistler	*Pachycephala inornata*				180
Golden Whistler	*Pachycephala pectoralis*				275
Rufous Whistler	*Pachycephala rufiventris*				1198
Grey Shrike-thrush	*Colluricincla harmonica*				2249
Leaden Flycatcher	*Myiagra rubecula*				36
Satin Flycatcher	*Myiagra cyanoleuca*				5
Restless Flycatcher	*Myiagra inquieta*				807
Magpie-lark	*Grallina cyanoleuca*				2208
Rufous Fantail	*Rhipidura rufifrons*				8
Grey Fantail	*Rhipidura fuliginosa*				1065
Willie Wagtail	*Rhipidura leucophrys*				3161
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*				1557
White-bellied Cuckoo-shrike	*Coracina papuensis*				58
Cicadabird	*Coracina tenuirostris*				1
Ground Cuckoo-shrike	*Coracina maxima*		VU	L	3
White-winged Triller	*Lalage sueurii*				270
Olive-backed Oriole	*Oriolus sagittatus*				198
White-breasted Woodswallow	*Artamus leucorynchus*				187
Masked Woodswallow	*Artamus personatus*				82
White-browed Woodswallow	*Artamus superciliosus*				289
Black-faced Woodswallow	*Artamus cinereus*				47
Dusky Woodswallow	*Artamus cyanopterus*				827

English Name	Scientific Name	EPBC	Vic	FFG	No.
Little Woodswallow	*Artamus minor*				1
Grey Butcherbird	*Cracticus torquatus*				260
Pied Butcherbird	*Cracticus nigrogularis*				543
Australian Magpie	*Gymnorhina tibicen*				3743
Pied Currawong	*Strepera graculina*				300
Grey Currawong	*Strepera versicolor*				74
Australian Raven	*Corvus coronoides*				2589
Little Raven	*Corvus mellori*				777
Little Crow	*Corvus bennetti*				46
White-winged Chough	*Corcorax melanorhamphos*				1132
Apostlebird	*Struthidea cinerea*			L	85
Satin Bowerbird	*Ptilonorhynchus violaceus*				31
Spotted Bowerbird	*Chlamydera maculata*		VU	L	1
Singing Bushlark	*Mirafra javanica*				86
Skylark*	*Alauda arvensis*				33
Richard's Pipit	*Anthus novaeseelandiae*				294
House Sparrow*	*Passer domesticus*				1327
Eurasian Tree Sparrow*	*Passer montanus*				38
Zebra Finch	*Taeniopygia guttata*				455
Double-barred Finch	*Taeniopygia bichenovii*				11
Red-browed Finch	*Neochmia temporalis*				353
Diamond Firetail	*Stagonopleura guttata*		VU	L	271
European Greenfinch*	*Carduelis chloris*				5
European Goldfinch*	*Carduelis carduelis*				356
Mistletoebird	*Dicaeum hirundinaceum*				692
White-backed Swallow	*Cheramoeca leucosternus*				96
Welcome Swallow	*Hirundo neoxena*				2095
Tree Martin	*Hirundo nigricans*				648
Fairy Martin	*Hirundo ariel*				224
Clamorous Reed Warbler	*Acrocephalus stentoreus*				451
Little Grassbird	*Megalurus gramineus*				249
Rufous Songlark	*Cincloramphus mathewsi*				368
Brown Songlark	*Cincloramphus cruralis*				189
Golden-headed Cisticola	*Cisticola exilis*				129
Silvereye	*Zosterops lateralis*				476
Bassian Thrush	*Zoothera lunulata*				3
Common Blackbird*	*Turdus merula*				663
Common Starling*	*Sturnus vulgaris*				1722
Common Myna*	*Acridotheres tristis*				62
Mammals					
Short-beaked Echidna	*Tachyglossus aculeatus*				89
Platypus	*Ornithorhynchus anatinus*				61
Spot-tailed Quoll	*Dasyurus maculatus*	VU	EN	L	3
Brush-tailed Phascogale	*Phascogale tapoatafa*		VU	L	15
Yellow-footed Antechinus	*Antechinus flavipes*				123
Agile Antechinus	*Antechinus agilis*				38
Dusky Antechinus	*Antechinus swainsonii*				12
Common Dunnart	*Sminthopsis murina*		VU		1

English Name	Scientific Name	EPBC	Vic	FFG	No.
Fat-tailed Dunnart	*Sminthopsis crassicaudata*		NT		62
Giles' Planigale	*Planigale gilesi*		NT	L	16
Long-nosed Bandicoot	*Perameles nasuta*				13
Koala	*Phascolarctos cinereus*				266
Common Wombat	*Vombatus ursinus*				10
Common Ringtail Possum	*Pseudocheirus peregrinus*				350
Greater Glider	*Petauroides volans*				12
Yellow-bellied Glider	*Petaurus australis*				1
Squirrel Glider	*Petaurus norfolcensis*		EN	L	100
Sugar Glider	*Petaurus breviceps*				82
Common Brushtail Possum	*Trichosurus vulpecula*				814
Mountain Brushtail Possum	*Trichosurus caninus*				1
Eastern Pygmy-possum	*Cercartetus nanus*				1
Little Pygmy-possum	*Cercartetus lepidus*		NT		1
Feathertail Glider	*Acrobates pygmaeus*				18
Rufous Bettong	*Aepyprymnus rufescens*		RX	L	1
Eastern Grey Kangaroo	*Macropus giganteus*				354
Western Grey Kangaroo	*Macropus fuliginosus*				107
Red Kangaroo	*Macropus rufus*		NT		40
Black Wallaby	*Wallabia bicolor*				61
Grey-headed Flying-fox	*Pteropus poliocephalus*	VU	VU	L	2
Little Red Flying-fox	*Pteropus scapulatus*				10
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*			L	1
White-striped Freetail Bat	*Nyctinomus australis*				250
Southern Freetail Bat (long penis)	*Mormopterus sp.* 1				124
Southern Freetail Bat (short penis)	*Mormopterus sp.* 2				6
Freetail Bat (eastern form)	*Mormopterus sp.* EG				21
Greater Long-eared Bat	*Nyctophilus timoriensis*	VU	VU	L	1
Gould's Long-eared Bat	*Nyctophilus gouldi*				63
Lesser Long-eared Bat	*Nyctophilus geoffroyi*				304
Gould's Wattled Bat	*Chalinolobus gouldii*				341
Chocolate Wattled Bat	*Chalinolobus morio*				281
Southern Myotis	*Myotis macropus*		NT		20
Little Broad-nosed Bat	*Scotorepens greyii*				1
Inland Broad-nosed Bat	*Scotorepens balstoni*				57
Southern Forest Bat	*Vespadelus regulus*				105
Little Forest Bat	*Vespadelus vulturnus*				526
Large Forest Bat	*Vespadelus darlingtoni*				98
Water Rat	*Hydromys chrysogaster*				96
Mitchell's Hopping-mouse	*Notomys mitchelli*		NT		9
Bush Rat	*Rattus fuscipes*				93
Black Rat*	*Rattus rattus*				45
House Mouse*	*Mus musculus*				359
Brown Hare*	*Lepus capensis*				105
European Rabbit*	*Oryctolagus cuniculus*				462
Dingo/Dog (feral)	*Canis familiaris*				9
Dog*	*Canis familiaris familiaris*				2
Red Fox*	*Canis vulpes*				223

English Name	Scientific Name	EPBC	Vic	FFG	No.
Cat (feral)*	*Felis catus*				29
Horse (feral)*	*Equus caballus*				14
Pig (feral)*	*Sus scrofa*				21
Cattle (feral)*	*Bos taurus*				8
Goat (feral)*	*Capra hircus*				3
Sheep (feral)*	*Ovis aries*				11
Reptiles					
Broad-shelled Tortoise	*Chelodina expansa*		EN	L	24
Common Long-necked Tortoise	*Chelodina longicollis*				106
Murray River Tortoise	*Emydura macquarii*				52
Marbled Gecko	*Phyllodactylus marmoratus*				249
Southern Spiny-tailed Gecko	*Diplodactylus intermedius*				22
Tessellated Gecko	*Diplodactylus tessellatus*		NT		79
Wood Gecko	*Diplodactylus vittatus*				25
Tree Dtella	*Gehyra variegata*				30
Bynoe's Gecko	*Heteronotia binoei*				17
Beaded Gecko	*Diplodactylus damaeus*				56
Beaked Gecko	*Rhynchoedura ornata*		CR	L	1
Thick-tailed Gecko	*Nephrurus milii*				27
Pink-nosed Worm-Lizard	*Aprasia inaurita*				7
Southern Legless Lizard	*Delma australis*				11
Striped Legless Lizard	*Delma impar*	VU	EN	L	6
Olive Legless Lizard	*Delma inornata*				24
Butler's Legless Lizard	*Delma butleri*				1
Burton's Snake-Lizard	*Lialis burtonis*				7
Common Scaly-foot	*Pygopus lepidopodus*				4
Hooded Scaly-foot	*Pygopus schraderi*		CR	L	7
Tree Dragon	*Amphibolurus muricatus*				70
Nobbi Dragon	*Amphibolurus nobbi coggeri*				44
Mallee Dragon	*Ctenophorus fordi*				12
Painted Dragon	*Ctenophorus pictus*				9
Eastern Bearded Dragon	*Pogona barbata*		DD		87
Central Bearded Dragon	*Pogona vitticeps*				25
Lined Earless Dragon	*Tympanocryptis lineata lineata*		EN	L	1
Sand Goanna	*Varanus gouldii*				25
Tree Goanna	*Varanus varius*		VU		124
Eastern Three-lined Skink	*Bassiana duperreyi*				2
Southern Rainbow Skink	*Carlia tetradactyla*				17
Carnaby's Wall Skink	*Cryptoblepharus carnabyi*				265
Murray Striped Skink	*Ctenotus brachyonyx*				18
Brooks's Striped Skink	*Ctenotus brooksi iridis*				1
Regal Striped Skink	*Ctenotus regius*				34
Large Striped Skink	*Ctenotus robustus*				81
Copper-tailed Skink	*Ctenotus taeniolatus*				1
Eastern Striped Skink	*Ctenotus orientalis*				8
Cunningham's Skink	*Egernia cunninghami*				41
Desert Skink	*Egernia inornata*		NT		9
Black Rock Skink	*Egernia saxatilis intermedia*				1

English Name	Scientific Name	EPBC	Vic	FFG	No.
Tree Skink	*Egernia striolata*				122
White's Skink	*Egernia whitii*				1
Yellow-bellied Water Skink	*Eulamprus heatwolei*				36
Eastern Water Skink	*Eulamprus quoyii*		NT		20
Southern Water Skink	*Eulamprus tympanum tympanum*				1
Three-toed Skink	*Hemiergis decresiensis*				47
Garden Skink	*Lampropholis guichenoti*				203
Bougainville's Skink	*Lerista bougainvillii*				59
Mueller's Skink	*Lerista muelleri*		EN	L	31
Spotted Burrowing Skink	*Lerista punctatovittata*				12
Grey's Skink	*Menetia greyii*				91
Samphire Skink	*Morethia adelaidensis*		EN	L	7
Boulenger's Skink	*Morethia boulengeri*				729
Obscure Skink	*Morethia obscura*				8
Western Blue-tongued Lizard	*Tiliqua occipitalis*		DD		3
Common Blue-tongued Lizard	*Tiliqua scincoides*				31
Stumpy-tailed Lizard	*Tiliqua rugosa*				62
West Australian Blind Snake	*Ramphotyphlops australis*				11
Peters's Blind Snake	*Ramphotyphlops bituberculatus*				29
Gray's Blind Snake	*Ramphotyphlops nigrescens*				5
Woodland Blind Snake	*Ramphotyphlops proximus*		NT		31
Carpet Python	*Morelia spilota metcalfei*		EN	L	86
Common Death Adder	*Acanthophis antarcticus*		DD	L	1
Eastern Small-eyed Snake	*Rhinoplocephalus nigrescens*				1
Yellow-faced Whip Snake	*Demansia psammophis*		NT		6
Red-naped Snake	*Furina diadema*		EN	L	8
Tiger Snake	*Notechis scutatus*				52
Red-bellied Black Snake	*Pseudechis porphyriacus*				59
Western Brown Snake	*Pseudonaja nuchalis*		DD		2
Eastern Brown Snake	*Pseudonaja textilis*				93
Coral Snake	*Simoselaps australis*		NT		22
Mitchell's Short-tailed Snake	*Suta nigriceps*				9
Curl Snake	*Suta suta*		VU		24
Dwyer's Snake	*Suta dwyeri*				2
Bandy Bandy	*Vermicella annulata*		NT	L	7
Amphibians					
Plains Froglet	*Crinia parinsignifera*				488
Common Froglet	*Crinia signifera*				524
Sloane's Froglet	*Crinia sloanei*				14
Victorian Smooth Froglet	*Geocrinia victoriana*				1
Southern Bullfrog	*Limnodynastes dumerilii*				458
Southern Bullfrog (northern)	*Limnodynastes dumerilii dumerilii*				24
Barking Marsh Frog	*Limnodynastes fletcheri*		DD		105
Giant Bullfrog	*Limnodynastes interioris*		CR	L	8
Spotted Marsh Frog	*Limnodynastes tasmaniensis*				891
Spotted Marsh Frog (northern call race)	*Limnodynastes tasmaniensis* (northern call race)				16
Mallee Spadefoot Toad	*Neobatrachus pictus*				10

English Name	Scientific Name	EPBC	Vic	FFG	No.
Common Spadefoot Toad	*Neobatrachus sudelli*				61
Brown Toadlet	*Pseudophryne bibronii*		EN		48
Rugose Toadlet	*Uperoleia rugosa*		DD	L	1
Southern Brown Tree Frog	*Litoria ewingii*				15
Lesueur's Frog	*Litoria lesueuri*				1
Plains Brown Tree Frog	*Litoria paraewingi*				15
Peron's Tree Frog	*Litoria peronii*				218
Growling Grass Frog	*Litoria raniformis*	VU	EN	L	67
Fish					
Short-headed Lamprey	*Mordacia mordax*				7
Bony Bream	*Nematalosa erebi*				126
Broadfin Galaxias	*Galaxias brevipinnis*				8
Common Galaxias	*Galaxias maculatus*				2
Flat-headed Galaxias	*Galaxias rostratus*		DD		13
Mountain Galaxias	*Galaxias olidus*			L	42
Freshwater Catfish	*Tandanus tandanus*		EN	L	49
Crimson-spotted Rainbowfish	*Melanotaenia fluviatilis*		DD	L	51
Fly-specked Hardyhead (southern form)	*Craterocephalus stercusmuscarum fulvus*		DD	L	38
Murray Hardyhead	*Craterocephalus fluviatilis*	VU	CR	L	23
Agassiz's Chanda Perch	*Ambassis agassizii*		RX	L	1
Australian Smelt	*Retropinna semoni*				263
Murray Cod	*Maccullochella peelii peelii*	VU	EN	L	360
Trout Cod	*Maccullochella macquariensis*	EN	CR	L	64
Macquarie Perch	*Macquaria australasica*	EN	EN	L	12
Golden Perch	*Macquaria ambigua*		VU		482
Silver Perch	*Bidyanus bidyanus*		CR	L	171
Southern Pigmy Perch	*Nannoperca australis*				28
Redfin*	*Perca fluviatilis*				517
Two-spined Blackfish	*Gadopsis bispinosus*				89
River Blackfish	*Gadopsis marmoratus*				46
Western Carp Gudgeon	*Hypseleotris klunzingeri*				232
Southern Purple-spotted Gudgeon	*Mogurnda adspersa*		EX	L	1
Flatheaded Gudgeon	*Philypnodon grandiceps*				152
Dwarf Flat-headed Gudgeon	*Philypnodon sp. nov.*				8
Rainbow Trout*	*Oncorhynchus mykiss*				39
Brown Trout*	*Salmo trutta*				86
Goldfish*	*Carassius auratus*				355
Carp*	*Cyprinus carpio*				825
Mirror Carp*	*Cyprinus carpio var. mirror*				5
Tench*	*Tinca tinca*				49
Oriental Weatherloach*	*Misgurnus anguillicaudatus*				17
Mosquitofish*	*Gambusia holbrooki*				201
Invertebrates					
Southern Freshwater Prawn	*Macrobrachium australiense australiense*				38
Murray Spiny Cray	*Euastacus armatus*		DD	L	49
Murray Freshwater Shrimp	*Caridina mccullochi*				5
Common Freshwater Shrimp	*Paratya australiensis*				39

English Name	Scientific Name	EPBC	Vic	FFG	No.
Freshwater shrimp	*Paratya* sp.				9
Hairy Burrowing Cray	*Engaeus sericatus*				5
Common Yabbie	*Cherax destructor*				82
South-eastern River Mussel	*Velesunio ambiguus*				2
Mildura Ogyris	*Ogyris subterrestris subterrestris ssp.*			L	1
River snail	*Notopala sublineata*			L	13
Freshwater snail	*Physa* sp.				1
Bullant	*Myrmecia* sp. 17		VU	L	1
Spider	Superord. Acarina				2
Spider	Ord. Acariformes				2
Aquatic mite	Subord. Astigmata				2
Aquatic mite	Superfam. Acaroidea				2
Aquatic mite	Superfam. Hemisarcoptadea				2
Aquatic mite	Superfam. Histiostomatidae				2
Aquatic mite	Subord. Orbatida				2
Aquatic mite	Superfam. Crotonioidea				2
Aquatic mite	Superfam. Ameronothroidea				2
Aquatic mite	Superfam. Hydrozetoidea				2
Aquatic mite	Subord. Prostigmata				2
Aquatic mite	Superfam. Raphignathoidea				2
Aquatic mite	Superfam. Halacaroidea				2
Aquatic mite	Superfam. Arrenuroidea				2
Aquatic mite	Superfam. Eylaioidea				2
Aquatic mite	Superfam. Hydrachnoidea				2
Aquatic mite	Fam. Hydrachnidae				4
Aquatic mite	Superfam. Hydryphantoidea				2
Aquatic mite	Superfam. Hygrobatoidea				2
Aquatic mite	Fam. Hygrobatidae				1
Aquatic mite	Ord. Acariformes Fam. Unionicolidae				1
Aquatic mite	Superfam. Lebertioidea				2
Aquatic mite	Fam. Oxidae				3
Mite (may not be aquatic)	Ord. Parasitiformes				2
Mite (may not be aquatic)	Subord. Stigmata				2
Mite (may not be aquatic)	Superfam. Ascoidea				2
Mayfly	Fam. Baetidae				1
Mayfly	*Edmundsiops* sp.				6
Mayfly	Fam. Coloburiscidae				4
Mayfly	*Coloburiscoides* sp.				2
Mayfly	*Coloburiscoides munionga*				2
Mayfly	*Coloburiscoides giganteus*				2
Mayfly	*Coloburiscoides haleuticus*				2
Mayfly	*Atalophlebia* sp.				1
Mayfly	*Austrophlebioides* sp.				5
Mayfly	*Nousia* sp.				2
Mayfly	Fam. Caenidae				1
Mayfly	*Tasmanocoenis* sp.				1
Mayfly	*Caenid* sp.				2
Alderflies/Dobsonflies	*Archichauliodes* sp.				4

English Name	Scientific Name	EPBC	Vic	FFG	No.
Dragonfly	*Hemigomphus* sp.				4
Dragonfly	*Austroaeschna* sp.				1
Stonefly	Fam. Gripopterygidae				1
Stonefly	*Dinotoperla* sp.				3
Stonefly	*Illiesoperla* sp.				2
Stonefly	*Leptoperla* sp.				1
Stonefly	*Riekoperla* sp.				1
Stonefly	*Trinotoperla* sp.				1
Caddisfly (5008)	*Archaeophylax canarus*			L	1
Caddisfly	Fam. Hydrobiosidae				1
Caddisfly	*Tanjilana* sp.				1
Caddisfly	*Taschorema* sp.				2
Caddisfly	*Ulmerochorema* sp.				4
Caddisfly	*Agapetus* sp.				4
Caddisfly	*Hydroptila* sp.				2
Caddisfly	Fam. Hydropsychidae				2
Caddisfly	*Asmicridea* sp.				2
Caddisfly	*Cheumatopsyche* sp.				5
Caddisfly	*Ecnomus* sp.				2
Caddisfly	*Conoesucus* sp.				2
Caddisfly	*Hampa* sp.				1
Caddisfly	*Tamasia* sp.				1
Caddisfly	*Notalina* sp.				2
Caddisfly	*Triplectides* sp.				1
Water boatmen	*Micronecta* sp.				3
Ground beetle	Fam. Carabidae				1
Scavenger water beetle	*Hydrochus* sp.				1
Scavenger water beetle	*Berosus* sp.				2
Riffle beetles	*Austrolimnius* sp.				5
Riffle beetles	*Notriolus* sp.				3
Riffle beetles	*Kingolus* sp.				2
Water penny beetle	*Sclerocyphon* sp.				5
Byrrocryptus	*Byrrocryptus* sp.				1
Midge	*Paraheptagyia* sp.				1
Midge	Subfam. Orthocladiinae				4
Midge	*Cardiocladius* sp.				1
Midge	*Cricotopus* sp.				2
Midge	*Riethia* sp.				2
Midge	*Cladotanytarsus* sp.				1
Midge	*Rheotanytarsus* sp.				1
Midge	*Dicrotendipes* sp.				1
Midge	*Polypedilum* sp.				2
Biting midge	Fam. Ceratopogonidae Gen. EPA sp. 6				1
Biting midge	Fam. Ceratopogonidae Gen. SRV sp. 20				4
Black fly	*Austrosimulium* sp.				6
Black fly	*Simulium* sp.				1
Black fly	*Cnephia* sp.				1
Crane fly	Fam. Tipulidae Gen. EPA sp. 1				2
Crane fly	Fam. Tipulidae Gen. EPA sp. 10				1
Crane fly	Fam. Tipulidae Gen. SRV sp. 18				6
Crane fly	Fam. Tipulidae Gen. SRV sp. 19				5
Athericid	Fam. Athericidae				1
Dance fly	Fam. Empididae				2
Dance fly	Fam. Empididae Gen. MV sp. 3				2
Dance fly	Fam. Empididae Gen. SRV sp. 6				1
Dance fly	Fam. Empididae Gen. SRV sp. 7				1
Dolichopodid	Fam. Dolichopodidae				1
Dolichopodid	Fam. Dolichopodidae Gen. EPA sp. 1				1
Flatworm	*Dugesia* sp.				1
Tubificid Worm	*Tubificidae* sp.				3
Naidid Worm	*Naididae* sp.				1
Lumbiculid worm	Fam. Lumbriculidae				1

The table below lists fauna species once recorded in the study area but now extinct[1] and other species that were also recorded in the study area but are now extinct in Victoria[2] (and not recorded in the Atlas of Victorian Wildlife). These species are not in the main list of species recorded in the study area. A number of other species possibly occurred in the study area at the time of European settlement[3] (Menkhorst 1995).

English Name	Scientific Name
Pig-footed bandicoot[1]	*Chaeropus ecaudatus*
Eastern hare-wallaby[1]	*Lagorchestes leporides*
An undescribed short-nosed bandicoot[1]	*Isoodon* sp.
Lesser stick-nest rat[1]	*Leporillus apicalis*
Eastern quoll[2]	*Dasyurus viverrinus*
Red-tailed phascogale[2]	*Phascogale calura*
Western barred bandicoot[2]	*Perameles bougainville fasciata*
Brush-tailed bettong[2]	*Bettongia penicillata penicillata*
Bridled nailtail wallaby[2]	*Onychogalea fraenata*
Western quoll[3]	*Dasyurus geoffroii*
Kultarr[3]	*Antechinornys laniger*
Greater stick-nest rat[3]	*Leporillus conditor*
Bolam's mouse[3]	*Pseudomys bolami*
Desert mouse[3]	*Pseudomys desertor*
White-footed rabbit-rat[3]	*Conilurus albipes*

APPENDIX 6: Reservation Status of Ecological Vegetation Classes (EVCs)

A vegetation community is a collection of co-occurring plant species—it reflects the vegetation's response to environmental influences such as geology, soils, landform and rainfall. Ecological Vegetation Classes (EVCs) are groups of one or more vegetation communities which exist under a common regime of ecological processes and which are linked to broad landscape features. The similarity of environmental regimes is apparent in comparable life forms, genera and vegetation structure. The communities within an EVC differ due to geographical separation rather than major ecological differences.

Once EVCs have been identified, it is possible to map their distributions with the aid of maps of sites where they are known to occur; aerial photographs; maps of the main environmental determinants of vegetation distribution (such as soils, rainfall, topography); any pre-existing vegetation mapping; and extensive field work to identify boundaries and ground-check that EVCs do indeed occur where they have been mapped.

As well as the standard EVCs, the process of mapping generates two variations of the standard EVCs—mosaics and complexes. A mosaic consists of two or more discrete EVCs that cannot be mapped separately due to the scale of the map. A complex occurs where two or more EVCs are unable to be distinguished in an area but are known to exist discretely elsewhere. A slash is used to separate the component EVCs in the name of a mosaic or complex. For example, Aquatic Herbland/Floodplain Grassy Wetland Mosaic. Some EVCs occur only in mosaics. The units identified on a single vegetation map may be communities, EVCs, mosaics or complexes, depending on the resolution at which the units were described and mapped. However, for convenience, mapped vegetation units of any of these types are referred to simply as 'EVCs'.

The extent to which vegetation has been depleted—that is, cleared as a result of European settlement—is a key consideration in the establishment of conservation reserve systems (see chapter 10). To assess the extent of depletion of each EVC, it is necessary to map the extent of EVCs prior to European settlement, as well as the current distribution of EVCs. The mapping of vegetation prior to European settlement is called 'pre-1750 mapping'; 1750 being a round-number year closely pre-dating European settlement in Australia. Essentially pre-1750 mapping involves predicting, or modelling, the vegetation that was originally cleared from areas which no longer support indigenous vegetation. It involves a similar process to mapping the current distribution of EVCs, but (of course) with little or no assistance from aerial photographs and ground-checking.

In most regions, the EVC currently found at any given location where native vegetation remains is nearly always the same as that which would have been there pre-1750—even if it has been cleared and regrown, most of the fundamental determinants of that EVC remain in place (e.g. slope, soil type, climate) and so the same EVC should re-establish (although probably in a poorer state). In the River Red Gum Forests study area, one of the most pervasive environmental changes has been the alteration of flood regimes across wetlands and forests. Flood regime is one of the primary determinants of EVCs in these environments, and so in many instances the vegetation present at a site will differ from that present prior to river regulation. One of the best known examples of this phenomenon is the invasion of Moira grass plains (Floodplain Grassy Wetland EVC) by river red gums (probably Riverine Swamp Forest EVC) and giant rush. As a result it is impossible to reliably map all pre-1750 EVCs, and some apparently straightforward changes in EVC extent (such as a reduction from pre-1750 extent to current extent) may mask more complex changes such as a greater total reduction countered by a smaller increase in some areas. Overall, this problem would generally lead to around 10 percent variation in the total extent of some EVCs.

The vegetation of the study area is mapped in Map B. Because of the large number of EVCs, and the closely interwoven occurrence of EVCs in many areas (e.g. see the Barmah forest inset in Map B), it is not possible to discern individual EVCs over much of a map of this scale. Accordingly, EVCs have been grouped for presentation in Map B—with EVCs of similar composition and environmental determinants shown in the same colour. Complementing Map B is Appendix 7, which provides descriptions of each of the main EVCs in the study area.

The EVC mapping on which Map B is based is also the basis of the Representation Table following. Broadly, this table lists all the EVCs mapped in the study area, and quantifies their current and pre-1750 extent in the study area, as well as their current extent in conservation reserves and other public land. Preceding the table is the following detailed key for the column headings and symbols used in the table.

KEY

Data in the Representation Table were derived by GIS analysis, that is overlaying, on computer, maps of:

- the pre-1750 extent of EVCs (data used to derive Map B); that is, the distribution of EVCs as it is thought to have been immediately prior to European settlement;
- current extent of intact native vegetation, based on a separate mapping exercise to the EVC mapping; and
- current extent of each public land use category.

Many small public land units may not be picked up in the public land GIS layer. For example, none of these figures include roads and roadsides, for which no estimate of extent exists. In addition to the Representation Table for the study area as a whole, presented here, VEAC has prepared Representation Tables for each of the main bioregions which overlap with the study area. These tables are available on the VEAC website (www.veac.vic.gov.au) or by request from VEAC.

The total extent of both public land (see Table 10.1) and the conservation reserve system in the study area is greater than the figures shown in the Representation Table because several thousand hectares of public land that do not support intact native vegetation are not included relevant totals in the Representation Table below.

It is important to understand that the figures in the Representation Table are generated by computer-based spatial analysis, and are not meant to be interpreted with the level of precision at which they are provided. That is, for example, the table should not be interpreted as saying that the current extent of Alluvial Plains Semi-arid Grassland is exactly 3517 hectares—as opposed to 3516, 3518, or indeed 3520 hectares. As general rule, the focus should be on changes to the vegetation more generally, or on more extensive EVCs. In addition, all area figures are rounded to the nearest hectare. As a result several EVCs have '0' pre-1750 extent in the table e.g. Sedgy Riverine Forest/Spike-sedge Wetland Mosaic, for which the precise figure is 0.46 hectares.

Column 1: Ecological Vegetation Classes

The names of the 169 EVCs mapped within the River Red Gum Forests study area. Here, the term 'EVCs' is used to describe several units of classification: EVCs *per se*, and complexes and mosaics—see above for definitions of these units and their relationships to each other. The last row ('other - natural') is mostly river bank, sandy beach, and other bare ground.

Column 2: Pre-1750 Extent

The total area in hectares thought to have been occupied by each EVC prior to European settlement, corresponding to the mapped extent of EVCs used to generate Map B.

Column 3: Current Extent (public and private land)

The total area in hectares currently occupied by each EVC—that is, that part of the pre-1750 distribution where intact native vegetation is currently present.

Column 4: Percent Remaining

The current extent (column 3) as a percentage of the pre-1750 extent (column 2), for each EVC.

Column 5: Conservation Status (JANIS)

A simplified version of the status of each EVC in terms of the categories developed by JANIS, and the DSE the Bioregional Conservation status (see below). The assessments refer to the study area as a whole and take no account of EVC distributions outside the study area or in bioregions within the study area. The percent remaining (column 4) is a key factor in assigning EVCs to JANIS categories. E = endangered, V = vulnerable, R = rare.

Column 6: Dedicated Reserve System

The total area in hectares of each EVC in existing public land categories that comprise the conservation reserve system (see chapter 10).

Column 7: Other Public Land

The total area in hectares of each EVC in all public land categories outside the dedicated reserve system. Note that some of these areas will be in informal reserves such as Special Protection Zones in state forest.

Column 8: Dedicated Reserves as % of Pre-1750 Extent

The area of dedicated reserves (column 6) as a percentage of the pre-1750 extent (column 2), for each EVC.

Definitions of Bioregional Conservation Status for Ecological Vegetation Classes. Note the different categories and definitions used for EVCs compared with the conservation status categories and definitions used for flora and fauna species in Appendices 4 and 5.

Status	Code	Criteria
Presumed extinct	X	Probably no longer present in the Bioregion (the accuracy of this assumption is limited by the use of remotely sensed 1:100,000 scale woody vegetation cover mapping to determine depletion – grassland, open woodland and wetland types are particularly affected).
Endangered	E	Contracted to less than 10% of former range; OR Less than 10% pre-European extent remains; OR Combination of depletion, degredation, current threats and rarity is comparable overall to the above: • 10 to 30% pre-European extent remains and severely degraded over a majority of this area; or • naturally restricted EVC reduced to 30% or less of former range and moderately degraded over a majority of this area; or • rare EVC cleared and/or moderately degraded over a majority of former area.
Vulnerable	V	10 to 30% pre-European extent remains; OR Combination of depletion, degradation, current threats and rarity is comparable overall to the above: • greater than 30% and up to 50% pre-European extent remains and moderately degraded over a majority of this area; or • greater than 50% pre-European extent remains and severely degraded over a majority of this area; or • naturally restricted EVC where greater than 30% pre-European extent remains and moderately degraded over a majority of this area; or • rare EVC cleared and/or moderately degraded over a majority of former area.
Depleted	D	Greater than 30% and up to 50% pre-European extent remains; OR Combination of depletion, degradation and current threats is comparable overall to the above and: • greater than 50% pre-European extent remains and moderately degraded over a majority of this area; or
Rare	R	Rare EVC (as defined by geographic occurrence) but neither depleted, degraded nor currently threatened to an extent that would qualify as Endangered, Vulnerable or Depleted.
Least concern	LC	Greater than 50% pre-European extent remains and subject to little to no degradation over a majority of this area.

Source: MDBC (2005b)

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Alluvial Plains Semi-arid Grassland	3,520	3,517	99.9		1,568	1,548	44.5
Alluvial Terraces Herb-rich Woodland/Creekline Grassy Woodland Mosaic	15	9	61.6	R	0	5	0.0
Aquatic Herbland	139	139	100.0	R	0	139	0.0
Aquatic Herbland/Floodplain Grassy Wetland Mosaic	59	59	100.0	R	0	59	0.0
Aquatic Herbland/Floodway Pond Herbland	1	1	100.0	R	0	1	0.0
Aquatic Herbland/Riverine Swamp Forest Mosaic	1	1	100.0	R	0	1	0.0
Aquatic Herbland/Tall Marsh Mosaic	68	68	100.0	R	0	68	0.0
Billabong Wetland	1,315	1,096	83.4		17	618	1.3
Billabong Wetland/Red Gum Wetland Mosaic	21	1	7.1	E, R	0	0	0.0
Box Ironbark Forest	49	17	34.1	R	0	3	0.0
Brackish Lake Mosaic	1,982	1,884	95.0		0	1,382	0.0
Cane Grass Wetland	46	7	16.3	V, R	0	0	0.0
Chenopod Grassland	108,008	17,461	16.2	V	280	511	0.3
Chenopod Mallee	4,871	2,986	61.3		233	1,928	4.8
Creekline Grassy Woodland	2,415	938	38.8	R	4	100	0.2
Disused Floodway Shrubby Herbland	23	23	100.0	R	13	10	56.1
Drainage-line Aggregate/Riverine Swamp Forest Mosaic	116	116	100.0	R	0	113	0.0
Drainage-line Aggregate/Sedgy Riverine Forest Mosaic	23	23	100.0	R	0	23	0.0
Drainage-line Aggregate/Tall Marsh Mosaic	3	3	100.0	R	0	3	0.0
Drainage-line Complex	3,669	2,522	68.7		25	1,282	0.7
Drainage-line Grassy Woodland/Lake Bed Herbland Mosaic	765	0	0.0	X	0	0	0.0
Floodplain Grassy Wetland	581	577	99.2	R	0	569	0.0
Floodplain Grassy Wetland/Floodway Pond Herbland Mosaic	6	6	100.0	R	0	6	0.0
Floodplain Grassy Wetland/Riverine Swamp Forest Mosaic	101	101	100.0	R	0	101	0.0
Floodplain Grassy Wetland/Riverine Swampy Woodland Mosaic	9	5	54.5	R	0	2	0.0
Floodplain Grassy Wetland/Spike-sedge Wetland Mosaic	22	22	100.0	R	0	22	0.0
Floodplain Grassy Wetland/Tall Marsh Mosaic	21	21	100.0	R	0	21	0.0
Floodplain Riparian Woodland	22,101	15,593	70.6		57	7,670	0.3
Floodplain Riparian Woodland/Floodway Pond Herbland Mosaic	3	3	96.5	R	0	2	0.0
Floodplain Riparian Woodland/Grassy Riverine Forest Mosaic	34	34	100.0	R	0	22	0.0

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Floodplain Riparian Woodland/Riverine Grassy Woodland Mosaic	27	18	67.5	R	0	11	0.0
Floodplain Riparian Woodland/Riverine Swamp Forest Mosaic	237	55	23.3	V, R	0	49	0.0
Floodplain Riparian Woodland/Sedgy Riverine Forest Mosaic	207	205	99.0	R	0	139	0.0
Floodplain Riparian Woodland/Tall Marsh Mosaic	1	1	100.0	R	0	1	0.0
Floodplain Wetland Complex	1,163	912	78.4	R	3	353	0.2
Floodway Pond Herbland	1,166	1,156	99.2		183	871	15.7
Floodway Pond Herbland/Riverine Swamp Forest Complex	2,523	2,523	100.0		0	2,518	0.0
Floodway Pond Herbland/Riverine Swamp Forest Mosaic	89	32	36.3	R	0	7	0.0
Floodway Pond Herbland/Tall Marsh Mosaic	7	7	100.0	R	0	7	0.0
Freshwater Lake Mosaic	4,220	4,203	99.6		1	4,157	0.0
Gilgai Plain Woodland/Wetland Mosaic	1,733	186	10.7	V, R	0	20	0.0
Grassy Dry Forest	711	266	37.4	R	0	80	0.0
Grassy Riverine Forest	9,474	8,929	94.2		1,725	6,399	18.2
Grassy Riverine Forest/Drainage-line Aggregate Mosaic	3	3	100.0	R	0	3	0.0
Grassy Riverine Forest/Floodway Pond Herbland Complex	1,142	1,127	98.7		268	777	23.5
Grassy Riverine Forest/Floodway Pond Herbland Mosaic	5	5	100.0	R	0	5	0.0
Grassy Riverine Forest/Riverine Grassy Woodland Mosaic	23	23	100.0	R	0	23	0.0
Grassy Riverine Forest/Riverine Swamp Forest Complex	8,323	6,367	76.5		0	4,497	0.0
Grassy Riverine Forest/Riverine Swamp Forest Mosaic	67	67	100.0	R	0	67	0.0
Grassy Riverine Forest/Riverine Swampy Woodland Mosaic	1	1	100.0	R	0	1	0.0
Grassy Riverine Forest/Sedgy Riverine Forest Mosaic	344	344	100.0	R	0	344	0.0
Grassy Riverine Forest/Tall Marsh Mosaic	2	2	100.0	R	0	2	0.0
Grassy Woodland	4,137	714	17.3	V, R	47	54	1.1
Grassy Woodland/Valley Grassy Forest Mosaic	64	5	7.6	E, R	0	0	0.0
Heathy Dry Forest	6	5	88.2	R	0	0	0.0
Herb-rich Foothill Forest	230	114	49.7	R	0	13	0.0
Intermittent Swampy Woodland	9,205	9,157	99.5		5,750	2,665	62.5
Lake Bed Herbland	3,695	3,649	98.8		1,850	1,309	50.1
Lignum Shrubland	16,673	16,045	96.2		5,655	6,286	33.9
Lignum Swampy Woodland	69,685	41,331	59.3		5,726	17,016	8.2

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Lignum Swampy Woodland/Lake Bed Herbland Mosaic	125	64	51.2	R	0	35	0.0
Lignum Swampy Woodland/Plains Grassland Mosaic	12,638	1,352	10.7	V	9	20	0.1
Lignum Wetland	51,420	17,101	33.3		1,938	2,123	3.8
Loamy Sands Mallee	1,399	1,384	99.0		1,336	10	95.6
Low Chenopod Shrubland	40,849	38,819	95.0		5,972	5,443	14.6
Low Rises Woodland	3,020	716	23.7	V, R	54	308	1.8
Low Rises Woodland/Riverine Swampy Woodland Mosaic	2	2	100.0	R	0	2	0.0
Lunette Woodland	1,581	131	8.3	E, R	0	25	0.0
Mosaic of Aquatic Herbland/Floodway Pond Herbland-Riverine Swamp Forest Complex	2	2	100.0	R	0	2	0.0
Mosaic of Aquatic Herbland/Sedgy Riverine Forest-Riverine Swamp Forest Complex	0	0	100.0	R	0	0	0.0
Mosaic of Drainage-line Aggregate/Floodway Pond Herbland-Riverine Swamp Forest Complex	1	1	100.0	R	0	1	0.0
Mosaic of Drainage-line Aggregate/Grassy Riverine Forest-Riverine Swamp Forest Complex	146	146	100.0	R	0	146	0.0
Mosaic of Drainage-line Aggregate/Sedgy Riverine Forest-Riverine Swamp Forest Complex	67	67	99.8	R	0	19	0.0
Mosaic of Floodplain Grassy Wetland/Floodway Pond Herbland-Riverine Swamp Forest Complex	1	1	100.0	R	0	1	0.0
Mosaic of Floodplain Grassy Wetland/Grassy Riverine Forest-Riverine Swamp Forest Complex	23	23	100.0	R	0	22	0.0
Mosaic of Floodplain Grassy Wetland/Sedgy Riverine Forest-Riverine Swamp Forest Complex	2	2	100.0	R	0	2	0.0
Mosaic of Floodplain Riparian Woodland/Sedgy Riverine Forest-Riverine Swamp Forest Complex	0	0	100.0	R	0	0	0.0
Mosaic of Floodway Pond Herbland/Grassy Riverine Forest-Riverine Swamp Forest Complex	4	4	100.0	R	0	4	0.0
Mosaic of Floodway Pond Herbland/Sedgy Riverine Forest-Riverine Swamp Forest Complex	8	8	100.0	R	0	8	0.0
Mosaic of Grassy Riverine Forest-Riverine Swamp Forest Complex/Riverine Swamp Forest	239	239	100.0	R	0	238	0.0
Mosaic of Grassy Riverine Forest/Floodway Pond Herbland-Riverine Swamp Forest Complex	379	379	100.0	R	0	379	0.0

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Mosaic of Grassy Riverine Forest/Plains Grassy Woodland-Grassy Woodland Complex	0	0	100.0	R	0	0	0.0
Mosaic of Grassy Riverine Forest/Sedgy Riverine Forest-Riverine Swamp Forest Complex	76	76	100.0	R	0	76	0.0
Mosaic of Riverine Grassy Woodland/Floodway Pond Herbland-Riverine Swamp Forest Complex	1	1	100.0	R	0	1	0.0
Mosaic of Riverine Swamp Forest/Floodway Pond Herbland-Riverine Swamp Forest Complex	882	882	100.0	R	0	881	0.0
Mosaic of Riverine Swampy Woodland/Sedgy Riverine Forest-Riverine Swamp Forest Complex	32	32	100.0	R	0	32	0.0
Mosaic of Sedgy Riverine Forest-Riverine Swamp Forest Complex/ Floodway Pond Herbland-R	65	65	100.0	R	0	65	0.0
Mosaic of Sedgy Riverine Forest-Riverine Swamp Forest Complex/Tall Marsh	7	7	100.0	R	0	7	0.0
Mosaic of Sedgy Riverine Forest/Floodway Pond Herbland-Riverine Swamp Forest Complex	31	31	100.0	R	0	31	0.0
Mosaic of Sedgy Riverine Forest/Sedgy Riverine Forest-Riverine Swamp Forest Complex	1,253	1,231	98.2		0	1,135	0.0
Mosaic of Tall Marsh/Floodway Pond Herbland-Riverine Swamp Forest Complex	83	83	100.0	R	0	83	0.0
Mountain Valley Riparian Woodland	1,325	892	67.3	R	0	515	0.0
Plains Grassland	251,131	37,784	15.0	V	1,969	980	0.8
Plains Grassland/Plains Grassy Woodland/Gilgai Wetland Mosaic	13,188	1,391	10.5	V	19	192	0.1
Plains Grassy Wetland	2,172	645	29.7	V, R	121	23	5.6
Plains Grassy Woodland	13,851	1,532	11.1	V	3	112	0.0
Plains Grassy Woodland/Creekline Grassy Woodland/Floodplain Riparian Woodland Mosaic	1,291	80	6.2	E, R	0	2	0.0
Plains Grassy Woodland/Creekline Grassy Woodland/Wetland Formation Mosaic	0	0	96.6	R	0		0.0
Plains Grassy Woodland/Gilgai Wetland Mosaic	6	1	10.7	V, R	0	0	0.0
Plains Grassy Woodland/Grassy Woodland Complex	95	30	31.2	R	0	2	0.0
Plains Grassy Woodland/Valley Grassy Forest Complex	14	1	3.8	E, R	0	0	0.0
Plains Grassy Woodland/Valley Grassy Forest/Grassy Woodland Complex	194	15	7.6	E, R	0	4	0.0

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Plains Saltmarsh Complex	298	266	89.3	R	3	257	0.9
Plains Savannah	14,083	2,257	16.0	V	12	66	0.1
Plains Woodland	135,204	22,055	16.3	V	313	4,827	0.2
Plains Woodland/Lignum Wetland Mosaic	1,250	137	11.0	V, R	0		0.0
Plains Woodland/Plains Grassland/Gilgai Wetland Mosaic	6	2	27.3	V, R	0		0.0
Plains Woodland/Red Gum Wetland Mosaic	1,034	169	16.4	V, R	0	4	0.0
Red Gum Wetland	1,706	1,600	93.8		45	1,350	2.7
Red Gum Wetland/Plains Grassy Wetland Mosaic	718	398	55.4	R	1	200	0.2
Ridged Plains Mallee	1,825	463	25.4	V, R	112	83	6.1
Riparian Forest	400	319	79.9	R	0	246	0.0
Riparian Forest/Swampy Riparian Woodland Mosaic	42	34	80.8	R	0	1	0.0
Riparian Forest/Swampy Riparian Woodland/Riparian Shrubland/Riverine Escarpment Scrub	1	1	100.0	R	0	1	0.0
Riverine Chenopod Woodland	140,361	60,556	43.1		13,430	17,221	9.6
Riverine Chenopod Woodland/Lignum Wetland Mosaic	24	13	54.5	R	0	0	0.0
Riverine Chenopod Woodland/Plains Grassland Mosaic	1,113	266	23.9	V, R	0	15	0.0
Riverine Ephemeral Wetland	1	1	100.0	R	0	1	0.0
Riverine Grassland	65	62	95.4	R	0	61	0.0
Riverine Grassy Woodland	56,116	28,684	51.1		3,376	13,054	6.0
Riverine Grassy Woodland/Grassy Riverine Forest-Riverine Swamp Forest Complex	0	0	100.0	R	0	0	0.0
Riverine Grassy Woodland/Plains Woodland Complex	1,355	283	20.9	V, R	0	42	0.0
Riverine Grassy Woodland/Plains Woodland/Gilgai Wetland Complex	829	146	17.6	V, R	0	6	0.0
Riverine Grassy Woodland/Plains Woodland/Riverine Chenopod Woodland Complex	1,131	280	24.8	V, R	0	1	0.0
Riverine Grassy Woodland/Riverine Chenopod Woodland/Wetland Mosaic	50	9	18.5	V, R	0	0	0.0
Riverine Grassy Woodland/Riverine Swamp Forest Mosaic	14	14	100.0	R	0	14	0.0
Riverine Grassy Woodland/Riverine Swampy Woodland Mosaic	13,942	4,250	30.5		12	1,022	0.1
Riverine Grassy WoodlandSedgy Riverine Forest Mosaic	885	566	63.9	R	0	532	0.0
Riverine Swamp Forest	12,687	12,043	94.9		34	11,234	0.3
Riverine Swamp Forest/Riverine Swampy Woodland Mosaic	55	55	100.0	R	0	51	0.0

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Riverine Swamp Forest/Sedgy Riverine Forest Mosaic	475	396	83.3	R	13	265	2.8
Riverine Swamp Forest/Sedgy Riverine Forest-Riverine Swamp Forest Complex	1,325	1,218	91.9		0	1,160	0.0
Riverine Swamp Forest/Spike-sedge Wetland Mosaic	6	6	100.0	R	0	6	0.0
Riverine Swamp Forest/Tall Marsh Mosaic	573	573	100.0	R	0	573	0.0
Riverine Swampy Woodland	8,938	6,182	69.2		48	3,542	0.5
Riverine Swampy Woodland/Lignum Wetland Mosaic	5,824	2,231	38.3		8	210	0.1
Riverine Swampy Woodland/Plains Grassy Wetland Mosaic	308	30	9.7	E, R	1	0	0.3
Riverine Swampy Woodland/Sedgy Riverine Forest Mosaic	348	345	99.2	R	0	321	0.0
Rocky Outcrop Shrubland	141	43	30.4	R	0	1	0.0
Rushy Riverine Swamp	293	206	70.4	R	0	193	0.0
Saline Lake Mosaic	182	181	99.0	R	35	141	19.0
Samphire Shrubland	1,351	1,266	93.7		307	518	22.7
Sand Ridge Woodland	1,845	727	39.4	R	1	124	0.1
Sandstone Ridge Shrubland/Low Rises Woodland Mosaic	147	8	5.3	E, R	0	0	0.0
Sedgy Riverine Forest	17,613	16,534	93.9		203	14,183	1.2
Sedgy Riverine Forest/Riverine Swamp Forest Complex	3,876	3,831	98.8		0	3,737	0.0
Sedgy Riverine Forest/Spike-sedge Wetland Mosaic	0	0	100.0	R	0	0	0.0
Sedgy Riverine Forest/Tall Marsh Mosaic	2	2	100.0	R	0	2	0.0
Semi-arid Chenopod Woodland	33,408	20,148	60.3		1,977	7,589	5.9
Semi-arid Parilla Woodland	1,839	482	26.2	V, R	18	233	1.0
Semi-arid Woodland	18,870	12,337	65.4		7,137	3,567	37.8
Shallow Freshwater Marsh	619	618	99.9	R	43	572	7.0
Shrubby Dry Forest	9	8	84.1	R	0	0	0.0
Shrubby Riverine Woodland	7,961	7,950	99.9		2,373	4,915	29.8
Spike-sedge Wetland	795	726	91.3	R	78	615	9.8
Spike-sedge Wetland/Tall Marsh Mosaic	59	59	100.0	R	50	9	84.5
Sub-saline Depression Shrubland	1,011	932	92.1	R	113	664	11.2
Swampy Riparian Woodland	9	3	37.5	R	0	1	0.0
Swampy Woodland	9,937	1,712	17.2	V	0	384	0.0

1	2	3	4	5	6	7	8
Ecological Vegetation Classes (EVCs)	Area in ha		Percent Remaining	Conservation Status	Area in ha		Dedicated Reserves as % of Pre-1750 Extent
	Pre-1750 Extent	Current Extent			Dedicated Reserve System	Other Public Land	
Tall Marsh	1,437	1,411	98.2		53	1,291	3.7
Tall Marsh/Aquatic Herbland Mosaic	7	7	100.0	R	0	7	0.0
Tall Marsh/Non-Vegetation Mosaic	16	16	100.0	R	0	16	0.0
Tall Marsh/Open Water Mosaic	185	184	99.7	R	0	156	0.0
Tall Marsh/Riverine Swamp Forest Mosaic	3	3	100.0	R	0	3	0.0
Valley Grassy Forest	1,560	214	13.7	V, R	0	28	0.0
Valley Grassy Forest/Grassy Dry Forest Mosaic	3	1	35.7	R	0	0	0.0
Wetland Formation	11,885	3,625	30.5		24	255	0.2
Woorinen Mallee	2,465	1,393	56.5		668	486	27.1
Woorinen Sands Mallee	2,672	2,450	91.7		2,265	33	84.8
water body - natural or man made	6,000	6,646	110.8		307	4,847	5.1
other - natural	3,833	3,822			125	2,175	
Totals:	**1,215,774**	**483,360**	**39.8**		**68,010**	**179,926**	**5.6**

APPENDIX 7: Descriptions of the Main EVCs in the River Red Gum Forests Study Area

Appendix 6 provides definitions of vegetation communities, EVCs, mosaics and complexes. The following pages provide descriptions of the main 34 EVCs in the study area.

EVC 806 Alluvial Plains Semi-arid Grassland

Defining characteristics: Grassland (turf) to herbland with only incidental shrubs. Flood-promoted flora, potentially including a wide range of opportunistic ephemeral / annual species.

Structure: Grassland / herbland - variable according to seasonal conditions and site-wetness, mostly < 0.2 m. The potential dominant, Red-tail Couch *Sporobolus mitchellii*, is a species with warm season growth, with vigour and performance flood-promoted, but apparently not emergent until after flood recession.

Habitat: Low-lying areas within at least previously flood-prone (mostly) higher-level terraces. These can be effectively shallow lakes when flooded. Also sometimes on flats along creeks of the further north-west, in habitat akin to that of Floodway Pond Herbland (which mostly occurs nearer the Murray River).

Floristics: While some examples are virtually devoid of woody plants, incidental shrubs can include Tangled Lignum *Muehlenbeckia florulenta,* Nitre Goosefoot *Chenopodium nitrariaceum*, Streaked Copperburr *Sclerolaena tricuspis* and Spiny Lignum *Muehlenbeckia horrida.* The floristics are quite variable. In less desiccated examples, the vegetation is dominated by Red-tail Couch *Sporobolus mitchellii*. These habitats can be relatively species -poor or include a wide a range of associated species, mostly annual or ephemeral herbs, many of which are shared with more open versions of Lignum Shrubland (with which Alluvial Plains Semi-arid Grassland appears to intergrade). Pale Beauty-heads *Calocephalus sonderi* is sometimes co-dominant (or even effectively dominant in the absence of emergent growth of Red-tail Couch *Sporobolus mitchellii*. A range of other small chenopods (e.g. Bluebush *Maireana* spp., Star Bluebush *Stelligera endecaspinis*) can be present in the drier north-west. Additional species commonly recorded within this mapping unit include Salt Sea-spurrey *Spergularia* sp. 3, Grass Cushion *Isoetopsis graminifolia,* Mouse-tail *Myosurus minimus* var. *australis,* Crassula *Crassula* spp., Rough Raspwort *Haloragis aspera*, *Goodenia* spp., Clay Plantain *Plantago cunninghamii,* River Bluebell *Wahlenbergia fluminalis,* Hairy Burr-daisy *Calotis hispidula,* Hard-head Daisy *Brachyscome lineariloba,* Variable Daisy *Brachyscome ciliaris,* Rosinweed *Cressa cretica,* Warty Pepper-cress *Lepidium papillosum,* Slender Groundsel *Senecio glossanthus* and Desert Spinach *Tetragonia eremaea s.l.*

Distribution: Lindsay Island, Mulcra Island, Walpolla Island, Kings Billabong. Former distribution possibly obscured by impacts of land-use and altered hydrology in other parts of apparent potential range (e.g. Hattah - Kulkyne).

Vegetation Quality: While this habitat is capable of tolerating prolonged periods without flooding, it seems inevitable that, if sustained into the longer-term, the absence of flooding will result in permanent changes to the floristic composition (including the invasion of species from non-flooded habitats and loss of species dependant on at least occasional flooding). A range of significant flora can occur in this vegetation (including versions transitional to Lignum Shrubland).

EVC 653 Aquatic Herbland

Defining characteristics: Herbland of permanent to semi-permanent wetlands, dominated by sedges (especially on shallower verges) and/or aquatic herbs. Occurs on fertile paludal soils, typically heavy clays beneath organic accumulations. Previously widespread within restricted areas of suitable habitat across the study area but now greatly reduced through draining and use for agriculture.

Structure: Herbland, floating mat to weakly emergent.

Habitat: Permanent to seasonal wetland, in suitably sheltered sites with reliable water supply and soils staying moist at depth.

Floristics: Indicator species*:* Water-milfoil *Myriophyllum* spp., Water-ribbons *Triglochin procerum* spp. agg. with Running Mrash-flower *Villarsia reniformis* / Clove-strip *Ludwigia peploides* subsp. *montevidensis*, and variously Water-lily *Nymphaea* spp., River Buttercup *Ranunculus inundatus,* Australian Lilaeopsis *Lilaeopsis polyantha* and Swamp Crassula *Crassula helmsii*. Diversity is potentially higher on outer fringes, with a range of small herbs (e.g. Floating Club-sedge *Isolepis fluitans*, *Lobelia* spp., Swamp Goodenia *Goodenia humilis,* Centella *Centella cordifolia* and/or Shining Pennywort *Hydrocotyle sibthorpioides*).

EVC 829 Chenopod Grassland

Defining characteristics: Open to sparse shrubland with a more or less continuous tussock grass sward found on heavy clay plains fringing the active floodplains of major watercourses such as the Loddon and Avoca.

Structure: Open shrubland to 1 m with an inter-shrub sward of perennial caespitose grasses to 1 m. Short-lived perennial chenopod herbs and annual forbs variously and seasonally dominate the field layer.

Habitat: Occurs on relict alluvial plains and low rises associated with clay lunettes. The soils are commonly grey to red brown clays. Not normally subject to inundation as a consequence of overbank flows from major rivers but poorly drained settings may result in protracted pooling of water in winter months due to heavy rainfall. Typically found in 'inlying' slightly raised parts of the lower reaches of river systems.

Floristics: No remnants of this distinctive and once widespread vegetation formation remain in a substantially intact state in Victoria. As a consequence, detailed floristics cannot be specified. It is thought that divaricately branched chenopod shrubs such as Leafless Bluebush *Maireana aphylla,* Rohrlach's Bluebush *Maireana rohrlachii,* Nitre-bush *Nitraria billardierei* and Hedge Saltbush *Rhagodia spinescens* once dominated

this formation. Tangled Lignum *Muehlenbeckia florulenta* and the tall cane grass Southern Cane-grass *Eragrostis infecunda* may also be occasional co-dominants in localised depressions or gilgai. The inter-shrub spaces are typically dominated by medium to large caespitose grasses, particularly Rigid Panic *Whalleya proluta,* Spider Grass *Enteropogon acicularis,* Plump Spear-grass *Austrostipa aristiglumis*, Copper-awned Wallaby-grass *Austrodanthonia fulva*, and Brown-back Wallaby-grass *Austrodanthonia duttoniana*. Other common perennials include Black Roly-poly *Sclerolaena muricata,* Short-wing Saltbush *Sclerochlamys brachyptera,* Tangled Copperburr *Sclerolaena divaricata,* Bush Minuria *Minuria cunninghamii,* Woolly Buttons *Leiocarpa panaetioides,* Berry Saltbush *Atriplex semibaccata,* Rosinweed *Cressa australis* and Twiggy Lignum *Muehlenbeckia diclina*. The seasonal flora of this EVC would once have been very rich in annuals and geophytes including Sunray *Hyalosperma* spp. Sunray *Rhodanthe* spp. and Swainson Pea *Swainsona* spp.
Distribution: Highly modified and widely cleared, this EVC once occurred widely in the south and south-eastern riverine plains.

EVC 168 Drainage-line Aggregate

Defining characteristics: Eucalypt-dominated woodland with occasional scattered shrub layer over a mostly grassy/sedgy to herbaceous ground-layer. Occurs on low-gradient ephemeral to intermittent drainage lines, typically on fertile colluvial/alluvial soils, on a wide range of suitably fertile geological substrates.
Structure: Varies from grassy wetland to low open herbland or sedgeland, and can develop to a Red Gum Swamp in places.
Habitat: Ephemeral wetlands and floodways along defined drainage-lines on the riverine floodplain.
Floristics: River Red-gum *Eucalyptus camaldulensis*, Spiny Mud-grass *Pseudoraphis spinescens*, River Swamp Wallaby-grass *Amphibromus fluitans,* Common Spike-sedge *Eleocharis acuta,* Love Grass *Eragrostis* spp., small annuals such as Button Rush *Lipocarpha microcephala*, Fringe Sedge *Fimbristylis* spp., and various Sedge *Carex* spp. Potentially diverse range of associated species, variously including Water Ribbons *Triglochin procera* s.l.*,* Upright Water-milfoil *Myriophyllum crispatum,* Swamp Lily *Ottelia ovalifolia* subsp *ovalifolia,* Floating Pondweed *Potamogeton tricarinatus,* Common Sneezeweed *Centipeda cunninghamii,* Yellow Twin-heads *Eclipta platyglossa,* Knotweed *Persicaria* spp., Dock *Rumex* spp., Hypsela *Hypsela tridens,* Poison Pratia *Lobelia concolor,* Matted Starwort *Stellaria caespitosa*, and River Bluebell *Wahlenbergia fluminalis*. Total species richness can be high due to the complexity of microhabitats.

EVC 809 Floodplain Grassy Wetland

Defining characteristics: Wetland dominated by floating aquatic grasses (which persist to some extent as turf during drier periods), occurring in the most flood-prone riverine areas. Typically treeless, but sometimes with thickets of saplings or scattered more mature specimens of River Red-gum *Eucalyptus camaldulensis*.

Structure: Floating emergent aquatic grassland or turf-like grassland sward, according to prevailing conditions (in particular the relevant stage of flood cycles). Typically <15 cm emergent, but stoloniferous aquatic growth may exceed two metres, persisting as thick mats until grazed or cut back by frosts following flood recession.

Habitat: Temporary shallow lakes in the most flood-prone areas. This vegetation type also occurs as a narrow intermediate band around floodway ponds - between the outer zone dominated by Common Spike-sedge *Eleocharis acuta* and the Floodway Pond Herbland typically dominated by Sneezeweed *Centipeda* spp. and Small Knotweed *Polygonum plebium* (or sometimes Common Blown-grass *Lachnagrostis filiformis*, particularly during dry periods).

Floristics: Typically dominated by Spiny Mud-grass *Pseudoraphis spinescens*, sometimes with associated species including Common Spike-sedge *Eleocharis acuta*, Creeping Knotweed *Persicaria prostrata*, Common Blown-grass *Lachnagrostis filiformis*, Native Couch *Cynodon dactylon* var. *pulchellus*, Rat-tail Couch *Sporobolus mitchellii* and Sneezeweed *Centipeda* spp. Further upstream (e.g. Barmah), River Swamp Wallaby-grass *Amphibromus fluitans* (often with open Giant Rush *Juncus ingens*) can also locally dominate or co-dominate vegetation of similar character. Ranges (both spatially and temporally) from virtually monospecific (at optimum development) to diverse with opportunistic species.

Distribution: Rare, small areas dispersed localities.

Vegetation Quality: While a naturally very restricted vegetation type within the study area, Floodplain Grassy Wetland can be presumed to have become even rarer as a consequence of reduced flooding. Introduced species are opportunistic in this habitat during dry phases only.

EVC 56 Floodplain Riparian Woodland

Defining characteristics: An open woodland dominated by River Red-gum *Eucalyptus camaldulensis* over a medium to tall shrub layer with a ground layer consisting of amphibious and aquatic herbs and sedges.
Habitat: Occurs along the banks and floodplains of the larger meandering rivers and major creeks, often in conjunction with one or more floodplain wetland communities. Elevation and rainfall are relatively low and soils are fertile alluviums subject to periodic flooding and inundation.
Floristics: River Red-gum *Eucalyptus camaldulensis* is the typical dominant overstorey species. The occasional specimen of Manna Gum *E. viminalis* and Mountain Swamp Gum *E. camphora* or Swamp Gum *E. ovata* may occur in the upper reaches of the Ovens, King and Kiewa Rivers in transition to other EVCs such as Riparian Forest or Swampy Woodland. Shrubs are predominantly Silver Wattle *Acacia dealbata*, and Tree Violet *Hymenanthra dentata*. The ground cover on the drier, elevated banks consists mainly of Common Tussock Grass *Poa labillardierei* with other species such as Bent-grass *Deyeuxia* spp. On the wetter, lower banks Tall Sedge *Carex appressa*, Common Reed *Phragmites australis*, Silky Browntop *Eulalia aurea*, and various Rush *Juncus* spp. and Sedge *Cyperaceae* spp. occur. Spike-sedge *Eleocharis sphaecalata*, Knotweed *Persicaria* spp. and other aquatic species are found in the low-lying wetland areas with a range of herbs occupying the seasonally exposed soil.
Comments: Floodplain Riparian Woodland represents a

mosaic of terraces, active floodways and former channels, and as such is not readily amenable to simple floristic description. In many instances, stream regulation has diminished the extent of flooding.

EVC 172 Floodplain Wetland Aggregate

Collective label for the various zones of vegetation associated with wetlands of riparian floodplains, best developed in association with Floodplain Riparian Woodland. Potentially includes mosaics of scrub/shrubland, reedbed, sedgeland, rushland, grassland and/or herbland zones. The following components are variously recognisable within Floodplain Wetland Aggregate: Aquatic Herbland, Aquatic Sedgeland, Tall Marsh, Floodway Pond Herbland and Dwarf Floating Aquatic Herbland. Billabong Wetland is also an aggregate EVC including many of these components.

EVC 810 Floodway Pond Herbland

Defining characteristics: Low herbland on the drying mud of floors of ponds on floodway systems (mainly riverine floodplains).
Structure: Low herbland, treeless (or virtually so), usually with a high content of ephemeral species.
Habitat: Drying mud within ponds on floodplains. It can also occur as a temporal component within some variants of Billabong Wetland Aggregate, in association with other wetland types.
Floristics: The floristics can be quite variable (both spatially and temporally), according to the traits of the relevant individual pond. The following generalised floristic variations are noted. The floristics also vary in temporal cycles and probably between seasons at some locations.

- Common Sneezeweed *Centipeda cunninghamii* – Matted Starwort *Stellaria caespitosa* (Riverine : mainly Barmah - Tocumwal, but extending upstream along tributaries - e.g. Loddon River at Lanacoorie)
- Knotweed *Persicaria* spp. (widespread, mainly south of divide, but also e.g. eastern end Barmah Forest)
- Globular Pigweed *Dysphania glomulifera* subsp. *glomulifera* – Fringe Sedge *Fimbystylis* spp. (rare and inadequately known, on sandy substrates - e.g. Dead River at Ulupna Island, Tarma at Barmah Forest)
- *Mallee* Floodway Pond Herbland : Sneezeweed *Centipeda* spp., Small Knotweed *Polygonum plebium* (Carpet Weed *Glinus* spp., Creeping Knotweed *Persicaria prostrata*, Globular Pigweed *Dysphania glomulifera* subsp. *glomulifera*, Joyweed *Alternanthera* spp., Common Blown-grass *Lachnagrostis filiformis*; with narrow fringes of Spiny Mud-grass *Pseudoraphis spinescens*, Common Spike-sedge *Eleocharis acuta* and sometimes Fen Sedge *Carex gaudichaudiana*). Semi-arid versions can include an increased component of species shared with the lacustrine habitat (notably Southern Liquorice *Glycyrrhiza acanthocarpa*, Heliotrope *Heliotropium* spp. and Small Mud-mat *Glossostigma elatinoides*). On rare occasions can occur in fine-scale mosaic with Floodplain Grassy Wetland. The association of Sneezeweed *Centipeda* spp. and Small Knotweed *Polygonum plebium* (often with Carpet Weed *Glinus* spp.) appears to be rare outside of Murray Mallee, e.g. Yarra River floodplain where apparently very rare and Ulupna Island) - the distinction between this and the *Dysphania - Fimbristylis* variant may be somewhat arbitrary.

Distribution: Widely dispersed along major riparian floodplains, but variable within restricted habitat and selectively depleted. Poorly known outside of Murray River and tributaries.
Vegetation Quality: In the Murray Mallee, subject to invasion by River Red-gum *Eucalyptus camaldulensis* seedlings under reduced frequency and depth of flooding. In general often grazed and vulnerable to hydrological modification and nutrient run-off in agricultural areas.

EVC 945 Floodway Pond Herbland/Riverine Swamp Forest Complex

Defining characteristics: Ground layer dominated by herbaceous species largely shared with floodway ponds (Floodway Pond Herbland/Aquatic Herbland), or virtually absent (due to thick accumulations of forest litter or persistence of black water, or sometimes excluded by dense thickets of young River Red-gum *Eucalyptus camaldulensis* regeneration).
Structure: Tall woodland or open forest (20 to 40+ m) with low herbaceous ground layer, to a mosaic of herbland (to 0.8 m, but mostly less than 0.2 m) with regeneration thickets of saplings (to c. 20 m).
Habitat: Occurs along floodway systems on low-lying terraces. Some occurrences appear to be a reflection of conditions naturally intermediate between the habitats of the respective EVCs, while others are within areas subject to ecological process, including ecological change due to decreased flooding.
Floristics: Major species vary between the two areas where the complex is documented.

- Murray Mallee – River Red-gum *Eucalyptus camaldulensis* with Common Blown-grass *Lachnagrostis filiformis*, Common Sneezeweed *Centipeda cunninghamii*, Joyweed *Alternanthera* spp. and Knotweed *Persicaria* spp. - especially Creeping Knotweed *P. prostrata* (sparse Common Spike-sedge *Eleocharis acuta* or Spiny Mud-grass *Pseudoraphis spinescens*; variously Indian Cudweed *Gnaphalium polycaulon*, Couch *Cynodon dactylon* var. *pulchellus*, Spreading Sneezeweed *Centipeda minima* s.s. and Yellow Twin-heads *Eclipta platyglossa*).
- Mid-Murray (e.g. Barmah) – River Red-gum *Eucalyptus camaldulensis* with Common Blown-grass *Lachnagrostis filiformis* and *Lachnagrostis filiformis* var. 2, Matted Starwort *Stellaria caespitosa*, Sneezeweed *Centipeda* spp., especially Common Sneezeweed *C. cunninghamii*, Lesser Joyweed *Alternanthera denticulata*, Knotweed *Persicaria* spp. (Creeping Knotweed *P. prostrata*, Slender Knotweed *P. decipiens*, Water Pepper *P. hydropiper*), Upright Water-milfoil *Myriophyllum crispatum*, Common Spike-sedge *Eleocharis acuta* (sometimes with a component of Giant Rush *Juncus ingens*, Flecked Flat-sedge *Cyperus gunnii* subsp. *gunnii* or Bulrush *Typha* spp.).

The abundance of annual species can be highly variable between seasons (and equivalent seasons in different years).
Distribution: Widely dispersed, but within restricted habitat along the Murray River and major tributaries.
Vegetation Quality: Sites supporting Floodway Pond Herbland / Riverine Swamp Forest Complex are typically

undergoing floristic change as a consequence of changed hydrology (reduced flooding, and in parts of Barmah Forest, increased incidence of minor summer flooding).

EVC 106 Grassy Riverine Forest

Defining characteristics: Open eucalypt forest (to woodland) with grassy understorey, dominated by species indicative of at least occasional flooding, but also tolerant of sustained dry periods.
Structure: Open forest to tall open forest or tall woodland, with (tufted) grassy understorey.
Habitat: More elevated flood-prone river terraces (or otherwise free-draining if in locations subject to deeper or more frequent inundation).
Floristics: River Red-gum *Eucalyptus camaldulensis* with Warrego Summer-grass *Paspalidium jubiflorum* dominant in the groundlayer (associated species include Common Sneezeweed *Centipeda cunninghamii*, Woodland Swamp-daisy *Brachyscome basaltica* var. *gracilis*, River Bluebell *Wahlenbergia fluminalis*, Flat Spurge *Chamaesyce drummondii*, Cotton Fireweed *Senecio quadridentatus*, Slender Dock *Rumex brownii* and Native Couch *Cynodon dactylon* var. *pulchellus*; with Common Spike-sedge *Eleocharis acuta* relatively minor if present).
Distribution: Widespread along Murray River, in most areas within restricted habitat (lower terraces), rare in far north-west.
Vegetation Quality: While a number of introduced species are often present in the vegetation, Warrego Summer-grass *Paspalidium jubiflorum* tends to retain dominance in the absence of other major forms of disturbance. This vegetation type occurs within a zone that mostly still receives some flooding. While indicative of flood-prone areas and only producing vigorous growth in warm weather following flooding, tussocks of Warrego Summer-grass *Paspalidium jubiflorum* are able to persist over a number of seasons without flood.

EVC 812 Grassy Riverine Forest/Riverine Swamp Forest Complex

Defining characteristics: Eucalypt forest of flood-prone areas, where the understorey dominants (e.g. Common Spike-sedge *Eleocharis acuta* and/or Spiny Mud-grass *Pseudoraphis spinescens*) of Riverine Swamp Forest are conspicuous in association or fine-scale mosaic with the larger tussock species (Warrego Summer-grass *Paspalidium jubiflorum*) characteristic of Grassy Riverine Forest.
Structure: Usually a tall open forest to open forest (sometimes woodland), with a grassy-herbaceous ground-layer (to c. 1 m).
Habitat: Grassy Riverine Forest/Riverine Swamp Forest Complex occurs in flood-prone areas, where inundation is regular but mostly shallower or less frequent/sustained relative to sites supporting Riverine Swamp Forest. These include broad shallow floodways and low-lying river terraces prone to reasonably regular flooding.
Floristics: River Red-gum *Eucalyptus camaldulensis*, with Warrego Summer-grass *Paspalidium jubiflorum*, in association or mosaic with Common Spike-sedge *Eleocharis acuta* and/or Spiny Mud-grass *Pseudoraphis spinescens* (other conspicuous species variously include Knotweed *Persicaria* spp. - in particular Creeping Knotweed *P. prostrata*, Native Couch *Cynodon dactylon* var. *pulchellus*, Common Sneezeweed *Centipeda cunninghamii*, Yellow Twin-heads *Eclipta platyglossa*, Riverina Bitter-cress *Cardamine moirensis*, Lesser Joyweed *Alternanthera denticulata* s.l., Common Blown-grass *Lachnagrostis filiformis*, Spreading Sneezeweed *Centipeda minima* subsp. *minima* s.s. and River Bluebell *Wahlenbergia fluminalis*).
Distribution: Scattered distribution along river, but very restricted outside of Barmah Forest.

EVC 813 Intermittent Swampy Woodland

Defining characteristics: Eucalypt (*Acacia*) woodland with (variously shrubby) rhizomatous sedgy - turf grass understorey, at best development dominated by flood stimulated species in association with flora tolerant of inundation.
Structure: Woodland with (variously shrubby) rhizomatous grassy - sedgy (to herbaceous) ground-layer.
Habitat: Floristics are indicative of flooding which is unreliable but extensive when it happens and usually also traces of salinity. Low elevation areas on river terraces (mostly at the rear of point-bar deposits or adjacent to major floodways) and lacustrine verges (where sometimes localised to narrow transitional bands). Soils often have a shallow sand layer over heavy and frequently slightly brackish soils.
Floristics: River Red-gum *Eucalyptus camaldulensis* with Eumong *Acacia stenophylla* (+/- Black Box *Eucalyptus largiflorens* and relatively open Tangled Lignum *Muehlenbeckia florulenta*). Floristics is variable and often appears skewed by disturbance. Major species include Rat-tail Couch *Sporobolus mitchellii,* Spiny Flat-sedge *Cyperus gymnocaulos,* Rosinweed *Cressa australis,* Rough Raspwort *Haloragis aspera,* Common Sneezeweed *Centipeda cunninghamii,* Spreading Nut-heads *Sphaeromorphaea australis,* Blue Rod *Stemmodia florulenta,* Common Blown-grass *Lachnagrostis filiformis,* River Bluebell *Wahlenbergia fluminalis* and Pale Beauty-heads *Calocephalus sonderi,* with Warrego Summer-grass *Paspalidium jubiflorum* typically a very minor species present. On flood-prone sandy terraces connected to the river or major floodway creeks, Love-grass *Eragrostis* spp. and Native Couch *Cynodon dactylon* var. *pulchellus* can be locally dominant - this variant is transitional towards Riverine Swamp Forest. The relevant habitat is extremely restricted, and the sandy terraces variant is very rare - small areas are known from Belsar Island and Barmah Forest.
Distribution: In further North-West Victoria, Intermittent Swampy Woodland is of scattered distribution along Murray River, mostly downstream of Robinvale but extending to near the Murrumbidgee River confluence (e.g. Lake Walla Walla and Lindsay Island, Kings Billabong, Kulkyne Forest and presumed formerly extensive along the Chalka Creek system at Hattah Lakes).
Vegetation Quality: The relevant vegetation is extensively invaded by *Fog-fruit *Phyla canescens* at Kings Billabong, and in general floristically altered through desiccation and grazing (extremely so at Hattah). The EVC is quite variable, and may have included a number of communities, but the original floristic patterns are often obscured by the impacts of disturbance (grazing and desiccation).

EVC 107 Lake Bed Herbland

Defining characteristics: Herbland dominated by species adapted to drying mud within lake beds. Some evade periods of prolonged inundation as seed, others as dormant tuber-like rootstocks.

Structure: Herbland, varying from very low to medium height (0.02 -) 0.1- 0.5 (- 1.0 m), sometime with low open shrubland component to 0.5 m. Subject to invasion by River Red-gum *Eucalyptus camaldulensis* seedlings under reduced frequency and depth of flooding - sometimes with regeneration thickets of young trees.

Habitat: Drying deep-cracking mud of lakes on floodplains. While flooding events are mostly intermittent, lakes can retain water for several or more seasons. Actively growing at the drying mud stage. Typically heavy clay soils. This vegetation can be in temporal phase with the open water / bare mud 'unvegetated' unit.

Floristics: Can vary seasonally, depending on when and how much water has been available / other seasonal conditions. The main native species include Southern Liquorice *Glycyrrhiza acanthocarpa,* Australian Hollyhock *Malva australiana* s.l.*,* Clammy Goosefoot *Chenopodium pumilio,* Heliotrope *Heliotropium* spp. and Small Mud-mat *Glossostigma elatinoides*. Oondoroo *Solanum simile* is also reported as being abundant on occasions at some sites. Other species that are present at some sites include Mallee Cucumber *Mukia micrantha,* Glaucous Goosefoot *Chenopodium glaucum,* Heliotrope *Heliotropium* spp. and Hairy Carpet-weed *Glinus lotoides*. In sites where inundation periods are not too extended (and grazing pressure has not eliminated the species), the low shrub Spiny Lignum *Muehlenbeckia horrida* can also be locally conspicuous.

Distribution: Very localised habitat, mainly at Hattah Lakes, Lake Walla Walla and Lake Bael Bael.

Vegetation Quality: Annual or other opportunistic species may colonise or invade during dry phases, especially in lakes that are now rarely filled. In the extreme, a low open chenopod shrubland can develop, in which species including Ruby Saltbush *Enchylaena tomentosa* var*. tomentosa,* Nodding Saltbush *Einadia nutans* subsp*. nutans,* Flat-top Saltbush *Atriplex lindleyi* and a range of introduced annuals predominate, sometimes along with sparse drought-stressed individuals of indicator species such as Southern Licquorice *Glycyrrhiza acanthocarpa*. While the vegetation is typically treeless, thickets of saplings of River Red-gum *Eucalyptus camaldulensis* can be present on the outer verges (or across the beds of less frequently inundated shallow lakes), indicative of a process of contraction of the vegetation type due to decreased flooding.

Comments: Some wetlands of depressions on higher terraces in the north-west may have supported vegetation referrable to this EVC. The EVC is also presumed to have had additional limited occurrences within shallow lakes in the general vicinity of Mildura, in habitats now extremely altered by saline discharges.

EVC 808 Lignum Shrubland

Defining characteristics: Relatively open shrubland of species of divaricate growth form. The ground-layer is typically herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods. The shrubs are of more open and even distribution and of relatively small stature in comparison to the denser thickets of robust lignum with patchy open areas included in Lignum Swamp. Species diversity is typically much higher (and consistent through the vegetation) in Lignum Shrubland, whereas most of the species diversity in Lignum Swamp occurs within gaps in the thicket.

Structure: Shrubland/open shrubland, with ground-layer herbaceous or a turf grassland, rich in annual/ephemeral herbs and small chenopods.

Habitat: Heavy soil plains along Murray River, low-lying areas on higher-level (but still potentially flood-prone) terraces. Flooding is mostly now rare due to reduced peak river flows.

Floristics: Tangled Lignum *Muehlenbeckia florulenta* and/or Nitre Goosefoot *Chenopodium nitrariaceum* (sometimes Cane Grass *Eragrostis australasica*) with diverse ground-layer small chenopods and annual herbs. Two structural variants are noted - these may each include more than one floristic variant.

1) Riverine Lignum Shrubland

Tangled Lignum *Muehlenbeckia florulenta* and/or Nitre Goosefoot *Chenopodium nitrariaceum* (or sometimes Cane Grass *Eragrostis australasica*); +/- Warrego Summer-grass *Paspalidium jubiflorum* and Streaked Cooperburr *Sclerolaena tricuspis* (common species include Short-wing Saltbush *Sclerochlamys brachyptera,* Clay Plantain *Plantago cunninghamii, Goodenia* spp., Leek Lily *Bulbine semibarbata*, Hard-head Daisy *Brachsycome lineariloba,* Fringed Brachyloma *Brachyscome ciliatum,* Grass Cushion *Isoetopsis graminifolia,* Paper Sunray *Rhodanthe corymbiflora,* Slender Groundsel *Senecio glossanthus,* Desert Spinach *Tetragonia eremaea* s.l*,* Slender-fruit Saltbush *Atriplex leptocarpa,* Hairy Burr-daisy *Calotis hispidula,* Pale Beauty-heads *Calocephalus sonderi* and Rat-tail Couch *Sporobolus mitchellii).*

2) Tall Cane Grass Lignum Shrubland

Cane Grass *Eragrostis australasica* is rare and localised in north-western Victoria, but potentially locally dominant within small areas of suitable habitat. In the further north-west, associated species include Common Blown-grass *Lachnagrostis filiformis,* Twin-leaf Bedstraw *Asperula gemella,* Nitre Goosefoot *Chenopodium nitrariaceum,* Pale Spike-sedge *Eleocharis pallens* and Tall Fireweed *Senecio runcinifolius*. These occurrences are here considered a variant of Lignum Shrubland, at least in the case of the far north-western examples.

Distribution: Dicot shrub (riverine) communities: Murray River in further north-west, downstream from Belsar Island, also including Walpolla Island, Mulcra Island, Lindsay Island, Lake Walla Walla, and presumably formerly Hattah - Kulkyne. Cane Grass communities: Rare and localised in Victoria - e.g. with floristic variants in the far north-west (south of Lindsay and Walpolla Islands).

Vegetation Quality: Riverine Community - While the component species are tolerant of prolonged periods without flooding, this vegetation type appears vulnerable to floristic changes (possibly including loss of the structural dominants) in the longer-term, due to reduced river flows. Annual grasses and medics can be very prevalent in the vegetation, particularly in more open variants and where grazing has been more intense. Nevertheless, a high diversity of native herbs is often detectable in relatively intact examples. The relative abundance of *Sporobolus* and *Eragrostis* spp. is difficult to reliably assess under conditions of desiccation.

EVC 104 Lignum Swamp

Defining characteristics: Typically treeless, with dense and robust (but sometimes patchy) growth of lignum. Gaps in the denser vegetation may occur in association with lower-lying areas where water persists longer - these may support cane-grass, sedgeland and / or ephemeral herbs. The character of the vegetation of these gaps varies with time since flooding and disturbance history.

Structure: Shrubland to closed scrub, to 3-4 m. Usually herbland or sedgeland in gaps, mostly <0.5m.

Habitat: Backplains and shallow depressions on floodplains. Commonly associated with other low-lying areas such as insipient drainage lines, relict lakebeds and floodways. Soils are typically heavy cracking grey or black clays. It is tolerant of prolonged inter-flood phases - up to 8 years - and extended periods – up to 3 months - of shallow inundation

Floristics: Tangled Lignum *Muehlenbeckia florulenta*, with associated species including Common Spike-sedge *Eleocharis acuta,* Pale Beauty-heads *Calocephalus sonderi,* Tall Fireweed *Senecio runcinifolius,* Twin-leaf Bedstraw *Asperula gemella,* Common Nardoo *Marsilea drummondii* and sometimes Southern Cane-grass *Eragrostis infecund*a. Denser patches may comprise a virtually mono-specific inter-woven tangle of Tangled Lignum *Muehlenbeckia florulenta*. Some examples may have included Cane Grass *Eragrostis australasica*, however most instances where the latter is present appear to be best referred to the more open and species-rich, less robust shrublands of Lignum Shrubland. In the further north-west, a range of chenopods can be present, notably Streaked Copperburr *Sclerolaena tricuspis* and Flat-top Saltbush *Atriplex lindleyi*, however Nitre Goosefoot *Chenopodium nitrariaceum* is characteristically absent from well-developed examples of Lignum Swamp.

Distribution: Loddon River floodplain south of Kerang, and scattered downstream of Mitchell Lagoons, including Hattah-Kulkyne (where degraded). Particularly robust examples occur at Mulcra Island. A more open vegetation dominated by Tangled Lignum *Muehlenbeckia florulenta* at Lake Walla Walla has substantial floristic differences (see relevant comments within the description of Lignum Shrubland).

Vegetation Quality: In the further north-west, a range of chenopods is present, notably Streaked Copperburr *Sclerolaena tricuspis*. While some floristic differences in the vegetation of the further north-west can be attributed to inherent environmental factors, there is strong evidence of invasion of a range of species from the adjacent Riverine Chenopod Woodland as a consequence of reduced flooding. Tangled Lignum *Muehlenbeckia florulenta* can be displaced by a combination of desiccation and grazing such as occurs at Hattah. A particularly extensive example of Lignum Swamp is believed to have formerly occurred at Karadoc Swamp, but the prior vegetation has been eliminated by salinisation. It is considered that Lignum Swamp has contracted in extent (e.g. from floodway systems on higher terraces at Walpolla Island and Lindsay Island) as a consequence of reduced frequency and amplitude of flooding.

EVC 823 Lignum Swampy Woodland

Defining characteristics: Understorey dominated by Tangled Lignum *Muehlenbeckia florulenta*, typically of robust character and relatively dense (at least in patches), in association with a low Eucalypt and/or *Acacia* woodland. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.

Structure: Woodland or open woodland to c. 10 (-15) m, with well-developed shrub layer to c. 2 - 3 m, residue of understorey mostly < 1m.

Habitat: Shallow wetland associated with floodway systems on (relatively) higher terraces. Soils are heavy and water-retentive.

Floristics: The tallest stratum is dominated by Eumong *Acacia stenophylla* and Black Box *Eucalyptus largiflorens*, with River Red-gum *Eucalyptus camaldulensis* sometimes also present. A shrub layer of Tangled Lignum *Muehlenbeckia florulenta* is conspicuous. Common associated species variously include Southern Cane-grass *Eragrostis infecunda,* Common Nardoo *Marsilea drummondii,* Twin-leaf Bedstraw *Asperula gemella,* Variable Daisy *Brachyscome ciliaris,* Pale Beauty-heads *Calocephalus sonderi,* Nodding Saltbush *Einadia nutans* subsp. *nutans,* Slender Groundsel *Senecio glossanthus,* Warrego Summer-grass *Paspalidium jubiflorum,* Flat-top Saltbush *Atriplex lindleyi,* Slender-fruit Saltbush *Atriplex leptocarpa,* Native Peppercress *Lepidium pseudohyssopifolium,* Tall Fireweed *Senecio runcinifolius,* Salt Sea-spurrey *Spergularia* sp. 3*,* Annual Cudweed *Euchiton sphaericus,* Rat-tail Couch *Sporobolus mitchellii* and Common Spike-sedge *Eleocharis acuta.* Nitre Goosefoot *Chenopodium nitrariaceum* is characteristically rare if at all present. Similarly absent are the range of other shrubs (e.g. Wattle *Acacia* spp., Emu-bush *Eremophila* spp., Weeping Pittosporum *Pittosporum angustifolium*) which are characteristic of relatively intact Riverine Chenopod Woodland.

Distribution: Scattered on Murray River floodplain generally west of Nathalia.

Vegetation Quality: This vegetation is vulnerable to desiccation from prolonged reduced flooding - local severe die back of the major structural dominants was observed in places (notably on Walpolla Island). Many examples include a conspicuous component of shrubby chenopods (notably *Enchylaena tomentosa* and *Sclerolaena tricuspis*), particularly in the further north-west. It is considered likely that these species have invaded or at least substantially increased as a reflection of reduced flooding. *Muehlenbeckia florulenta* is vulnerable to prolonged desiccation and heavy grazing.

EVC 102 Low Chenopod Shrubland

Defining characteristics: Low chenopod – dominated, largely treeless shrublands occupying the highest terraces on the floodplain of the Murray River and other major river systems such as the Loddon. Also found in narrow bands fringing raak and saline lakes such as Lake

Tyrell and on relict lakebed surfaces such as Pine Plains.
Structure: Open shrubland to 1 m (but typically less), with a field layer variously and seasonally dominated by short lived perennial chenopod herbs, caespitose grasses, annual forbs and prostrate succulent herbs
Habitat: Occurs in areas with a distinctly semi-arid climate on relict alluvial plains and abandoned stream structures typically lightly mantled with parna. These plains are rarely flooded but are poorly drained and may be subject to periods of inundation following heavy rains. The soils are commonly grey to brown clays and duplex soils with loamy clays and loams above clay sub-soils. Occupies plains – formed by recent alluvial processes with insignificant topographic relief. Not subject to inundation as a consequence of overbank flows from major rivers but poorly drained settings may result in protracted pooling of water in winter months due to heavy rainfall. The climate can be described as semi-arid to arid with low but highly variable rainfall. Soils are typically clays with minor or shallow deposition of aeolian materials at the surface. Surface soils are red-brown sandy clay loams and sandy clays giving way to heavier textured brown-grey clay soils within 50 cm of the surface. The soils are sub-saline (sodic) with comparatively high EC (generally above 2 dS/m and up to 9 dS/m) at depth and high pH (generally above 8) at or near the surface, due to the proximity of saline groundwater and the shallow surface deposition of reworked Woorinen sediments respectively.
Floristics: Trees are virtually absent from this EVC due to summer drought stress in the heavy textured soils – occasional Umbrella Wattle *Acacia oswaldii* or Cattle-bush *Alectryon oleifolius* subsp. *canescens* may be present on slightly deeper drifts of coarser soils. Two relatively distinct floristic entities are here described.
The shrub layer is variously dominated by Bladder Saltbush *Atriplex vesicaria,* Desert Glasswort *Pachycornia triandra,* Nitre-bush *Nitraria billardierei* and other perennial woody chenopods such as Kidney Saltbush *Atriplex stipitata,* Thorny Lawrencia *Lawrencia squamata,* Twin-flower Saltbush *Dissocarpus biflorus* var. *biflorus* and depending on the degree to which saline groundwater affects the site various Sea Heath *Frankenia* species. A range of Copperburr *Sclerolaena* species may also be prevalent – becoming more so following heavy grazing episodes, protracted dry spells or flooding – including Tangled Copperburr *S. divaricata,* Limestone Copperburr *S. obliquicuspis,* Grey Copperburr *S. diacantha* and Streaked Copperburr *S. tricuspis*. Old-man Saltbush *Atriplex nummularia* is occasional in areas receiving local runoff. The ground layer is highly variable and composition responds readily to the vagaries of the prevailing weather. In particular, the season of significant rainfall events may promote a significantly different suite of annual taxa. Some common species include Rounded Noon-flower *Disphyma crassifolium* subsp. *clavellatum*, Pale Beauty-heads *Calocephalus sonderi,* Desert Spear-grass *Austrostipa eremophila,* Yakka Grass *Sporobolus caroli,* Bristly Wallaby-grass *Austrodanthonia setacea*, Rough Spear-grass *Austrostipa scabra,* Windmill Grass *Chloris truncata,* Pink Bindweed *Convolvulus erubescens* s.l., Hairy Bluebush *Maireana pentagona,* Goat Head *Malacocera tricornis,* Babbagia *Osteocarpum acropterum* var. *diminuta,* Woolly-fruit Bluebush *Eriochiton sclerolaenoides* Short-wing Saltbush *Sclerochlamys brachyptera,* Shrubby Twin-leaf *Zygophyllum aurantiacum* subsp. *aurantiacum,* Bristly Love-grass *Eragrostis setifolia,* Hairy Bluebush *Maireana pentagona,* and Flat-top Saltbush *Atriplex lindleyi, Frankenia* spp., Common White Sunray *Rhodanthe floribunda,* Warty Pepper-cress *Lepidium papillosum,* Small Podolepis *Podolepis muelleri*, and Yellow Tails *Ptilotus nobilis* var. *nobilis.* In temporarily wet depressions, Cane Grass *Eragrostis australasica* maybe locally common to dominant and on localised areas of saline clay Slender Glasswort *Sclerostegia tenuis* becomes an important and often dominant component of the vegetation.
Distribution: Large relatively intact remnants of the northern floristic variant of this EVC persist on the raised tertiary terraces of the Murray river floodplain downstream of Mildura – the soils generally being too heavy and the climate too dry for cropping. The fringes of the major discharge basins throughout the study area including the Sunset Raak Plains, Rocket Lake, Lake Tyrrell, and deflations in the Morkalla and Murrayville area. This EVC has proved to be sensitive to the impacts of grazing and historic records show that saltbush plains were once scattered throughout the study area as far south as Pine Plains in Wyperfeld National Park.
Comments: The EVC is quite variable, and may have included a number of communities, but the original floristic patterns are often obscured by the impacts of disturbance (grazing and desiccation).

EVC 66 Low Rises Woodland

Defining characteristics: Eucalypt woodlands on elevated plains, and low rises with a diverse shrub understorey and grassy field layer.
Habitat: Occurs in a range of environmental settings that have resulted in well-drained surface soils mantling clay sub-soils. Within the study area, it typically occurs on deep fans of weathered Parilla sandstone on the margins and crests of broad or subdued sandstone ridges and residuals but may also occur on source-bordering sand deposits such as lunettes. The duplex soils are typically well-drained, brown sandy clay-loam surface soils above heavy to medium clay sub-soils. This rather abrupt textural change usually occurs at 20-60 cm.
The climate across the range of this EVC is variable but is generally high – in comparison with most of the study area. The average annual precipitation is calculated to be 435 mm with a median annual rainfall of 367 mm.
Structure: Woodland to 20 m with an open tall shrub stratum to 3 m. Smaller shrubs are common above a generally grassy field layer of tussock and sward grasses.
Floristics: Across most of its range within the study area the characteristic overstorey trees are Buloke *Allocasuarina luehmanni,* Yellow Gum *Eucalyptus leucoxylon* (typically Waxy Yellow Gum *Eucalyptus leucoxylon* subsp. *pruinosa*) and Slender Cypress-pine *Callitris gracilis* subsp. *murrayensis.*
A storied shrub layer is usually well developed in less disturbed remnants of this EVC. Commonly encountered species include Hooked Needlewood *Hakea tephrosperma,* Sweet Bursaria *Bursaria spinosa* subsp. *spinosa,* Golden Wattle *Acacia pycnantha,* Moonah *Melaleuca lanceolata* subsp. *lanceolata,* Sweet

Quandong *Santalum acuminatum,* Leafless Ballart *Exocarpos aphyllus,* Sugarwood *Myoporum playtcarpum,* Weeping Pittosporum *Pittosporum angustifolium,* Wedge-leaf Hop-bush *Dodonaea viscosa* subsp. *cuneata,* Gold-dust Wattle *Acacia acinacea* s.l., Grey Mulga *Acacia brachybotrya,* Common Eutaxia *Eutaxia microphylla* var. *microphylla,* Pimelea Daisy-bush *Olearia pimeleoides* and Ruby Saltbush *Enchylaena tomentosa* var. *tomentosa.*
The field layer across the range of this broad EVC is variable. It is typically dominated by a sward of caespitose grasses such as Common Wallaby-grass *Austrodanthonia caespitosa,* Bristly Wallaby-grass *Austrodanthonia setacea,* Spider Grass *Enteropogon acicularis,* Grey Tussock-grass *Poa sieberiana* var. *sieberiana* and Common Wheat-grass *Elymus scaber* var. *scaber*. Common inter-tussock herbs and semi-shrubs include Mallee Flax-lily *Dianella* sp. aff. *revoluta* (Mallee), Wingless Bluebush *Maireana enchylaenoides,* Frosted Goosefoot *Chenopodium desertorum,* Sticky Sword-sedge *Lepidosperma viscidum,* Fuzzy New Holland Daisy *Vittadinia cuneata,* Lemon Beauty-heads *Calocephalus citreus,* Grassland Wood-sorrel *Oxalis perennans,* Mulla Mulla *Ptilotus exaltatus*, Variable Sida *Sida corrugata,* Scented Mat-rush *Lomandra effusa,* Nodding Saltbush *Einadia nutans* subsp. *nutans* and Cut-leaf Goodenia *Goodenia pinnatifida.*
Distribution: Scattered on riverine plains between Swan Hill and Cobram. Widely cleared for cereal cropping.

EVC 132 Plains Grassland

Defining characteristics: Tussock grassland, rich in a wide variety of (mostly perennial) forbs, particularly *Asteraceae*, geophytes and small chenopods. Woody plants are absent.
Habitat: Moderately poorly drained quaternary alluvial and paleo-lacustrine clay deposits in areas with less than 500mm/pa rainfall. Poor drainage characteristics of the substrates are attributed as the principal reason for the absence of trees and larger shrubs.
Floristics: As so few examples remain, it is difficult to assemble the true floristic nature of this EVC. Remnants are often dominated by Rough Spear-grass *Austrostipa scabra* and/or Common Wallaby-grass *Austrodanthonia caespitosa*, although a number of other dominants may be encountered, and there is little confidence that the above species are the true dominants of pre-European vegetation.
On the heaviest soils, often demonstrating a 'gilgai' nature, Plump Spear-grass *Austrostipa aristiglumis* and Brown-back Wallaby-grass *Austrodanthonia duttoniana* are the dominant tussocks. Rigid Panic *Whalleya proluta* and Common Tussock-grass *Poa labillardierei* may also be present (the latter less so). A range of forbs adapted to an edaphic environment which may experience both seasonal waterlogging and summer moisture deficit occur in the inter-tussock spaces. Such forbs include Rosinweed *Cressa australis,* Pale Beauty-heads *Calocephalus sonderi,* Milky Beauty-heads *Calocephalus lacteus,* Paper Sunray *Rhodanthe corymbiflora,* Joyweed *Alternanthera* spp., Rough Burr-daisy *Calotis scabiosifolia,* Woodland Swamp-daisy *Brachyscome basaltica* var. *gracilis* Prickly Woodruff *Asperula scoparia,* Poison Pratia *Lobelia concolor,* Broughton Pea *Swainsona procumbens,* Prickfoot *Eryngium vesiculosum,* and Long Eringyum *Eryngium paludosum.*
In areas experiencing less waterlogging, the original dominants are thought to be (variously) Kangaroo Grass *Themeda triandra* or Spider Grass *Enteropogon acicularis,* with the latter dominating in slightly wetter areas. Geophytes are prevalent in this vegetation and include lilies such as Bulbine Lily *Bulbine bulbosa,* Milkmaids *Burchardia umbellata,* Blue Grass-lily *Caesia calliantha,* Small Vanilla-lily *Arthropodium minus,* Chocolate Lily *Arthropodium strictm* s.l, Common Early Nancy *Wurmbea dioica* and Yellow Star *Hypoxis glabella* s.l.. Other forbs include Grassland Wood-sorrel *Oxalis perennans,* Blushing Bindweed *Convolvulus angustissimus,* Lemon Beauty-heads *Calocephalus citreus,* Cut-leaf Burr-daisy *Calotis anthemoides,* Blue Devil *Eryngium ovinum,* Cut-leaf Goodenia *Goodenia pinnatifida,* Variable Sida *Sida corrugata,* Frosted Goosefoot *Chenopodium desertorum,* Wingless Bluebush *Maireana enchylaenoides,* Bottle Bluebush *Maireana excavata,* Hairy Bluebush *Maireana pentagona*, Black Cotton-bush *Maireana decalvans,* Yam Daisy *Microseris scapigera* spp.agg., Woolly New Holland Daisy *Vittadinia gracilis,* Nodding Saltbush *Einadia nutans subsp. nutans,* Berry Saltbush *Atriplex semibaccata,* and Mulla Mulla *Ptilotus exaltatus..*
Distribution: Formerly on heavy soil plains west of Echuca in the Victorian Riverina such as the Patho Plains.

EVC 55 Plains Grassy Woodland

Defining characteristics: An open, eucalypt woodland occurring on a number of geologies and soil types. Occupies poorly drained, fertile soils on flat or gently undulating plains at low elevations. The understorey consists of a few sparse shrubs over a species-rich grassy and herbaceous ground layer.
Structure: An open woodland with an understorey of scattered shrubs and a high species diversity of grasses, sedges, lilies, orchids and herbs.
Floristics: Dominanted by River Red-gum *Eucalyptus camaldulensis* and often Grey Box *Eucalyptus microcarpa*. The shrub layer includes Gold-Dust Wattle *Acacia acinacea*, Hedge Wattle Acacia paradoxa, Dwarf Bush-pea *Pimelea humilis*, Guinea-flower *Hibbertia* spp, Sweet Bursaria *Bursaria spinosa* and occasionally *Acacia williamsonii* Whirrakee Wattle near creeks around Broadford. Black Wattle *Acacia mearnsii* may also occur in the south west of the study area. The ground layer includes: a dense layer of Kangaroo Grass *Themeda triandra*, Spear grasses *Stipa* spp., and Common Wheat-grass *Elymus scaber var. scaber*. Typical forbs include Blue Devil *Eryngium ovinum*, Common Everlasting, *Chrysocephalum apiculatum* s.l., Lemon Beauty-heads *Calocephalus citreus*, Pale Sundew *Drosera peltata*, Pink Bindweed *Convolvulus erubescens*, Scaly Buttons *Leptorhyncos squamatus*, Chocolate Lily *Arthropodium strictum* s.l., Early Nancy *Wurmbea diocea*, Yellow Rush-lily *Tricoryne elatior*, Bulbine Lily *Bulbine bulbosa*, Common Onion-orchid *Microtis unifolia* and Milkmaids *Burchardia umbellata*. Sedges and rushes present include Common Bog-sedge *Schoenus apogon*, Club Sedge *Isolepis* spp., Sedge *Carex* spp. and Rush *Juncus* spp.
Distribution: Formerly an extensive distribution across the southern and eastern Victorian Riverina in areas of higher effective rainfall than Plains Woodland.

EVC 803 Plains Woodland

Defining characteristics: Grassy woodland, rich in small chenopods and annual or geophytic forbs, occurring on non-riverine alluvial deposits. Outside of included small seasonal wetlands or associated gilgai depressions lacking flood dependant species in the ground-layer.

Structure: Woodland (sometimes including areas of tussock grassland). In most remnants, shrubs are a minor component, but it is considered that the abundance and diversity of the shrub layer has generally been reduced in diversity by grazing.

Habitat : Low-lying areas within former drainage systems on heavy soils plains. The habitat is not subject to flooding, though can include low-lying seasonally water-logged areas. Clay alluvial soils, sometimes with shallow sandy overlay, at elevations of c. 70 - 130 m.

Floristics: The overstorey comprises Black Box *Eucalyptus largiflorens* (sometimes with other box eucalypts, e.g. Grey Box *Eucalyptus microcarpa*, Yellow Box *Eucalyptus melliodora)* and/or Buloke *Allocasuarina luehmannii*, with sometimes scattered Gold-dust Wattle *Acacia acinacea* s.l. in the understorey. Other rarely encountered shrubs include Umbrella Wattle *Acacia oswaldii*, Golden Wattle *Acacia pycnantha,* Small Hop-bush *Dodonaea bursariifolia,* Silver Needlewood *Hakea leucoptera* subsp*. leucoptera,* Weeping Pittosporum *Pittosporum angustifolium,* Pale-fruit Ballart *Exocarpos strictus,* Water Bush *Myoporum montanum,* Sugarwood *Myoporum platycarpum* subsp. *platycarpum*, Common Eutaxia *Eutaxia microphylla,* Cranberry heath *Astroloma humifusum* and Peach Heath *Lissanthe strigosa* subsp*. subulata*. A grassy ground layer is dominated by species of Wallaby-grass *Austrodanthonia* and Spear-grass *Austrostipa* and a diversity of small chenopod (saltbush) species. Main dominants in the ground layer include Bristly Wallaby-grass *Austrodanthonia setacea,* Rough Spear-grass *Austrostipa scabra* subsp. *falcata,* Kneed Wallaby-grass *Austrodanthonia geniculata,* Common Wheat-grass *Elymus scaber var. scaber,* Grey Tussock-grass *Poa sieberiana* and Nigger-heads *Enneapogon nigricans* or with associated species including Mallee Love-grass *Eragrostis dielsii*, Spider Grass *Enteropogon acicicularis* and a diverse range of small chenopods, mainly Bluebush *Maireana* spp. (Wingless Bluebush *Maireana enchylaenoides*, Black Cotton-bush *Maireana decalvans*), Saltbush *Atriplex* spp. (Berry Saltbush *Atriplex semibaccata*, Small Saltbush *Atriplex eardleyae*, Mealy Saltbush *Atriplex pseudocampanulata*, Flat-top Saltbush *Atriplex lindleyi*), Ruby Saltbush *Enchylaena tomentosa* var. *tomentosa* and Nodding Saltbush *Einadia nutans* subsp*. nutans*. In relatively intact sites, a range of forbs and sedges can be found such as Sheep's Burr *Acaena echinata,* Blushing Bindweed *Convolvulus angustissimus,* Smooth Solenogyne *Solenogyne dominii,* Common Early Nancy *Wurmbea dioica,* Common Bog-sedge *Schoenus apogon,* Twining Fringe-lily *Thysanotus patersonii,* Ruby Saltbush *Enchylaena tomentosa* var*. tomentosa,* and Lemon Beauty-heads *Calocephalus citreus.* Small ephemeral depressions support Common Swamp Wallaby-grass *Amphibromus nervosus* and Spike-sedge *Eleocharis* spp. with a range of small herbs indicative of ephemeral wetland within gilgai terrain, or otherwise seasonally waterlogged soils, broader-scale wetland and species indicative of more sustained or deeper inundation are absent.

Distribution: Scattered in heavy soil areas of drier parts of the Northern Plains but principally around the fringes of the Murray River and Loddon River floodplains, but habitat now largely modified and few relatively intact remnants persist.

EVC 18 Riparian Forest

Defining characteristics: A tall forest along river banks and associated alluvial terraces with occasional occurrences in the heads of gullies leading into creeks and rivers.

Habitat: Confined to river flats, alluvial terraces and perennial streams on Quaternary alluviums derived from a variety of parent geologies.

Structure: A tall eucalypt forest over an open to secondary tree layer of wattles and scattered dense patches of shrubs, ferns, grasses and herbs.

Floristics: The overstorey is dominated by Manna Gum *Eucalyptus viminalis* though a range of other eucalypts may be present including Narrow-leaf Peppermint Eucalyptus radiata s.l. and Eurabbie *Eucalyptus globulus* subsp. *bicostata.* The EVC has a well-developed secondary tree layer with Blackwood *Acacia melanoxylon* and Silver Wattle *Acacia dealbata* being common.
A diversity of tall shrubs, also common to Wet or Damp Forest, form a major component in the understorey including Hazel Pomaderris *Pomaderris aspera*, Tree Lomatia *Lomatia fraseri* and Prickly Currant-bush *Coprosma quadrifida*.
The ground layer is generally diverse in both species and life forms. Due to the constant supply of water and, in many cases shade, ground ferns form a major component of Riparian Forest, often lining the stream-banks and are dispersed across the flats in moister sites. Common ferns include Fishbone Water-fern *Blechnum nudum*,, Soft Water-fern *Blechnum minus*, Mother Shield-fern *Polystichum proliferum* and Soft Tree-fern *Dicksonia antarctica.* Tall Sedge *Carex appressa* often dominates stream banks and the more open areas.
The most common forbs are Ivy-leaf Violet *Viola hederacea*, Bidgee Widgee *Acaena nova-zelandiae*, Creeping Cudweed *Euchiton involucratus* s.l. and Small-leaf Bramble *Rubus parvifolius*. Common grasses include Weeping Grass *Microlaena stipoidse* var*. stipoides*, Common Hedgehog-grass *Echinopogon ovatus* and Yorkshire Fog **Holcus lanatus* in disturbed sites. The common and seriously invasive weeds of this EVC are Willow **Salix* spp,, .Blackberry **Rubus fruticosus* spp. agg., Cat's Ear **Hypochoeris radicata*, Self Heal **Prunella vulgaris*, Yorkshire Fog **Holcus lanatus*, Musk Monkey Flower **Mimulus moschatus* and White Clover **Trifolium repens*.

EVC 103 Riverine Chenopod Woodland

Defining characteristics: Eucalypt woodland of most elevated riverine terraces, intact examples with a diverse shrubby-grassy understorey. Formerly prone to irregular shallow flooding.

Habitat: Heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.

Structure: Woodland, mostly, < c. 15 m but to c. 25 m in mature examples. In relatively intact examples the understorey is shrubby-grassy and can be rich in annual species. Where present the shrub component is to 2 (-5) m, with the grassy-herbaceous component typically mostly < 0.2 (-0.5) m) - depending on current grazing pressure.
Floristics: Dominated by an overstorey of Black Box *Eucalyptus largiflorens* (and in some areas Grey Box *Eucalyptus microcarpa*) with a characteristic salt-bush dominated understorey. Common species include Nodding Saltbush *Einadia nutans* subsp. *nutans,* and Ruby Saltbush *Enchylaena tomentosa* var. *tomentosa.* Other less common species are Prickly Saltwort *Salsola tragus,* Slender-fruit Saltbush *Atriplex leptocarpa,* Small Saltbush *Atriplex eardleyae,* Black Cotton-bush *Maireana decalvans,* Grey Roly-poly *Sclerolaena muricata* var *villosa,* Hedge Saltbush *Rhagodia spinescens,* Berry Saltbush *Atriplex semibaccata,* Sprawling Saltbush *Atripex suberecta,* Old-man Saltbush *Atriplex nummularia,* Mealy Saltbush *Atripex pseudocampanulata,* Flat-top Saltbush *Atriplex lindleyi,* Beaded Glasswort *Sarcocornia quinqueflora,* Leafless Bluebush *Maireana aphylla,* Rounded Noon-flower *Disphyma crassifolium* subsp. *clavellatum,* Saloop *Einadia hastata,* Cottony Saltbush *Chenopodium curvispicatum,* Nitre Goosefoot *Chenopodium nitrariaceum* and Tangled Lignum *Muehlenbeckia florulenta*.
A number of shrubs can also be present, including Emu-bush *Eremophila* spp. – Bignonia Emu-bush *Eremophila bignoniiflora,* Spotted Emu-bush *Eremophila maculata* var. *maculata* and Spreading Emu-bush *Eremophila divaricata* subsp. *divaricata*; also Wattle *Acacia* spp. - variously including Eumong *Acacia stenophylla,* Hakea Wattle *Acacia hakeoides* and Willow Wattle *Acacia salicina*. Small locally elevated areas can have a mixture of Black Box *Eucalyptus largiflorens* and Moonah *Melaleuca lanceolata* subsp. *lanceolata* - these represent a transition towards Semi-arid Woodland and are delineated below as Black Box - Moonah Woodland. Similarly, the woody species Cattle Bush *Alectryon oleifolius* subsp. *canescens* and Slender Cypress-pine *Callitris gracilis* subsp. *murrayensis* can be sparsely present in some drier sites. Many areas are severely disturbed by grazing and have a high proportion of introduced grasses.
Common introduced grasses include *Perennial Rye-grass *Lolium perenne,* *Soft Brome *Bromus hordeaceus* subsp. *hordeaceus,* *Sterile Brome *Bromus sterilis,* *Rat's-tail Fescue *Vulpia myuros,* *Squirrel-tail Fescue *Vulpia bromoides,* *Spider Grass *Enteropogon acicularis and* *Barley-grass *Hordeum murinum* s.l. In contrast Bristly Wallaby-grass *Austrodanthonia setacea* and Warrego Summer-grass *Paspalidium jubiflorum* are the only common native grass species although Rough Spear-grass *Austrostipa scabra* subsp. *falcata* may be present.
A diverse range of ephemeral/annual herbs and semi-shrubs include Hairy Burr-daisy *Calotis hispidula,* Sand Spurrey *Spergularia* sp. 3, Slender-fruit Saltbush *Atriplex leptocarpa,* Variable Daisy *Brachyscome ciliaris,* Leek Lily *Bulbine semibarbata,* Pale Beauty-heads *Calocephalus sonderi,* Crassula *Crassula spp*., Nodding Saltbush *Einadia nutans subsp. nutans,* Peppercress *Lepidium* spp., Clay Plantain *Plantago cunninghamii,* Variable Sida *Sida corrugata,* Common Nardoo *Marsilea drummondii,* Slender Groundsel *Senecio glossanthus, Goodenia* spp.. The following variations are noted:
Distribution: Widespread along Murray River downstream from Gunbower and major Wimmera drainage lines and Loddon River floodplains.
Vegetation Quality: Relatively intact remnants of Riverine Chenopod Woodland are extremely rare due to modification through grazing and reduced incidence and extent of flooding. Large Saltbush *Atriplex* spp., notably Old-man Saltbush *Atriplex nummularia* have declined greatly as a consequence of grazing in most former habitats. Remnants of the habitat (e.g. around small lakes) can also be vulnerable to salinization. These modifications include reduction of diversity, notably loss of shrubby species, increases in abundance of species from drier habitats and reduction in the vigour of the structural dominant. In some areas grazing and desiccation have resulted in woodland vegetation with a grassy understorey, typically dominated by Bristly Wallaby-grass *Austrodanthonia setacea* (or sometimes Rough Spear-grass *Austrostipa scabra* subsp. *falcata*) and introduced annuals. In such situations a component of more resilient chenopod species is usually present. In some localities, notably at Hattah, extension of wind-blown sand into former Riverine Chenopod Woodland has resulted in major floristic changes, with colonisation of species indicative of adjacent non-riverine vegetation (e.g. Tangled Burr-daisy *Calotis erinacea*, Poached-eggs Daisy *Polycalymma stuartii,* Velvet Tobacco *Nicotiana velutina,* Cushion Knawel *Scleranthus miniscuIus,* Purslane *Calandrinia* spp.). This change appears to be permanent and ultimately at the EVC level, with future recruitment of Black Box *Eucalyptus largiflorens* in these areas now appearing ecologically impossible.
Comments: Riverine Chenopod Woodland is potentially subject to only incidental shallow flooding from the most extreme inundation events (e.g. once in a hundred year floods) and would generally not be considered as functionally representing wetland. Due to the drought conditions of 2002 when the survey was carried out, herbaceous species were rare but Paper Sunray *Rhodanthe corymbiflora* and Woolly Buttons *Leiocarpa panaetioides* may be more common after spring rains.
A variable component of associated shrubby chenopods (e.g. Ruby Saltbush *Enchylaena tomentosa* var. *tomentosa,* Streaked Copperburr *Sclerolaena tricuspis,* Hedge Saltbush *Rhagodia spinescens*) reflects both inherent site factors and disturbance history.

EVC 295 Riverine Grassy Woodland

Defining characteristics: Eucalypt woodland of relatively elevated sections of floodplain, understorey grassy (to lightly shrubby), dominated by species not ecologically reliant on flooding (but tolerant of relatively brief and superficial inundation).
Structure: Woodland to c. 25 m, often lower. The understorey is generally dominated by tussock grasses, sometimes lightly shrubby or with chenopod semi-shrubs. The ground-layer is typically grazed by kangaroos to <0.1 m height.
Habitat: Prone to high-level flooding only and thus occupies the least flooded red gum environment and occasionally grades into mixtures with Black Box

Eucalyptus largiflorens and Grey Box *Eucalyptus microcarpa*. This is reflected in reduced tree height, frequently severe crown die-back and an open woodland formation that includes many of the low shrubs that occur scattered in the Black Box and Grey Box woodlands. It occupies higher ground throughout the forest and along the river levees. The understorey is dominated by species that respond to winter and spring rains and do not depend upon flooding. Soils are often sandy to silty.
Floristics: Overstorey of River Red-gum *Eucalyptus camaldulensis*, variously with a component of Black Box *Eucalyptus largiflorens*. There is generally a sparse scattering of low shrubs frequently including Nodding Saltbush *Einadia nutans* subsp. *nutans* but Berry Saltbush *Atriplex semibaccata,* Small Saltbush *Atriplex eardleyae,* Grey Roly-poly *Sclerolaena muricata* var*. villosa,* Ruby Saltbush *Enychlaena tomentosa* var*. tomentosa,* Black Cotton-bush *Maireana decalvans,* Cottony Saltbush *Chenopodium curvispicatum* and Prickly Saltwort *Salsola tragus* occasionally occur at different times.
The ground-layer is grassy and potentially herb-rich in relatively intact vegetation. The dominant ground-layer species are Bristly Wallaby-grass *Austrodanthonia setacea* and Rough Spear-grass *Austrostipa scabra.* The dominant native grass Bristly Wallaby-grass *Austrodanthonia setacea* is one of the few able to persist under grazing pressure. Other native grasses rarely recorded include Common Wallaby-grass *Austrodanthonia caespitosa,* Velvet Wallaby-grass *Austrodanthonia pilosa* and Rough Spear-grass *Austrostipa scabra*. Other persistent species in the ground-layer include Nodding Saltbush *Einadia nutans* subsp*. nutans,* River Bluebell *Wahlenbergia fluminalis,* Knob Sedge *Carex inversa,* Grassland Wood-sorrel *Oxalis perennans,* Finger Rush *Juncus subsecundus,* Slender Dock *Rumex brownii,* Cotton Fireweed *Senecio quadridentatus,* Cranesbill *Geranium* sp., Variable Sida *Sida corrugata,* Fuzzy New Holland Daisy *Vittadinia cuneata,* Woolly New Holland Daisy *Vittadinia gracilis* and Black Roly-poly *Sclerolaena muricata.* Dominant weeds include *Soft Brome *Bromus hordeaceus* subsp*. hordeaceus,* *Red Brome *Bromus rubens* and *Barley-grass *Hordeum murinum* s.l.
Distribution: Once common along Murray River floodplain downstream from Lake Hume to Echuca and in small, localised patches downstream of Echuca.
Vegetation Quality: Typically it has been heavily overgrazed in Gunbower State Forest. Less flood-prone areas along river banks are prone to degradation and weed invasion as a consequence of intensive recreational use (and at least elsewhere concentration of herbivores during flood events).

EVC 814 Riverine Swamp Forest

Defining characteristics: Tall open eucalypt forest (to woodland), to 30 - 40 m or more in height with understorey dominated by obligate wetland species (or opportunistic annuals during sustained dry periods).
Structure: Tall open forest (to woodland). The ground-layer can range from +/- low closed sedgeland or herbland to grassy-herbaceous (mostly < O.3 m emergent) or extremely sparse and with cover primarily leaf-litter, black water or exposed alluvium.
Habitat: Low-lying areas subject to reasonably regular flooding, typically flood-prone lower river terraces and low-lying areas adjacent to floodways through or within riverine forest, recorded from elevation of c. 95 - 135 m.
Floristics: River Red-gum *Eucalyptus camaldulensis* with species-poor ground-layer dominated by Spiny Mud-grass *Pseudoraphis spinescens* and/or Common Spike-sedge *Eleocharis acuta*, (locally) River Swamp Wallaby-grass *Amphibromus fluitans*, or sometimes bare (leaf-litter/mud). Where present, associated species variously include Common Blown-grass *Lachnagrostis filiformis*, Riverina Bitter-cress *Cardamine moirensis*, Ferny Small-flower Buttercup *Ranunculus pumilio*, Water Ribbons *Triglochin procera* s.l. and Common Sneezeweed *Centipeda cunninghamii*).
[On localised areas of flood-prone sandy terraces, connected to the river or major floodway creeks, Love-grass *Eragrostis* spp. and Native Couch *Cynodon dactylon* var. *pulchellus* can be locally dominant.
Distribution: Restricted, by far the most extensive occurrences at Barmah.
Vegetation Quality : Often subject to modification due to changed river flows. Grazed by cattle (and brumbies) at Barmah, and subject to intense pugging. Feral pigs can also create considerable soil disturbance within the relevant habitat.

EVC 815 Riverine Swampy Woodland

Defining characteristics: Eucalypt woodland to open woodland, ground-layer grassy to sedgy - herbaceous, with species indicative of periodic water-logging (and with floristic affinities with Plains Grassy Wetland).
Structure: Seasonally wet herbland, grassland or open woodland (to woodland), sometimes with treeless grassy /sedgy areas; ground-layer grassy to sedgy – herbaceous.
Habitat: Areas subject to shallow inundation only from higher-level flooding. Soils are typically heavy, cracking mottled grey-brown clays/clay-loams and water-retentive, often with a gilgai profile which can be wet during winter. Site range in elevation from c. 95 - 150 m.
Floristics: River Red-gum *Eucalyptus camaldulensis* (sometimes with scattered Black Box *E. largiflorens*), with species including Brown-back Wallaby-grass *Austrodanthonia duttoniana*, Common Swamp Wallaby-grass *Amphibromus nervosus*, Common Spike-sedge *Eleocharis acuta*, Small Spike-sedge *Eleocharis pusilla*, Poison Pratia *Lobelia concolor*, River Bluebell *Wahlenbergia fluminalis*, *Goodenia* spp., Burr-daisy *Calotis* spp., Nardoo *Marsilea* spp. and Woodland Swamp-daisy *Brachyscome basaltica* var. *gracilis*. Sparse tussocks of Poong'ort *Carex tereticaulis* or Warrego Summer-grass *Paspalidium jubiflorum* can also be present.
Distribution: Mostly Murray River system upstream of Wakool Junction. Depleted and rare, most extensive at Barmah and upstream to Lake Hume. Grey Box *Eucalyptus microcarpa* dominated variant occurs in seasonally wet sites in the central area of the riverine plains, e.g. Echuca and Shepparton districts
Vegetation Quality: Distribution of remnants requires further investigation. Much of the former extent is cleared and heavily modifed by agricultural use. The former habitat of the Grey Box dominated variant in particular is mainly in private ownership. Most remnants are grazed.

EVC 264 Sand Ridge Woodland

Defining characteristics: Open pine-box woodland with a small or medium shrub layer of variable density and including a range of annual herbs, grasses and geophytes, in the dense ground layer. Occupies distinctive sandy rises (or sand mounts) adjacent to major rivers and wetlands. Very sandy, deep, free-draining, moderately fertile soil, developed on sand blown up by wind action from a prior stream bed.

Habitat: Source-bordering dunes composed of deep sandy soils support this vegetation. These soils types are developed on sand blown up by wind action from the prior stream bed.

Structure: A woodland to low open forest. The understorey appears to be dominated by grasses at the sites in Victoria, however less disturbed remnants in N.S.W. have a moderately dense shrub layer.

Floristics: The overstorey is often dominated by White Cypress-pine *Callitris glaucophylla* with Yellow Box *Eucalyptus melliodora* and Drooping Sheoke *Allocasuarina verticillata*. Sites adjacent to the riverine environment may also support River Red-gum *Eucalyptus camaldulensis*. Shrubs recorded from a range of sites include: Common Fringe-myrtle *Calytrix tetragona*, Grey Mulga *Acacia brachybotrya*, Lightwood *Acacia implexa*, Golden Wattle *Acacia pycnantha*, Mallee Wattle *Acacia montana*, Gold-dust Wattle *Acacia acinacea*, Weeping Pittosporum *Pittosporum angustifolium*, Sweet Bursaria *Bursaria spinosa*, and Drooping Cassinia *Cassinia arcuata*. The few native ground layer species detected in Victoria provide an indication of the distinctive and unusual flora. Grasses are Jericho Wire-grass *Aristida jerichoensis* var. *subspinulifera* and Purple Wire-Grass *Aristida personata*, Summer Grass *Digitaria* spp., Hairy Panic *Panicium effusum*, Nigger-heads *Enneapogon nigricans*, Common Wheat-grass *Elymus scaber* var. *scaber* and Spear Grasses *Austrostipa* spp. including (yet to be confirmed) Balcarra Spear-grass *Austrostipa nitida*. Herbs include Blue-bush, *Maireana* spp., Small Scurf-pea *Cullen parvum*, and Smooth Minuria *Minuria integerrima.*

Historical records indicate a number of species which once occurred on sandy ridges : Silver Banksia *Banksia marginata*, Yarran Wattle *Acacia omalophylla*, and Hooked Needlewood *Hakea tephrosperma*. Sand ridges adjacent to rivers may also have supported River Bottlebrush *Callistemon sieberi* on the fringe. Northern Sandalwood *Santalum lanceolatum* once occurred on sandy rises near creeks and the Murray River.

Distribution: Within close proximity to the Murray upstream of Echuca and lower Goulburn floodplain.

EVC 816 Sedgy Riverine Forest

Defining characteristics: Eucalypt forest (to woodland) with understorey dominated by larger sedges (to sedgy-herbaceous), floristics with some affinities to Red Gum Swamp.

Structure: Open forest to woodland - at Barmah, mostly c. 20 - 35 m in height, sometimes with taller emergent veteran trees.

Habitat: Typically on heavy clay/clay-loam soils in areas prone to only shallow (but more than occasional and originally reasonably regular) flooding. The habitat can include billabongs, floodways and old anabranches.

Floristics : River Red-gum *Eucalyptus camaldulensis* with Poong'ort *Carex tereticaulis*, with understorey ranging from closed-tussock sedgeland (e.g. at Barmah where including with Marsh Club-sedge *Bolboschoenus medianus*) to more open sedgy-grassy with Warrego Summer-grass *Paspalidium jubiflorum* also present. Other common species include Common Spike-sedge *Eleocharis acuta*, Hollow Rush *Juncus amabilis*, Poison Pratia *Lobelia concolor*, *Brachyscome basaltica* var.*gracilis*, Common Swamp Wallaby-grass *Amphibromus nervosus*, Common Blown-grass *Lachnagrostis filiformis* and Burr-daisy *Calotis* spp., with Small Spike-sedge *Eleocharis pusilla* on drier margins). Where not grazed out of the vegetation, other associated species can include Swamp Starwort *Stellaria angustifolia*, Common Reed *Phragmites australis* and Swamp Billy-buttons *Craspedia paludicola*. Obligate wetland species such as Common Spike-sedge *Eleocharis acuta* and Common Nardoo *Marsilea drummondii* may be prevalent in inter-tussock gaps, but are not dominant over sustained areas - if so, then the vegetation represents a complex with Riverine Swamp Forest.

Distribution: Widespread (within restricted floodplain habitat) in less arid riverine areas, but absent from further north-west of State (Murray River and major tributaries, downstream to Murphy Island near the Murrumbidgee junction).

Vegetation Quality: Remaining areas of Sedgy Riverine Forest are mostly subject to disturbance (variously from timber harvesting, recreational vehicles and/or grazing). Within the Wimmera and outside of larger tracts of riverine forests, substantially reduced by clearing (for grazing land and irrigation farming). Disturbed areas lacking regular flooding are vulnerable to weed invasion, notably by *Fog-fruit *Phyla canescens* along the Murray River (e.g. at Nyah and Vinifera Forests, where the original floristics of this vegetation are almost obscured).

EVC 817 Sedgy Riverine Forest/Riverine Swamp Forest Complex

Defining characteristics: Understorey dominants of Riverine Swamp Forest conspicuous in association or fine-scale mosaic with larger tussock or rhizomatous species characteristic of Sedgy Riverine Forest.

Structure: Eucalypt forest (to tall open forest) with open sedgy-herbaceous ground-layer.

Habitat: Flood-prone areas, where inundation is reasonably regular and reasonably sustained but shallower and typically less frequent or sustained relative to sites supporting Riverine Swamp Forest. Recorded from elevations of c. 80 - 110 m, on mottled heavy clay/clay-loam soils.

Floristics: River Red-gum *Eucalyptus camaldulensis*, with Poong'ort *Carex tereticaulis* and, variously Marsh Club-sedge *Bolboschoenus medianus*, Common Reed *Phragmites australis* and Warrego Summer-grass *Paspalidium jubiflorum* in association or mosaic with Common Spike-sedge *Eleocharis acuta* and/or Spiny Mud-grass *Pseudoraphis spinescens* (also Common Swamp Wallaby-grass *Amphibromus nervosus*, Knotweed *Persicaria* spp. - in particular Creeping Knotweed *P. prostrata*, Common Sneezeweed *Centipeda cunninghamii*, Yellow Twin-heads *Eclipta platyglossa* and Poison Pratia *Lobelia concolor*.

Distribution: Low-lying river terraces prone to reasonably regular flooding, most extensive at Barmah.
Vegetation Quality: In the north-west part of its range, Sedgy Riverine Forest is heavily invaded and largely dominated by the introduced *Fog-fruit *Phyla canescens*. In some areas, particularly where the floodplain is restricted to narrow terraces, the respective habitat is subject to extensive disturbance due to recreational pressure. The respective habitats (of Sedgy Riverine Forest) at Barmah Forest are within areas subject to cattle grazing. However the denser variants of Sedgy Riverine Forest vegetation are mostly of lower interest to cattle, which prefer the more open grassy types of ground-layer. Consequently, while the habitat may be crossed by a network of cattle (and brumby) tracks, it still provides some refugia for a range of relatively grazing-sensitive species. In general it is considered that these species would mostly have been more abundant in other habitats, but have been eliminated either by selective grazing or vulnerability to the deep pugging caused by stock when the soil is wet.

EVC 818 Shrubby Riverine Woodland

Defining characteristics: Eucalypt woodland (to open forest) of less flood-prone (riverine) watercourse fringes, principally on levees and higher sections of point-bar deposits. Understorey includes a range of species shared with drier floodplain habitats (e.g. those supporting Black Box *Eucalyptus largiflorens*), with a sparse shrub component, ground-layer patchily dominated by various growth-forms. A range of large dicot herbs (mostly herbaceous perennial, several with a growth-form approaching that of small shrub) are conspicuous, notably daisies and peas) are conspicuous in relatively intact vegetation.
Structure: Woodland (to open forest), mostly c. 15- 25 m, but sometimes taller with veteran trees. The ground-layer is primarily grassy - herbaceous to c. 1 m. A sparse component of shrubs to 2m or small trees is typically present.
Habitat: River verges (and also along major anabranch creeks), on more elevated portions of lower terraces. Flooding is infrequent, and the habitat is free-draining following recession of floodwaters. The alluvial soils often have a conspicuous sandy component.
Floristics: River Red-gum *Eucalyptus camaldulensis* (+/- Black Box *Eucalyptus largiflorens*, Eumong *Acacia stenophylla*), with open Warrego Summer-grass *Paspalidium jubiflorum* and scattered shrubs including Nitre Goosefoot *Chenopodium nitrariaceum,* Tangled Lignum *Muehlenbeckia florulenta,* Ruby Saltbush *Enchylaena tomentosa* var*. tomentosa and* Hedge Saltbush *Rhagodia spinescens*. Dicot herbs include Branching Groundsel *Senecio cunninghamii* var. *cunninghamii,* Variable Groundsel *Senecio pinnatifolius,* Golden Everlasting *Xerochrysum bracteatum,* Squat Picris *Picris squarrosa*, Grey Germander *Teucrium racemosum* s.l*.,* Austral Trefoil *Lotus australis,* Blue Burr-daisy *Calotis cuneifolia* and (very localised) Hairy Darling-pea *Swainsona greyana*.
Distribution: Murray River, best developed (both in terms of floristics and extent) at Lindsay Island, Mulcra Island and Walpolla Island (far north-west), but more marginal examples are scattered upstream at least to near the junction with the Wakool River.
Vegetation Quality: Many examples are subject to recreational disturbance due to their proximity to watercourses. In general, weeds appear relatively minor (at least under drought conditions), and vegetation quality is high in areas not subject to major recreational pressure.

EVC 819 Spike-sedge Wetland

Defining characteristics: Low sedgy vegetation of species-poor seasonal or intermittent wetlands, dominated by spike-sedges.
Structure: Sedgeland (typically closed), mostly c. 0.2 - 0.5 m at maximum culm growth, with dead culms forming a dense prostrate mat during drier periods.
Habitat: Mostly confined to a narrow ring around the upper margins of floodway ponds. Soils are typically heavy clays (e.g. mottled yellow-grey clay, grey loamy clay), occasionally silty near the surface. The elevations of quadrat samples range from c. 60 - 130 m but can be presumed to occur over a somewhat wider elevation range. The relevant floristic balance appears to be determined by a subtle combination of reliability/variability, timing and depth of inundation, in association with soil characteristics (such that Common Spike-sedge *Eleocharis acuta* is able to form a competitive sward within stages of very shallow spring to early summer inundation). In some riverine sites, annual inundation is not reliable and the rhizomic rootstocks of Common Spike-sedge *Eleocharis acuta* appear capable of surviving at least occasional periods of longer dormancy.
Floristics: Common Spike-sedge *Eleocharis acuta* (and at some Barmah locations, with Small Spike-sedge *Eleocharis pusilla*). The vegetation is often virtually monospecific, but can be richer in drier or peripheral sites. Typically treeless, but sometimes with thickets of saplings or scattered more mature specimens of River Red-gum *Eucalyptus camaldulensis*. Shallow seasonal wetlands in flood-prone areas, dominated by low sedges that are tolerant of inundation. In its flooded and drying phase, some of the following may be present, Water Ribbons *Triglochin procera s.l.,* Upright Water-milfoil *Myriophyllum crispatum,* Common Nardoo *Marsilea drummondii, Ludwigia peploides* subsp*. montevidensis,* Poison Pratia *Lobelia concolor,* Drain Flat-sedge**Cyperus eragrostis,* Matted Water-starwort *Callitriche sonderi,* and Western Water-starwort *Callitriche cyclocarpa.* In a drier phase*,* Creeping Knotweed *Persicaria prostrata,* Common Blown-grass *Lachnagrostis filiformis* may be the most common associated species. Often dense stands of Cotton Fireweed *Senecio quadridentatus* occur on the margins of this community. Similar vegetation, occurs along many of the deeper creek channels. Where these receive irrigation effluent, some may remain perpetually wet and Water Couch**Paspalum distichum* may be prolific, replacing the Common Spike-sedge *Eleocharis acuta* and Common Sneezeweed *Centipeda cunninghamii.* In wet but unsaturated locations, dense stands of Tall Flat-sedge *Cyperus exaltatus* sometimes occur.
Distribution: Scattered distribution on the Riverina floodplain (eg. Benwell Swamp and Guttram Swamp near Levee Track in Gunbower State Forest)
Vegetation Quality: Spike-sedge Wetland is characteristically species-poor, except around the verges.

However, the species-richness of the relevant systems can be further reduced by grazing of cattle (through selective grazing, pugging and trampling). While reasonably resilient to longer dry periods, deterioration and contraction of riverine floodplain occurrences can be anticipated as a consequence of reduced flooding of the Murray River. When disturbed, Spike-sedge Wetland can be invaded by weeds such as Curled Dock **Rumex crispus*, **Sagittaria* spp., Water Plantain **Alisma lanceolata*, Water Couch**Paspalum distichum* and Lilaea**Lilaea scillioides*.

EVC 820 Sub-saline Depression Shrubland

Defining characteristics: Low open shrubland/herbland of the highest terraces of the former (i.e. pre-1750) Murray River floodplain in far north-west, dominated by chenopods and succulents, occupying semi-saline treeless pans within the Black Box - Chenopod Woodland zone.
Structure: Low open shrubland/herbland, dominated by chenopods and succulents, mostly < 0.5 - 1 m in height.
Habitat: Low-lying areas with very heavy and mildly saline clay soils. On higher terraces, and presumably no longer subject to occasional shallow flooding. Recorded from elevations within the range of c. 30 - 50 m.
Floristics: The major species include Streaked Copperburr *Sclerolaena tricuspis,* Goat Head *Malacocera tricornis* and Rounded Noon-flower *Disphyma crassifolium* subsp. *clavellatum*, variously with Hairy Bluebush *Maireana pentagona* and Rosinweed *Cressa cretica*/Sea Heath *Frankenia* spp./*Sarcocornia* spp.
South of Lindsay River: Streaked Copperburr *Sclerolaena tricuspis,* Goat Head *Malacocera tricornis,* Rosinweed *Cressa cretica,* Rounded Noon-flower *Disphyma crassifolium* subsp. *clavellatum,* Flat-top Saltbush *Atriplex lindleyi,* Hairy Bluebush *Maireana pentagona,* Short-wing Saltbush *Sclerochlamys brachyptera,* Slender Groundsel *Senecio glossanthus,* Salt Sea-spurrey *Spergularia* sp. 3, *Goodenia* spp. and Daisy *Brachyscome* spp.
Lambert Island: *Sarcocornia* spp. and Sea-heath *Frankenia* spp. in association with Streaked Copperburr *Sclerolaena tricuspis.*
Distribution: Very localised in far north-west, most extensive in the vicinity of Lindsay Island, with smaller examples at Walpolla Island and Lambert Island - original extent difficult to ascertain due to habitat degradation.
Vegetation Quality: The former floristics of higher-level floodway depressions are poorly understood due to the impacts of grazing and virtual cessation of higher-level flooding.

EVC 937 Swampy Woodland

Defining characteristics: Open eucalypt woodland with ground-layer dominated by tussock grasses and/or sedges and often rich in herbs. Occurs on poorly drained, seasonally waterlogged heavy soils, primarily on swamp deposits but extending to suitable substrates within some landscapes of sedimentary origin.
Once a common vegetation type along broad drainage lines with slight gradients and on lower slopes near streams or larger rivers, Swampy Riparian Woodland has been largely altered particularly by drainage for agriculture. It may be found growing on lower slopes near streams and less commonly in gentle basins on valley slopes in association with permanent soaks or springs, not necessarily associated with permanent streams. Rainfall is in the range of 900-1500 mm per year and the elevation range is between 300 and 800 m. The soils are generally Quaternary alluviums in stream environments derived from a broad range of parent geologies which are mostly Cambrian and Ordovician marine sediments and metamorphosed sediments.
The woodland overstorey often forms mosaics with wetter treeless areas dominated by sedges, rushes and many other plants associated with riparian environments. Mountain Swamp Gum *Eucalyptus camphora* is the dominant overstorey species. A wide range of other eucalypts can be present, mainly as adventive species from the surrounding drier forests, The understorey shrubs consist of Blackwood *Acacia melanoxylon* (as it rarely reaches tree-form in this community) and Prickly Currant-bush *Coprosma quadrifida.* Common Cassinia *Cassinia aculeata* and Silver Wattle *Acacia dealbata* are also sporadically present as adventive species from the surrounding drier vegetation. Ovens Wattle *Acacia pravissima,* Prickly Tea-tree *Leptospermum continentale* may also be present. The ground stratum is the most characteristic feature of this EVC and is normally dense with sedges such as Leafy Flat-sedge *Cyperus lucidus* and Tall Sedge *Carex appressa* competing for space with ferns like Fishbone Water-fern *Blechnum nudum*, Soft Water-fern *Blechnum minus* and Mother Shield-fern *Polystichum proliferum.* There are many other plants which also occur in Riparian Forest which compete for space between the inter-tussock gaps of sedges and ferns such as Bidgee Widgee *Acaena novae-zelandiae*, Kidney-weed *Dichondra repens*, Cinquefoil Cranesbill *Geranium potentilloides*, Austral Brooklime *Gratiola peruviana*, and Hairy Pennywort *Hydrocotyle hirta.*

EVC 821 Tall Marsh

Defining characteristics: Wetland dominated by tall emergent graminoids, typically in thick species-poor swards. Competitive exclusion in core wetland habitat - of optimum growing conditions for species tolerant of sustained shallow inundation.
Structure: Rushland, sedgeland or reedbed. Usually dense vegetation, varying from locally closed to in association or fine-scale mosaic with Aquatic Herbland (e.g. along floodway lagoons). Mostly within (1-) 2- 4 m height range.
Habitat: Wetlands (usually associated with anabranch creeks) and spontaneous along irrigation drains. Also in altered habitat where high water levels associated with locks create wet terraces, especially on small islands and in areas not subject to grazing by domestic stock. Soils are almost permanently moist. Dominant species are tolerant of relatively deep and sustained inundation, but not total immersion for any sustained period.
Floristics: Sparse specimens of *Eucalyptus camaldulensis* can be present (or form an overhanging canopy along narrow floodways), but well developed examples of this vegetation type are typically treeless or virtually so. In the far north-west, Bulrush *Typha* spp. (mainly Narrow-leaf Cumbungi *Typha domingensis* but tentatively also Broad-leaf Cumbungi *Typha orientalis*) are the usual dominant species, sometimes in association or mosaic with River Club-sedge *Schoenoplectus tabernaemontani.* Common Reed *Phragmites australis* sometimes occurs as

a thin riparian verge, but mostly below map scale. Other graminoids that can be present include Rush *Juncus* spp. such as Giant Rush *Juncus ingens*#and Sedge *Cyperus* spp. A range of aquatic and opportunistic herbaceous species is present in more open areas supporting Bulrush *Typha* spp. (e.g. within floodway channels). Common associated species include Slender Knotweed *Persicaria decipiens,* Pale Knotweed *Persicaria lapathifolia,* Small Loosestrife *Lythrum hyssopifolia,* Pacific Azolla *Azolla filiculoides,* Robust Water-milfoil *Myriophyllum papillosum,* Wavy Marshwort *Nymphoides crenata,* Common Spike-sedge *Eleocharis acuta,* Water Ribbons *Triglochin procera* s.l.*,* Floating Pondweed *Potamogeton tricarinatus* s.l.*,* Clove-strip *Ludwigia peploides* subsp*. montevidensis* and Spiny Mud-grass *Pseudoraphis spinescens.* Under drier conditions Common Sneezeweed *Centipeda cunninghamii,* Lesser Joyweed *Alternanthera denticulata* s.l. and Common Blown-grass *Lachnagrostis filiformis* may be present. Introduced herbaceous species (e.g. Marsh Yellow-cress**Rorippa palustris*, Dock **Rumex* spp., Sow-thistle **Sonchus* spp. and Lettuce **Lactuca* spp.) and the grass Annual Beard-grass **Polypogon monspeliensis* can also be conspicuous, especially during drier periods. In many areas the community has been invaded by Grey Sallow **Salix cinerea*. This Willow is well established along Gunbower Creek.
Distribution: Scattered, mostly as thin strips and disjunct small patches on the riverine floodplain such as on the southern verges of Kings Billabong.
Vegetation Quality: Smaller occurrences are typically highly modified by changed hydrology and weed invasions. Artificial habitats maintained by irrigation water can be colonised by tall emergent graminoids, notably Narrow-leaf Cumbungi *Typha domingensis*. This community occupies all the semi permanent water bodies of Gunbower Forest and has probably experienced a considerable decline with river regulation eg. this vegetation was probably well represented in Black Swamp before the installation of the regulator on Gunbower Creek. Traces of the community can be seen in some of the swamps within Gunbower Forest where they still receive irrigation waters eg. Batemans Lagoon.
Comments: Generally occupies deep water adjacent to the flooded Sedgy Riverine Forest/Riverine Swamp Forest. Tall Marsh can be adventive in Floodplain Grassy Wetland and Floodway Pond Herbland, (and related complexes and mosaics).
Ginat Rush #*Juncus ingens* occupies areas within the forest whose frequency and duration of flooding exceeds the tolerance of forest. Under natural flooding regimes, these low areas may remain flooded into the summer months when air temperatures are high. This feature, when combined with the dense resilient foliage has attracted colonies of breeding water birds in the past. The late spring/early summer flood recession results in high water temperatures and poor soil aeration during the growing season, causing tree death but which can be tolerated by Giant Rush *Juncus ingens*. This species is also capable of withstanding periods of drought provided these are infrequent and of short duration. It is probable that this community has contracted greatly at Gunbower Forest as a result of the hydrological changes that have occurred since flood control and it formerly would have been associated with most of the semi-permanent swamps within the forest. This contraction is still evident at the Reed Beds in Guttram State Forest.

APPENDIX 8: Potentially Threatening Processes in the River Red Gum Forests study area

Potentially threatening processes expected to occur in or have impacts within the River Red Gum Forests study area listed under the *Flora and Fauna Guarantee Act 1988* (FFG) or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC).

Potentially Threatening Process	Act
Alteration to the natural flow regimes of rivers and streams	FFG
Alteration to the natural temperature regimes of rivers and streams	FFG
Collection of native orchids	FFG
Degradation of native riparian vegetation along Victorian rivers and streams	FFG
Habitat fragmentation as a threatening process for fauna in Victoria	FFG
High frequency fire resulting in disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	FFG
Inappropriate fire regimes causing disruption to sustainable ecosystem processes and resultant loss of biodiversity	FFG
Increase in sediment input into Victorian rivers and streams due to human activities	FFG
Input of toxic substances into Victorian rivers and streams	FFG
Introduction of live fish into waters outside their natural range within a Victorian river catchment after 1770	FFG
Invasion of native vegetation by 'environmental weeds'	FFG
Loss of coarse woody debris from Victorian native forests and woodlands	FFG
Loss of hollow-bearing trees from Victorian native forests	FFG
Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases.	FFG
Predation of native wildlife by the cat, *Felis catus*	FFG
Predation of native wildlife by the introduced Red Fox *Vulpes vulpes*	FFG
Prevention of passage of aquatic biota as a result of the presence of instream structures	FFG
Reduction in biomass and biodiversity of native vegetation through grazing by the Rabbit *Oryctolagus cuniculus*	FFG
Removal of wood debris from Victorian streams	FFG
The introduction and spread of the Large Earth Bumblebee Bombus terrestris into Victorian terrestrial environments	FFG
Threats to native flora and fauna arising from the use by the feral honeybee *Apis mellifera* of nesting hollows and floral resources	FFG
Use of lead shot in cartridges for the hunting of waterfowl	FFG
Wetland loss and degradation as a result of change in water regime, dredging, draining, filling and grazing	FFG
Invasion of native vegetation by Blackberry *Rubus fruticosus* L. agg.	FFG
Competition and land degradation by feral Goats	EPBC
Competition and land degradation by feral Rabbits	EPBC
Infection of amphibians with chytrid fungus resulting in chytridiomycosis	EPBC
Land clearance	EPBC
Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases	EPBC
Predation by feral Cats	EPBC
Predation by the European Red Fox (*Vulpes vulpes*)	EPBC
Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs	EPBC
Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species	EPBC

APPENDIX 9: Extract of the Co-operative Management Agreement between Yorta Yorta Nation Aboriginal Corporation and The State of Victoria

Note: the agreement, map and a factsheet are available at the following website:
http://www.dse.vic.gov.au/dse/nrenlwm.nsf/LinkView/7FA349BEAE0F5A3FCA256E8D00210309A4AD52AC7C448F1A4A256DEA0024EDD2

Preamble

1. Yorta Yorta Nation Aboriginal Corporation represents the Yorta Yorta People who assert cultural connection, based on ancestry and tradition, to the Designated Areas (described in Schedule 2).
2. The State of Victoria recognises the cultural connection of the Yorta Yorta People to the Designated Areas.
3. Accordingly, the State has agreed to recommend to the Minister responsible for the *Conservation, Forests and Lands Act 1987* (Vic) the establishment of a committee pursuant to section 12 of that Act.
4. The committee will be known as the Yorta Yorta Joint Body.
5. In establishing the Yorta Yorta Joint Body the Minister or the Secretary intends to refer the matters described in this Agreement to it for consideration.
6. The Yorta Yorta Joint Body will formalise the Yorta Yorta People's involvement in the management of the Designated Areas and facilitate the development of a sustainable partnership based on recognition, mutual respect and agreed goals .
7. The State will adopt a flexible and learning approach to working with and meeting the aspirations of the Yorta Yorta People. The Yorta Yorta People will adopt a flexible and learning approach to state land management policies and processes.
8. The Yorta Yorta People and the State recognise that Schedule 2 of the Conservation, Forests and Lands Act has effect on committees established pursuant to section 12 of that Act.
9. The purpose of this Agreement is to set out the terms and conditions reached between the State and the Yorta Yorta People, including the Terms of Reference of the Yorta Yorta Joint Body (Schedule 3) that the State will recommend to the Minister.
10. This Agreement successfully completes negotiations for the co-operative management of the Designated Areas between the State and the Yorta Yorta People, consistent with the signed Negotiating Principles.

Acknowledgment

11. The State recognises:
    - the right of the Yorta Yorta People to retain their identity and intellectual property; and
    - the Yorta Yorta People's role in management decision making within the Designated Areas relating to the protection, maintenance and sustainable of cultural and environmental values.
12. The Yorta Yorta People recognise the State as the representative of all Victorians, and its established and on-going responsibilities for the sustainable management of the Designated Areas.

Objectives

13. The objectives of this Agreement are to facilitate:
    - 13.1 the active and resourced (in accordance with Schedule 4) involvement of the Yorta Yorta People in decisions about the management of the Designated Areas including the integration of Yorta Yorta knowledge, internal decision-making processes and perspectives into management planning and works programming;
    - 13.2 the development of mutual recognition and trust between the Yorta Yorta People and the State; and
    - 13.3 the identification and promotion of employment, training and economic development opportunities for the Yorta Yorta People.

Designated Areas

14. The Agreement will apply to the Designated Areas, as defined in Schedule 2.

Relationships

Relationship of the Yorta Yorta Joint Body with land management bodies

15. The State shall assist and to the extent possible require other organisations responsible for managing and/or providing advice regarding the management of the Designated Areas to develop communication protocols and working relationships with the Yorta Yorta Joint Body.

Relationship of the Yorta Yorta Joint Body with the Minister and Secretary

16. In the process of making a decision regarding the management of the Designated Areas, the Minister or the Secretary will take into account relevant advice and recommendations he or she has received from:
    - 16.1 the Yorta Yorta Joint Body in accordance with this Agreement; and
    - 16.2 the organisations responsible for managing and/or providing advice regarding the management of the Designated Areas.
17. If there is conflicting advice prior to making a decision regarding the management of the Designated Areas, the Minister or Secretary, as applicable, will take into account advice from the Yorta Yorta Joint Body in relation to that conflicting advice.
18. If the Minister or the Secretary, as applicable, in making a decision in relation to a matter on which the Yorta Yorta Joint Body has provided advice or a recommendation, decides to act otherwise than in accordance with that advice or recommendation, the Minister or Secretary, as applicable, may provide the Yorta Yorta Joint Body with written reasons for the decision.

Affect of this Agreement on rights and obligations

19. To be clear, nothing in this Agreement:
    - 19.1 compromises the legal rights or political aspirations of the Yorta Yorta People relative to any of their other social, cultural and economic goals;
    - 19.2 affects any rights that the Yorta Yorta People may have to their intellectual and cultural property;
    - 19.3 limits the State's prerogatives under any relevant laws and policies;
    - 19.4 limits the powers of the Minister or the Secretary in relation to any matter, in particular, the powers of the Minister under s12 of the *Conservation, Forests and Lands Act 1987* (Vic) to deal with the Yorta Yorta Joint Body;
    - 19.5 affects any rights, duties or obligations arising from the operation of the *Archaeological and Aboriginal Relics Preservation Act 1972* (Victoria) or the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* (Commonwealth);
    - 19.6 limits the capacity of organisations responsible for managing the Designated Areas to continue to perform their established functions including, as applicable, in relation to the management of lands or waters and the provision of independent advice; or
    - 19.7 affects the valid rights of parties, both Indigenous and non-Indigenous.

Review

20. The role and structure of the Yorta Yorta Joint Body will be subject to ongoing internal review.
21. The Minister may review the structure and role of the Yorta Yorta Joint Body, at the end of the first 2-year period from the date of its establishment.
    - 21.1 The review period shall be 30 days.
    - 21.2 In conducting a review, the Minister or the Secretary may take into account any Annual Report prepared by the Yorta Yorta Joint Body.
    - 21.3 At the end of the review period, the Minister or the Secretary shall discuss with the Yorta Yorta Joint Body any changes that the Minister or the Secretary wishes to make to the structure, role or terms of reference of the Yorta Yorta Joint Body.

Resources

22. The Yorta Yorta Joint Body will be resourced, as detailed in Schedule 4.

Termination by the Yorta Yorta People

23. The Yorta Yorta People may at any time, and in their sole discretion, provide a written request to the Minister or the Secretary to abolish the Yorta Yorta Joint Body.

Schedule 1

List of Definitions

"Convenor" means the person referred to in Clause 17 of Schedule 3.

"Cultural Heritage Officer" means the person referred by this name in Schedule 4.

"Designated Areas" means the areas set out in Schedule 2.

"Elders" according to Yorta Yorta traditional law and custom means a mature, capable, wise and respected adult Yorta Yorta person who has knowledge of Yorta Yorta culture and is recognised and respected by the Yorta Yorta People in general as having such knowledge.

"Elders Council" means a group of Yorta Yorta Elders, each nominated by their respective family groups, who are the guardians of the objects of YYNAC.

"Executive Officer" means the person referred to by this name in Schedule 4.

"Funding Agreement" means the Funding Agreement between the State and the YYNAC.

"Minister" means the Minister for Environment and delegates.

"Negotiation Principles" means the signed principles of negotiation approved by Cabinet in May 2002.

"Secretary" means the Secretary of the Department of Sustainability and Environment.

"Specialist Officer" means the person referred to by this name in Schedule 4.

"State" means the State of Victoria.

"VEAC" means the Victorian Environmental Assessment Council.

"Yorta Yorta Joint Body" means the Committee established under s12 of the *Conservation Forests and Lands Act 1987* (Vic).

"Yorta Yorta People" means the Indigenous peoples who are eligible to be members of the YYNAC.

"YYJB" means the Yorta Yorta Joint Body.

"YYNAC" means Yorta Yorta Nation Aboriginal Corporation, a body corporate incorporated under the *Aboriginal Councils and Associations Act 1976* (Cth) on 27 November 1998 to represent the Yorta Yorta People.

Schedule 2

Designated Areas

1. "Designated Areas" means (using the same land and water identification numbers (ID) referred to in the Yorta Yorta Proceedings) the following areas:
    - (a) Barmah State Park (IDs 58; 63); Barmah State Forest (IDs 56; 118); The Ranch (ID 134); Top Island Reference Area (ID 68); Top End Reference Area (ID 64); Murray River State Reserved Forest (IDS 46; 919); Murray River Reserve (ID 908) to and including Ulupna Creek Reserve (ID 909);
    - (b) Kow Swamp Water Supply Reserve (ID 82) ; and
    - (c) Goulburn River State Forest (IDs 145; 221); Kanyapella Timber Reserve (ID 159) ; Kanyapella State Forest (ID 160); Redgum Swamp State Forest (ID 176); Monroes Reserved Forest (ID 181) ; Loch Gary Wildlife Reserve (ID901); Reedy Swamp Wildlife Reserve (ID 203) ; Youngs Bend State Forest (ID 213) ; Gemmill Swamp Wildlife Reserve (ID 216); Goulburn River Reserved Forest (IDs 237; 240); Goulburn River Reserve (ID 912); and Murchison North Crown Land (ID 913).
2. A legal plan reflecting the Designated Areas will be drawn up within six months of the execution of this Agreement.

APPENDIX 10: Nature Conservation Reserves

Name of Reserve	Area (ha)	LCC rec	Current Reservation Status	Date of creation	Comments (see also information sources provided below)
Boort Flora Reserve	43	G2(a)	Not currently reserved	–	Scrub community of dumosa mallee and yellow gum woodland.
Cannie Flora Reserve	16	G69(c)	Not currently reserved	–	Relatively undisturbed buloke woodland and associated grassland growing on calcareous clays. Very little of this vegetation and soil type remain as public land in the southern Mallee.
Dartagook Wildlife Reserve	746	D9 and addition D15(c)	Not currently reserved	–	Nature Conservation Status pending reservation. The forest of black box, river red gum and lignum is part of the floodplain at the junction of the Loddon River and Sheepwash Creek.
Duck Lake Wildlife Reserve	413	D27(c)	Not currently reserved	–	Reservation as a wildlife reserve (no hunting) pending. This saline wetland has wide muddy shores frequented by wading birds.
Flannery Wildlife Reserve	51	C12(a)	Reserved for the management of wildlife under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1986	Wetland of lignum with some black box and dead trees.
Gemmill Swamp Wildlife Reserve	213	C17(a)	Reserved for the management of wildlife under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1986	Also known as 'Youngs Bend'. Semi-permanent fresh-water wetland comprising rushes and reeds with a river red gum forest and some yellow box woodland to the north.
Karadoc Flora Reserve	111	G56(c)	Not currently reserved	–	A reasonably intact remnant of the higher river terrace carrying alluvial-plain shrublands together with the black box and river red gum terraces descending to the River Murray afford this area significant botanical variety. The climbing herb twining purlane and the subshrub twin-flower saltbush, both being rare plants usually associated with saline shrublands, are found here.
Kings Billabong Wildlife Reserve	2135	D1(c)	Reserved for the management of wildlife under the *Crown Land (Reserves) Act 1978*	1979	Contains a mosaic of wet and dryland habitats on the Murray River floodplain. It has a large waterfowl population. A Proposed Management Plan was implemented in 1991.
Kotta Nature Conservation Reserve	226	No LCC rec (land purchase)	Temporarily reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	2004	Purchased through the National Reserve System Program. A management statement (2005) is in place. Contains a diverse example of endangered Northern Plains Grasslands with a number of threatened flora species. Provides habitat for plains-wanderer, barking marsh frog and fat-tailed dunnart. Adjoins Trust for Nature-owned Glassons Grassland and conservation covenant-protected grasslands. (2) (4)

Name of Reserve	Area (ha)	LCC rec	Current Reservation Status	Date of creation	Comments (see also information sources provided below)
Lake Moodemere Nature Conservation Reserve	12	No LCC rec (land purchase)	Part temporarily reserved for the conservation of an area of natural interest and part temporarily reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	2001	Purchased through the National Reserve System Program. A management statement (2005) is in place. Significant areas of threatened grey box-buloke woodland occur on the site and the vulnerable buloke mistletoe is also present. Adjoins Lake Moodemere Lake Reserve. (1) (5)
Lakes Powell and Carpul Wildlife Reserve	683	D2 and addition of D14[c]	Reserved for the management of wildlife and preservation of wildlife habitat under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1979	Lakes surrounded by river red gum and black box woodlands filled when the Murray River floods.
Lalbert Creek, Towaninny South Flora Reserve	81	G71[c]	Reserved for the preservation of species of native plants under the *Crown Land (Reserves) Act 1978*	1990	Black box wetland occupies a well-developed example of a gilgai soil.
Lambert Island Flora Reserve	948	G55[c]	Not currently reserved	1990	Extensive black box—chenopod woodlands and small stands of cypress-pine and river red gum, notable species include the flood-dependent herb jerry-jerry and a large colony of the endangered herb yellow tails. Currently has apiary sites.
Leaghur Wildlife Reserve	176	D33[c]	Not currently reserved	1990	Nature Conservation Status pending reservation. Portion of a braided stream. Lignum wetland, with common wetland grasses and herbs and relatively low weed cover. Moderately high native species diversity. Significant species are pale spike-sedge, bluish raspwort form glauca, and swamp buttercup (all vulnerable in Victoria).
One Tree Swamp Nature Conservation Reserve	676	No LCC rec (land purchase)	Reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*, small area currently a Water Reserve.	2003	Purchased through the National Reserve System Program. Large Cane Grass Wetland with small areas of Northern Plains Grassland and Plains Woodland. Important brolga breeding habitat. Adjoins Two Tree Swamp Wildlife Reserve to the north. (2)
Ovens River Flora Reserve (Peechelba)	220	G8[a]	Reserved for the preservation of species of native plants under the *Crown Land (Reserves) Act 1978*	1986	Also known as 'Peechelba Flora Reserve'. River red gum forest on the Ovens River with a shrub understorey of river bottlebrush, silver wattle, and swamp paperbark. The occurrence of this melaleuca here is unique in the area and of conservation significance. The Ovens Heritage River is an overlay.

Name of Reserve	Area (ha)	LCC rec	Current Reservation Status	Date of creation	Comments (see also information sources provided below)
Passage Camp Flora Reserve	21	G65[c]	Reserved under *Forests Act 1958*	1990	River red gum forest grows on an island bend of the River Murray with a large population of the grass silky browntop.
Patho Wildlife Reserve	75	C14[c]	Reserved for the management of wildlife under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1986	Permanent and semi-permanent wetland and lagoon system with river red gum open forest and black box open forest-woodland.
Pelican Lake Wildlife Reserve	38	D29[c]	Not currently reserved	–	Nature Conservation Status pending reservation. A brackish wetland, and degrading; it is used by large numbers of waterfowl.
Pine Grove Nature Conservation Reserve	38	No LCC rec (land purchase)	Temporarily reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	2001	Purchased through the National Reserve System Program. Management Statement in place (2005). Contains endangered Northern Plains Grasslands and habitat for plains-wanderer. Gilgais and drainage lines are still present, while the cracks in the heavier grey soils provide habitat for reptiles and fat-tailed dunnarts. (1) (6)
Red Gum Swamp Wildlife Reserve (Gannawarra)	148	C8[a]	Reserved for the management of wildlife under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1986	Wetland containing saltbush, lignum, and numerous dead river red gum trees.
Roslynmead Flora Reserve	574	G4[a] plus addition of purchased land	Partly reserved for the preservation of species of native plants, partly temporarily reserved for the conservation of an area of natural interest, partly temporarily reserved for public purposes, and partly temporarily reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	1986, 2001	Mostly purchased through the National Reserve System Program to be combined with Turrumberry North Flora Reserve as Roslynmead Nature Conservation Reserve. Management Statement in place (2005). Contains endangered Northern Plains Grasslands and habitat for plains-wanderer. Six threatened plant species have been recorded on the site and there is a high level of diversity and complexity in the habitats found across the site due to small changes in relief and varying soil types. (1) (7)
Rowland Wildlife Reserve	126	C11[a]	Reserved for the management of wildlife under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1986	Heathy wetland of saltbush with some black box and dead trees.

Name of Reserve	Area (ha)	LCC rec	Current Reservation Status	Date of creation	Comments (see also information sources provided below)
Ryans Lagoon Wildlife Reserve	151	C5[b]	Reserved for Public Purposes (Regional Parklands) under the *Crown Land (Reserves) Act 1978*	1987	Nature Conservation Status pending reservation. Managed as part of the Albury-Wodonga Regional Parklands. Shallow fresh-water swamp with floodways, lagoons, and grasslands. This reserve supports a breeding rookery of Australian white ibis, nankeen night herons, egrets, and other waterfowl.
Shepparton Flora and Fauna Reserve	21	No LCC rec	Reserved for the preservation of native flora and fauna under the *Crown Land (Reserves) Act 1978*	1972	Former township land excluded from LCC investigations.
Terrick Terrick East Nature Conservation Reserve	212	No LCC rec (land purchase)	Temporarily reserved for the conservation of an area of natural interest under the *Crown Land (Reserves) Act 1978*	2000	Purchased through the National Reserve System Program. Management Statement in place (2005). Contains endangered Northern Plains Grasslands community and habitat for plains wanderer. Contains populations of two nationally threatened plants: chariot wheels and slender darling-pea, as well as a number of species of state and regional significance. (1) (8)
Tomara Gilgais Nature Conservation Reserve	336	No LCC rec (land purchase)	Temporarily reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	2005	Purchased through the National Reserve System Program. Contains endangered Northern Plains Grasslands and habitat for plains-wanderer. Significant flora includes long eryngium, pin sida, umbrella wattle, spiny lignum and yakka grass. Brolgas have been recorded using the wetland area. (3)
Towaninny Flora Reserve	21	G70[c]	Not currently reserved	–	Relatively undisturbed grassland again occurs on calcareous clays, very little of which remains as public land in the southern Mallee.
Towaninny South Flora Reserve	81	G71[c]	Not currently reserved	–	Relatively undisturbed grassland again occurs on calcareous clays, very little of which remains as public land in the southern Mallee.
Tragowel Swamp Wildlife Reserve	274	C4[a]	Partly reserved for the management of wildlife, public purposes for recreation and public amenity under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1986	Grassy, fresh-water wetland with scattered black box. An ibis breeding area.
Two Tree Swamp Wildlife Reserve	167	C11[a]	Deemed reserved for the management of wildlife and preservation of wildlife habitat under the *Crown Land (Reserves) Act 1978*, and the *Wildlife Act 1975*	1982	Cane grass wetland. Adjoins One Tree Swamp Nature Conservation Reserve to the south.

Name of Reserve	Area (ha)	LCC rec	Current Reservation Status	Date of creation	Comments (see also information sources provided below)
Wandella Flora and Fauna Reserve	981	G38(c)	Not currently reserved	–	Black box with an understorey of lignum, grasses and herbs and excellent waterbird habitat.
Wanurp Nature Conservation Reserve	120	No LCC rec (land purchase)	Temporarily reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	2003	Purchased through the National Reserve System Program. Management Statement in place (2005). Contains endangered Northern Plains Grasslands and grassy woodlands, rare and threatened flora and known habitat for Bush stone-curlew. (3) (9)
Winlaton Nature Conservation Reserve	91	No LCC rec (land purchase)	Part temporarily reserved for the conservation of an area of natural interest and part reserved for the preservation of an area of ecological significance under the *Crown Land (Reserves) Act 1978*	2004	Main block purchased through the DSE Conservation Land Purchase Program with addition of small Crown land parcel. Contains Riverine Chenopod Shrubland EVC with a number of rare or threatened flora species. Adjoins land containing native vegetation protected by a conservation covenant. (3)
Yassom Swamp Flora and Fauna Reserve	362	G51(c)	Not currently reserved	–	Important breeding and feeding area for waterbirds and the grassland to the south is growing on red duplex soils of the higher alluvial plains of the Avoca River system. The grasslands are also the habitat of the endangered plains-wanderer.

Notes:

Nature Conservation Reserves includes the following reserves: Flora, Flora and Fauna, Nature Conservation, Wildlife Area (no hunting). All Nature Conservation Reserves are managed by Parks Victoria.

Although some of these areas are not formally reserved (i.e. LCC recommendation have not been implemented) or are temporarily reserved as Nature Conservation Reserves, all are managed as if they were so reserved.

LCC recommendations as follows: (a) Murray Valley (1985); (b) North-East (BUM) (1986); (c) Mallee Review (1989).

Source:

(1) Fitzsimons and Ashe (2003)

(2) Fitzsimons et al. (2004)

(3) Fitzsimons et al. (2006)

(4) Robertson & Fitzsimons (2005a)

(5) Robertson & Fitzsimons (2005b)

(6) Robertson & Fitzsimons (2005c)

(7) Robertson & Fitzsimons (2005d)

(8) Robertson & Fitzsimons (2005e)

(9) Robertson & Fitzsimons (2005f)

APPENDIX 11: Natural Features Reserves

Name of Reserve	Area (ha)	LCC/ECC recommendations	Date of creation
NATURAL FEATURES			
Murray River Reserve	16,061	Murray Valley (1985); Mallee Review (1989)	
PUBLIC LAND WATER FRONTAGES			
various public land water frontages	16,708	various	various
BUSHLAND RESERVES			
Barrakee Bushland Reserve	9	I162 Wimmera (1986)	1987
Barwo Bushland Reserve	10	H20 Murray Valley (1985)	1986
Barwo Bushland Reserve	6	H22 Murray Valley (1985)	1986
Bockie Bushland Reserve	5	I16 Mallee Review (1989)	–
Bonegilla Bushland Reserve	6	I97 North-eastern Area (Benalla-Upper Murray) Review (1986)	1987
Bonegilla Station Bushland Reserve	4	I98 North-eastern Area (Benalla-Upper Murray) Review (1986)	1987
Boosey Bushland Reserve	18	H42 Murray Valley (1985), H8 Box-Ironbark Investigation (2001)	1986
Bumbang Bushland Reserve	27	I261 Mallee Review (1989)	2005
Carlyle Bushland Reserve	5	H115 Murray Valley (1985)	1986
Carwarp Natural Features Reserve	6	No LCC Rec	1989
Chiltern West Bushland Reserve	4	H126 Murray Valley (1985)	–
Echuca South Bushland Reserve	28	H12 Murray Valley (1985) (also known as Nanneella Bushland Reserve)	1902
Gunbower Bushland Reserve	7	H4 Murray Valley (1985)	1986
Gunbower Bushland Reserve	9	H5 Murray Valley (1985)	1986
Kaarimba Bushland Reserve	32	H24 Murray Valley (1985)	1986
Kotta (Torrumbarry) Bushland Reserve	19	H9 Murray Valley (1985); proposed Little Kotta Nature Conservation Reserve	
Kotupna Bushland Reserve	4	H21 Murray Valley (1985)	1986
Kotupna Bushland Reserve	3	H23 Murray Valley (1985)	1986
Lockington Public Purposes Reserve	3	H9A Murray Valley Area	2002
Milloo Bushland Reserve	12	H8 Murray Valley (1985) then H8 Box-Ironbark Investigation (2001)	1986
Moira Bushland Reserve	8	H13 Murray Valley (1985) then H8 Box-Ironbark Investigation (2001)	1986
Moira Bushland Reserve	1	H14 Murray Valley (1985)	1986
Moira Bushland Reserve	2	H15 Murray Valley (1985)	1986
Mologa Bushland Reserve	3	H7 Murray Valley (1985)	1986
Murrabit Bushland Reserve	7	H3 Murray Valley (1985)	1986
Mystic Park Bushland Reserve	646	I291 Mallee Review (1989)	1990
Narioka Bushland Reserve	2	H16 Murray Valley (1985)	1986
Ninyeunook Bushland Reserve	8	I205 Mallee Review (1989)	1979
Nyah Bushland Reserve	150	I164 Mallee Review (1989)	1979
Piangil Bushland Reserve	1	I272 Mallee Review (1989)	1990
Quambatook Bushland Reserve	9	D8 Mallee Review (1989)	1979
Rushworth-Colbinabbin rail line Bushland Reserve	4	H114 Box-Ironbark Investigation (2001)	2002
Shepparton Bushland Reserve	4	H48 Murray Valley (1985)	1986
Strathmerton Bushland Reserve	4	H29 Murray Valley (1985), then H8 Box-Ironbark Investigation (2001)	1986

Name of Reserve	Area (ha)	LCC/ECC recommendations	Date of creation
Strathmerton Bushland Reserve	5	H30 Murray Valley (1985), then H8 Box-Ironbark Investigation (2001)	1986
Strathmerton Bushland Reserve	26	H31 Murray Valley (1985), then H8 Box-Ironbark Investigation (2001)	1986
Tallygaroopna Bushland Reserve	7	H25 Murray Valley (1985)	–
Terrapee Bushland Reserve	40	I183 North Central (1981)	1983
Towaninny Bushland Reserve	40	I203 Mallee Review (1989)	1979
Turrumberry North Bushland Reserve	7	H10 Murray Valley (1985)	1986
Undera Bushland Reserve	1	H24 Murray Valley (1985)	1990
Wharparilla Bushland Reserve	2	H11 Murray Valley (1985)	1986
Wodonga Bushland Reserve	5	I95 North-eastern Area (Benalla-Upper Murray) Review (1986)	1987
Wyuna Bushland Reserve	201	H113 Box-Ironbark Investigation (2001)	2002
HIGHWAY PARKS			
Ballendella (Campaspe River) Northern Highway Park	21	L9 Murray Valley (1985)	1986
Runnymede Highway Park	12	L12 North Central (1981), then H137 Box-Ironbark Investigation (2001)	1982
LAKE RESERVES			
Cranes Lake	34	U1 Mallee Review (1989)	
Lake Boort Lake Reserve	597	N2 Murray Valley (1985)	1986
Lake Marmal Lake Reserve	151	N1 Murray Valley (1985)	1986
Lake Meering Lake Reserve	205	T7 Mallee Review (1989)	1990
Lake Moodemere Lake Reserve	265	N3 Murray Valley (1985)	1986
SCENIC RESERVES			
Red Cliffs Scenic Reserve	23	M1 Mallee Review (1989)	1979
Roslynmead Natural Features Reserve	26	G4 Murray Valley (1985)	–
STREAMSIDE RESERVES			
Arcadia Streamside Reserve	143	K17 Murray Valley (1985), then H4 Box-Ironbark Investigation (2001)	1986
Campaspe River Streamside Reserve	20	K3 North Central Study (1981), H4 Box-Ironbark Investigation (2001)	1982
Dargalong Streamside Reserve	1	K48 North Central Study (1981)	1875
Deep Creek Streamside Reserve	5	K7 Murray Valley (1985)	1986
Englishs Bridge Streamside Area	14	H4 Box-Ironbark Investigation (2001)	1979
Eurobin Streamside Reserve	2	D5 North-eastern Victoria Oven Softwood Plantation Zone Special Investigation (1981) but not accepted by Government	–
Goulburn River Streamside Reserve	24	H4 Box-Ironbark Investigation (2001)	–
Goulburn River Streamside Reserve	3	K49 North Central Study (1981), then H4 Box-Ironbark Investigation (2001)	1982
Goulburn River Streamside Reserve	218	K50 North Central Study (1981), then H4 Box-Ironbark Investigation (2001)	1982
Goulburn River, McCoys Bridge Streamside Reserve	135	K6 Murray Valley (1985)	1986
Goulburn River, Yambuna Bridge Streamside Reserve	44	K5 Murray Valley (1985)	1986
Hayanmi Streamside Reserve	17	K30 North Central Study (1981), then H4 Box-Ironbark Investigation (2001)	1982
Kergunyah Streamside Reserve	2	K10 North-eastern Area (Benalla-Upper Murray) Review (1986)	1981
Murray River Streamside Reserve	11	K15 Murray Valley (1985), then H4 Box-Ironbark Investigation (2001)	1986
Murray River Streamside Reserve	14	K16 Murray Valley (1985)	1986
Ovens River Streamside Reserve	12	J5 North-eastern 3,4,5 (1977)	1979

Name of Reserve	Area (ha)	LCC/ECC recommendations	Date of creation
Ovens River Streamside Reserve	13	K15 North-eastern Area (Benalla-Upper Murray) Review (1986)	1987
Ovens River Streamside Reserve	11	K16 North-eastern Area (Benalla-Upper Murray) Review (1986)	1987
Oxley Streamside Reserve	1	J4 North-eastern 3,4,5 (1977), then H4 Box-Ironbark Investigation (2001)	1979
Pompapiel Watering Purpose Reserve	17	North Central (1981) (frontage to Bullock Creek)	–
Skeleton Creek Streamside Reserve	100	K8 Murray Valley (1985)	1986
Wahring Streamside Reserve	3	No LCC recommendation	–
various unnamed streamside reserves	219	various	various
WILDLIFE RESERVES (HUNTING ALLOWED)			
Baillieu (Richardsons) Lagoon Wildlife Reserve	191	C15 Murray Valley (1985)	1986
Big Reedy Lagoon Wildlife Reserve	274	C30 Murray Valley (1985)	1986
Cemetery Forest Wildlife Reserve	163	C3 Murray Valley (1985)	1986
Corop Wildlife Reserve	2	H1 Box Ironbark (2001)	
Cullens Lake Wildlife Reserve	749	D25 Mallee Review (1989)	1990
Gaynor Swamp Wildlife Reserve	452	C10 North Central Study (1981)	1982
Great Spectacle, Little Spectacle, Round Lake, Tobacco Lake, Little Lake Meran Wildlife Reserve	150	D32 Mallee Review (1989)	1990
Heywood Lake Wildlife Reserve	567	D18 Mallee Review (1989)	1990
Hird Swamp Wildlife Reserve	449	C10 Murray Valley (1985)	1986
Johnson Swamp Wildlife Reserve	465	C9 Murray Valley (1985)	1986
Kanyapella State Wildlife Reserve	9	No LCC Rec	
Koorangie (The Marshes & Avoca Floodway) Wildlife Reserve	3255	D8 Mallee Review (1989) and D16 Mallee Review (1989) (also known as Koorangie State Game Reserve)	1979
Lake Elizabeth Wildlife Reserve	121	D28 Mallee Review (1989)	1990
Lake Lyndger Wildlife Reserve	332	C2 Murray Valley (1985)	1986
Lake Mannaor Wildlife Reserve	87	D23 Mallee Review (1989)	1990
Lake Murphy Wildlife Reserve	222	D11 Mallee Review (1989)	1979
Lake Tutchewop Wildlife Reserve	515	D24 Mallee Review (1989)	1990
Lake Wandella Wildlife Reserve	62	D30 Mallee Review (1989)	1990
Lake Yando Wildlife Reserve	87	D12 Mallee Review (1989)	1979
Little Lake Charm Wildlife Reserve	61	D26 Mallee Review (1989)	1990
Mansfield Swamp Wildlife Reserve	490	C13 North Central Study (1981)	1982
McDonald Swamp Wildlife Reserve	215	C7 Murray Valley (1985)	1986
Mooroopna Sand Reserve	3	C12 Murray Valley (1985) (to be added to Gemmels Swamp)	
Murchison Lagoon Wildlife Reserve	6	C18 North Central Study (1981), then H1 Box-Ironbark Investigation (2001)	1982
Murphy Swamp Wildlife Reserve	85	C16 Murray Valley (1985)	1986
Reedy Swamp Wildlife Reserve	263	C18 Murray Valley (1985)	1986
Stevenson Swamp Wildlife Reserve	93	D10 Mallee Review (1989)	1979
Tang Tang Swamp Wildlife Reserve	129	C9 North Central Study (1981)	1982
The Meadows Wildlife Reserve	50	C13 Murray Valley (1985)	1986
Thunder Swamp Wildlife Reserve	90	C8 North Central Study (1981)	1982
Two Mile Swamp Wildlife Reserve	134	C5 Murray Valley (1985)	1986
Wallenjoe Swamp Wildlife Reserve	425	C12 North Central Study (1981)	1982
Westblades Swamp Wildlife Reserve	70	C6 Murray Valley (1985)	1986
Woolshed Swamp (Boort) Wildlife Reserve	472	C1 Murray Valley (1985)	1986

APPENDIX 12: Sites of Geological and Geomorphological Significance in and near the study area

Note: site numbering follows the conventions of GSA Heritage subcommittee- Mapsheets: BD Balranald and Deniliquin; BN Bendigo; SH Swan Hill; SR St Arnaud; MD Mildura; TL Tallangatta; and WN Wangaratta including part of Jerilderie.

Site Number	Site Name and Location
INTERNATIONAL SIGNIFICANCE	
BN 079	Murchison Meteorite fall site, Murchison East
MD 009	Raak Plain boinka, 16 km NW of Hattah
SH 002	Lake Boga granite quarry mineral type locality, Lake Boga
NATIONAL SIGNIFICANCE	
BD 001	Kow Swamp lake and lunette, 3 km S of Leitchville
BD 003	Barmah forest alluvial fan and anabranch network, Barmah forest
BN 053	Bama-Goulburn drainage complex, Murray / Goulburn confluence area, Echuca
MD 001	Hattah Lakes overflow land and anabranch system, Hattah
MD 007	Lindsay Island floodplain, scroll bars, active and abandoned channel complex, 15 km N of Meringur North
STATE SIGNIFICANCE	
BD 003.4	Moira and Barmah Lakes digitate delta and silt jetty, Barmah forest
BD 003.7	Barmah Choke River Murray constriction, Picnic Point to Barmah
BD 006	Ulupna Creek and Ulupna Island floodplain complex, N of Strathmerton
BD 009	Bumbang Bend recent meander cut-off (avulsion), Robinvale
BD 013	Wakool Junction abandoned channels and plains, near Kenley
BN 052	Palaeolake Kanyapella area, E of Echuca Village
BN 053.3	Murray and Goulburn rivers confluence area, Echuca
BN 057	Cadell Fault southern trace, Kanyapella South
BN 081	Lake Cooper quarry mineral locality, Colbinabbin
BN 086	Shepparton Formation type-section, Kialla West
MD 007.2	Websters Lagoon and Websters Island Reference Area disrupted drainage and scroll plain
MD 011	Kings Billabong and the floodplain between Butlers and Psyche Bends
MD 018	Olney Bore Eocene to Miocene Olney Formation type-section, SW of Pollard Island.
MD 019	Wallpolla Island and Creek anabranch and floodplain, W of Mildura
MD 022	Cowanna Bend neck meander and potential avulsion site, Redgrove
SH 006	Kerang ground-water discharge area, Kerang to Lake Boga
TL 139	Tawonga Fault, Kiewa Valley Highway
WN 042	Wodonga quarry outwash fans, 6 km W of Huon Hill
REGIONAL SIGNIFICANCE	
BD 002	Murray River cliffs, Robinvale, between Wemen Cliffs and Euston Lock
BD 003.3	Old Barmah palaeolake area, Barmah forest
BD 003.5	Barmah forest Grass Plains (Long Plain, Duck Hole Plain, Hut Lake Grass Plain, War Plain, and Top Lake)
BD 003.8	Buck's Ridge sand hill, Barmah forest
BD 004	Gunbower Island and Creek, Koondrook to Gunbower
BD 004.3	Little Reedy Lagoon plains area, Gunbower
BD 005	Gunbower Reach of the Murray River, Kate Malone's Bend
BD 006.3	Paddy Hennessy's Cutting, Ulupna Island
BD 007	Murray and Murrumbidgee rivers confluence, near Narrung
BD 010	River Murray floodplain accretion, Belsar Island, ~15 km SE of Robinvale
BD 012	Haywood Lake, 11 km SE of Boundary Bend
BD014	Murray River channel and concave beach, Boundary Bend
BN 006	Rochester Shire quarry, Rochester
BN 052.2	Bama Sandhill, ~16 km E of Echuca.
BN 053.1	Barmah palaeochannel complex, Barmah forest

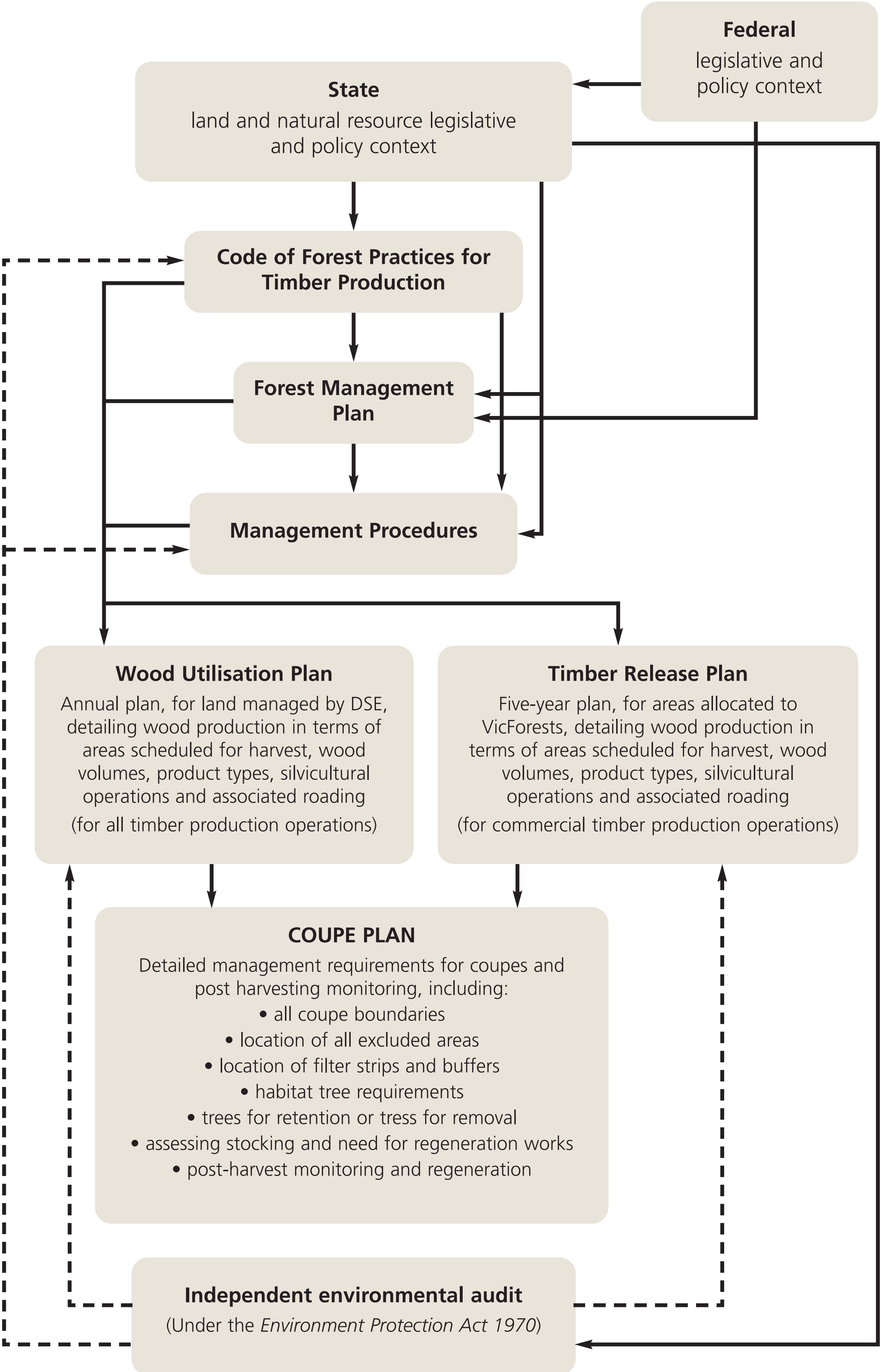
Site Number	Site Name and Location
BN 054	Kotupna gravel pit, Kotupna
BN 060	Lake Cooper and lunettes, E of the Heathcote
BN 074	Mt. Terrick Terrick, Mitiamo
MD 001.1	Chalka Creek, Yerring Crossing
MD 001.2	Red sand dune, Yerring Track
MD 004	Boundary Point, near state borders between SA, NSW and Victoria
MD 005	Merbein Cliffs, River Murray, Merbein
MD 006	Red Cliffs Murray River, Red Cliffs
MD 007.1	Mullaroo Ck, and floodplain south of the Creek
MD 011.1	Psyche Bend, Murray River
MD 012	Nangiloc cliffs Murray River, at Nangiloc
MD 015	Lake Wallawalla and lunette, 14 km W of Neds Corner homestead
MD 019.1	grass plain
MD 021	Yelta cliff exposures, Yelta
MD 024	Patterwallkagee Creek, Neds Corner Homestead
SH 003	Lake Tutchewop, Lake Charm
SH 005	Lake Boga and lunette, Lake Boga
SH 006.10	Kangaroo Lake and 3 lunettes, Lake Charm
SH 006.12	Lake Wandella and lunettes, Lake Charm
SH 006.7	Lake Bael Bael and lunette, Lake Charm
SH 013	Meering Lake (Meran Lake) and associated lakes and lunettes, 13 km SW of Kerang
SH 014	Tragowel Swamp, Two Mile Swamp, Kerang
SH 015	Avoca River terminus area, Lalbert-Kerang Road, Kerang
SH 016	Tyntynder palaeolake, Tyntynder
SH 016.1	Tyntynder choke, Vinifera
SR 001	Gredgwin Ridge quarry, 7 km south of Boort
SR 013.1	Tyrrell Marsh, Nineunook
SR 027	Loddon River distributary channel system, Serpentine to Kerang
SR 030	Parilla Sand exposure in Woollen Rises quarry, Narrewillock
SR 031	Barrakee Creek - Lake Marmal terminal system, Boort-Charlton road, NE of Charlton
SR 032	Boral hornfels quarry, 5 km E of Charlton

Site Number	Site Name and Location
TL 058	Hume Weir quarry and racing circuit, 2.5 km SE of Bonegilla
TL 059	Yackandandah Granite and Rubyview Gneiss exposures, Kookaburra Point, near Bonegilla
WN 002	Yackandandah and Mudgegonga granites and metamorphic aureole- crescentic valley and pinnacles, 11 km SE of Myrtleford
WN 005	Mitta Junction red clay dune/ ridge landform, Bonegilla
WN 026	Ordovician-Silurian Barnawartha Gneissic Granodiorite and pegmatite dykes, Huon Hill De Kerilleau Quarry, Wodonga
WN 063	Shepparton Formation Dongawarra Terrace landform, Bonegilla
WN 073	Oxley Flats avulsion channel, Tea Gardens Creek
WN 076	Buckland River and terraces, Buffalo River
WN 076.1	Buffalo River incision and Palaeozoic exposures, Osborne's Bridge,
WN 077	Confluence Ovens and King rivers, Wangaratta
WN 078	Boorhaman East 1 bore, 21 km N of Wangaratta
WN 079	Confluence Ovens- Murray rivers, Brimin
WN 081	Golf Course Bend, 4.5 km S of Corowa
WN 082	Source-bordering dunes Cobram to Cobram East
WN 082.1	Source-bordering dune, Dick's Bend, east Cobram
WN 084	Ovens River floodplain, NW of Wangaratta
WN 085	Yarrawonga Reach River Murray and floodplain, Bruce's Bend.
WN 087	Upstream Ulupna Creek, junction River Murray, Eastern end of Ulupna Island (part of BD 006)
WN 088	Horseshoe Lagoon, Ulupna Island (see BD 006)
LOCAL SIGNIFICANCE	
BD 001.1	Mt. Hope Creek, 4 km S of Leitchville
BD 001.2	Bullock Creek palaeo-drainage, 5 km S of Leitchville
BD 002.1	Happy Valley cliffs, Robinvale
BD 002.2	Euston Lock 15 cliffs, Robinvale
BD 002.3	Wemen cliffs, Wemen
BD 003.1	Tullah Creek, Double Crossing
BD 003.2	Barmah Borrow Pit, Barmah

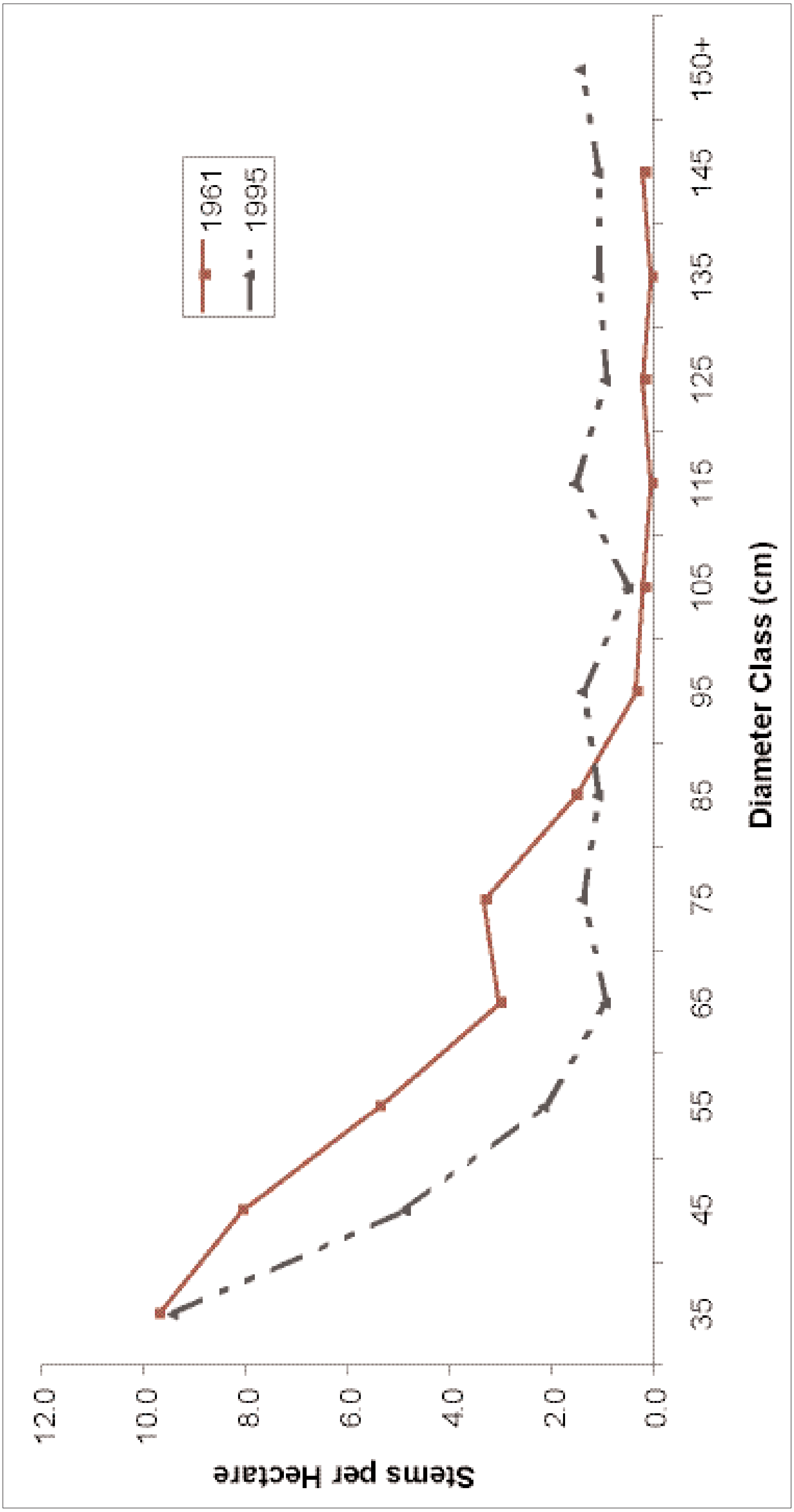
Site Number	Site Name and Location
BD 003.6	Punt Paddock Lagoon
BD 004.1	Reedy Lagoon, Gunbower
BD 004.2	Sandpit, Near the Spence Bridge Scout Camp
BD 006.1	Dead River Lagoon, Ulupna Island
BD 006.2	'The Junction', the downstream end of Ulupna Creek, Ulupna Island
BD 008	Haysdale palaeolake, Haysdale
BD 011	Narrung Bend, Narrung
BN 040	Goulburn Weir, Nagambie
BN 044	Reedy Lake, Nagambie
BN 051	Barmah sand pit, Barmah
BN 052.1	Kanyapella lake sediment, Echuca
BN 053.2	Goulburn River and lake sediments, Echuca
BN 055	Tallygaroopna Prior Stream, Tallygaroopna
BN 056	Little Lake Kanyapella and lunette, ~13 km E of Echuca
BN 056.1	Kanyapella prior stream, E of Echuca
BN 059	Goulburn River floodplain at McCoys Bridge, ~ 4 km SW of Kotupna
BN 083	Goulburn River ancestral point bars, N of Shepparton
BN 084	Loch Garry, Bunbartha
BN 085	Ancestral River Point Bars, near Yambuna
MD 010	Karadoc Swamp and lunette, ~10 km east of Yatpool
MD 013	Berribee Tank dry lake and lunette, Berribee Tank
MD 014	Horseshoe Bend and lagoon, Merbein
MD 016	Lake Hawthorn, Lake Ranfurley, Mildura
MD 017	Lake Iraak and lunette, Iraak
MD 023	Lake Cullulleraine, Lake Cullulleraine
SH 005.1	Round Lake and lunette, Lake Boga
SH 005.2	Long Lake and lunette, Lake Boga
SH 006.1	Pelican Lake and lunette, Lake Charm
SH 006.11	Third Lake and lunette, Lake Charm
SH 006.2	Reedy Lake and lunette, Lake Charm
SH 006.3	Lake Elizabeth and lunette, Lake Charm
SH 006.4	Duck Lake and lunette, Lake Charm
SH 006.5	Lake Cullen and lunette, Lake Charm
SH 006.6	The Marsh and lunette, Lake Charm
SH 006.8	Middle Lake and lunettes, Lake Charm
SH 006.9	Lake Charm and lunette, Lake Charm
SH 012	Foster Swamp, Nine-Mile Creek

Site Number	Site Name and Location
SH 016.2	River bank exposure, Tyntynder Central
SH 017	Little Murray River, Near Lake Boga
SR 013	Avoca River mid-system floodout, Glenloth Road / Avoca River bridge
SR 026	Boort lake and lunette system, Boort
WN 013	Pliocene gravel beds exposure in railway cutting, Bonegilla
WN 076.2	Pool-and-riffle stream forms at McGuffie's Bridge, Buffalo River
WN 082.2	Source-bordering dune landform, E of Cobram
WN 082.3	Source-bordering dune landform, ~5 km S of Tocumwal
WN 083	King River lagoonal floodplain, Wangaratta
WN 086	Torgannah Lagoon, Mays Bridge

APPENDIX 13: Planning hierarchy for timber harvesting in Victorian state forests



APPENDIX 14: Tree diameter distribution in Barmah forest



Source: DNRE (2002a)

Note: Diameter-class distribution of merchantable and potentially merchantable stems showing the increase over time of the number of larger trees in the forest and a reduction in the number of trees in the smaller size-classes.

APPENDIX 15: River red gum log grades

Three grades of river red gum log are applied, determined by size (diameter and length) and the amount of defect. Where the proportion of defect exceeds the maximum allowable, the log is consigned to a lower grade; the allowable proportion of defect increasing with the size of the log.

Red gum sawlog (RGSA)

Logs from which a higher proportion of the highest-quality timber can be expected.

Minimum dimensions:
- 40 cm small-end diameter
- 2.1 m length.

Allowable defect:
- 25% for RGSA with a centre diameter underbark less than or equal to 45 cm.
- 30% for RGSA with a CDUB greater than 45 cm.

Allowable sweep:

The maximum allowable sweep is 1/5 of the centre diameter underbark, measured over a minimum 2.1 m of log length.

Red gum standard log (RGSB)

Logs that are expected to produce mostly landscape and utility grade timbers, although some railway sleepers and high-quality timber may be produced.

Minimum dimensions:
- 30 cm small-end diameter
- 2.1 m length

Allowable defect:
- 20% for RGSB with a centre diameter underbark less than or equal to 35 cm
- 35% for RGSB with a centre diameter underbark between 36 cm and 50 cm (inclusive)
- 50% for RGSB with a centre diameter underbark greater than 50 cm.

Allowable sweep:

The maximum allowable sweep is 1/5 of the centre diameter underbark, measured over a minimum 2.1 m of log length.

Red gum residual log (RGRL)

Logs that are not expected to produce sawn timber, but will produce fuel wood. The purchaser, however, may be able to extract some sawn material, depending on how it is processed.

Minimum dimensions:
- 10 cm small-end diameter
- 1.8 m length.

Allowable defect and sweep:

No minimum is specified for defect or sweep.

Source: DSE (2005f)

APPENDIX 16: Timber productivity related to water and forest management strategies

	Timber Productivity (m3/ha/yr)					
	Scenario 1: current forest management, stand structure, environmental prescriptions		Scenario 2: timber production as primary aim but full cognisance of active water management, silviculture treatment and environmental prescriptions and conservation areas		Scenario 3: timber production as primary aim	
Present Flood Frequency	**sawlogs**	**other products**	**sawlogs**	**other products**	**sawlogs**	**other products**
10 years out of 10	1.48	1.10	2.12	1.57	2.50	1.85
7–8 years out of 10	0.78	0.57	1.35	1.00	1.87	1.39
4–5 years out of 10	0.22	0.16	0.43	0.32	0.75	0.56
≤2 years out of 10	negligible to negative		0.04	0.02	0.15	0.11

Source: Maunsell Australia Pty Ltd (2003)

Timber productivity averaged for all river red gum site qualities (SQ I, SQ II & SQ III) in the Barmah Forest under various forest and water management strategies.

Explanatory notes

Values are for timber productivity averaged across all site qualities for each forest management scenario under present/predicted and managed flood frequencies.

Level of management input:

1. Present forest management for timber production under present stand structure, current environmental prescriptions, forest flooding and water management policy.
2. Forest management in zones specified for sustainable timber production as a primary aim and in full cognisance of:
   - active water management in accordance with the Murray-Darling Basin Commission's approved Water Management Strategy for the Barmah–Millewa Forest
   - silvicultural treatment facilitating full stocking and subsequent progressive selective thinning over the rotation
   - environmental prescriptions that meet the Code of Forest Practice and ensure a high level of flora and fauna conservation
   - forest management takes account of significant areas set aside where environmental conservation is the primary aim to the exclusion of timber production.
3. Forest management for sustainable timber production as the primary aim.

Flood frequency:

10 years out of 10 – annual flooding.

Except in severe drought years, annual flooding may occur on small sections of forest, wetlands and low-lying plains fed from major flood runners via on-river regulators. These areas flood at low river flows below Yarrawonga/Tocumwal (6500–15,000 ML/day) and are the areas generally most prone to unseasonable flooding, particularly as a result of rain rejections in summer and early autumn.

7–8 years out of 10 – pre-river regulation flood frequency (1891–1934)

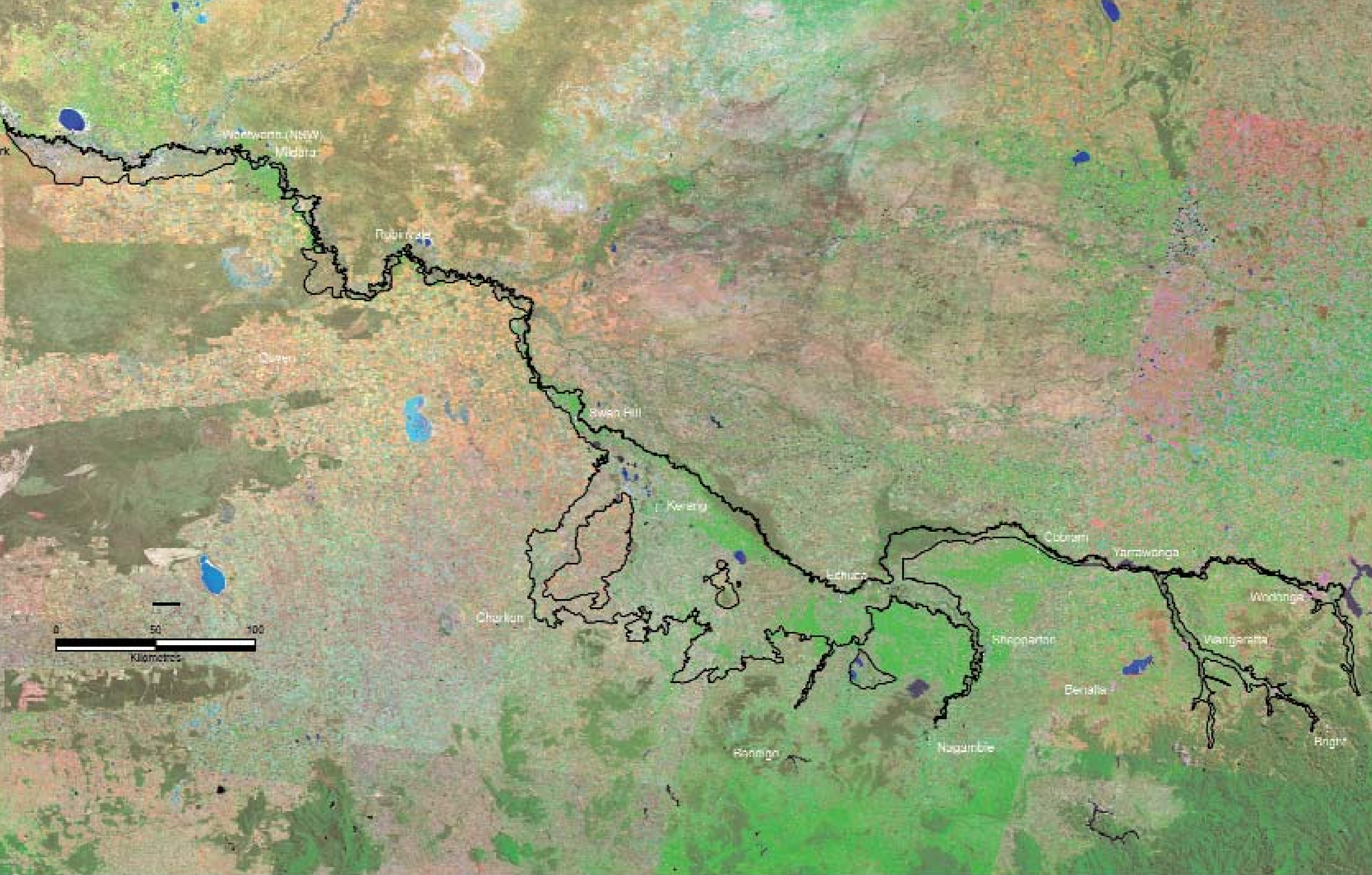
Only on very rare occasions were there three consecutive years without a flood and few occasions, usually widely spaced, when there were two consecutive years without some flooding over 75–80% of the forest and wetlands. Consequently, the forest did not experience severe cumulative drought stress. This situation is reflected in forest productivity described by Jacobs (1955).

4–5 years out of 10 - present flood frequency on 25–50% of the forest and wetlands as a result of actual Murray River flows below Yarrawonga/Tocumwal since 1955.

Cumulative drought stress results in a cessation of growth and recovery to pre-stressed levels takes several seasons. Flood duration, apart from 2–3 years each decade, is often less (up to 2 months) than that under natural (pre-regulation) flooding conditions. The shorter duration of flooding and season of flooding are considerably less than optimal for many biological processes including tree growth and overall vitality for flora and fauna (viz: moira grass, frogs and water bird breeding).

Equal to or less than 2 years out of 10 – present/predicted flood frequencies on up to 75% of the forest area as a consequence of MDBC and NSW and Victoria state land and water management policy decisions.

Tree vitality and growth are very significantly reduced. Cumulative drought stress is much more evident particularly as the frequency of two or more consecutive years without a flood is a regular occurrence. Biological activity, including tree growth, is also more dependent on general seasonal conditions and duration of any flooding. As rainfall decreases from east (700 mm per annum) to west (less than 200 mm), the lack of flooding results in severe cumulative drought stress as evidenced by recent surveys (Brett Lane & Associates Pty Ltd 2005).


Wentworth (NSW)
Mildura
Robinvale
Ouyen
Swan Hill
Kerang
Echuca
Cobram
Yarrawonga
Wodonga
Wangaratta
Shepparton
Benalla
Nagambie
Bright
Charlton
0
50
100
Kilometres