


NATURAL VICTORIA

Conservation Priorities for Victoria's Natural Heritage

NATURE CONSERVATION REVIEW 2014

Full Report

VICTORIAN NATIONAL PARKS ASSOCIATION
Be part of nature

Victorian National Parks Association (VNPA)

VNPA is Victoria's leading nature conservation organisation. An independent, non-profit, membership-based group, VNPA exists to protect Victoria's unique natural environment and biodiversity through the establishment and effective management of national parks, including marine national parks, conservation reserves and other measures. VNPA works by facilitating strategic campaigns and education programs, developing policies, conducting hands-on conservation work, and by running bushwalking and outdoor activity programs which promote the care and enjoyment of Victoria's natural heritage.

Published by the Victorian National Parks Association July 2014.

National Library of Australia Cataloguing-in-Publication entry

Author:	Booth, Carol, author.
Title:	Natural Victoria - conservation priorities for Victoria's natural heritage : nature conservation review full report / Carol Booth, Andrew Cox.
ISBN:	9781875100323 (ebook)
Subjects:	Conservation of natural resources--Victoria. National parks and reserves--Victoria.
Other Authors/Contributors:	Cox, Andrew, author. Victorian National Parks Association, issuing body.
Dewey Number:	333.7809945

Citation

VNPA (2014) Natural Victoria: Conservation Priorities for Victoria's Natural Heritage. Nature Conservation Review. Full Report. Victorian National Parks Association, Melbourne.

This report, a fifty page public summary of this report and past nature conservation reviews are available at www.vnpa.org.au.

Contributors

Project management: Andrew Cox. Text: Carol Booth. Maps, data analysis: Andrew Cox. Research: Carol Booth and Andrew Cox. Layout: Carol Booth. Management and strategic direction: Matt Ruchel.

VNPA expert reference group: Geoff Wescott, Ary Hoffman, James Fitzsimons, Chris Smyth, Tim Allen, Steve Mathews, Matt Ruchel, Phil Ingamells, Simon Branigan, Charles Meredith (to 2011), Ian Harris (2008) and Barry Pittock.

Proof reading: Jennifer Rolland, Euan Moore and Michael Howes. Design of cover & chapter headings: John Sampson.

Front cover photos: Red-capped Plovers, Wayne Butterworth (Creative Commons Licence - flickr flickr.com/photos/frankzed/); The Alps, Paul Sinclair; Goulburn Rapids, Alan Lam (Creative Commons Licence - flickr.com/photos/alanandanders/); Victorian grasslands, Michael Williams - It's a Wildlife; Old Wives, David Bryant.
Photos for chapter covers: Marine & Coastal Ecosystems - Old Wives, Dave Bryant; Terrestrial Ecosystems - River Red Gum, David Neilson; Freshwater Ecosystems, Alan Lam, Creative Commons Licence (flickr.com/photos/alanandanders); Environmental Governance - Snow Gum, Dargo High Plains, Alpine National Park, Phil Ingamells; Consolidated Recommendations - Striated Fieldwren, Geoff Gates.

Chapter 1 illustrations: Rhyll Plant and Jess McGeachin.

Disclaimer

Acknowledgements

The preparation of the VNPA Nature Conservation Review 2014 began in 2008 and is the product of the work and expertise of a large number of people over a long period.

Phil Ingamells, Simon Branigan, Paige Shaw, Megan Clinton, Karen Alexander and Nick Roberts: contributions as VNPA staff members.

Heath Rickard, Maxine Hawkins, Emily Clough, Charlotte Kandelaars, Caitlin Griffith, Ann Strunks, Shanti Fowler and Irina De Loche: VNPA office support.

Matt Edmunds, Chris Smyth, Ross Scott, Jacquomo Monk, Jo Klemke, Jonathan Stephenson, Neil Blake, Randell Lee, Michelle Grady, Bryan Woods, Steffan Howe, Daniel Ierodiaconou and Tim Tan: information and advice on the marine and coastal chapter.

Yasmin Kelsall, Andrew Silcocks, Robert Costello, Geoff Carr, Val Stajsic, Tom May, Richard Loyn, Neville Walsh, Peter Robinson, Peter Menkhorst, Euan Moore, Paul Peake, David Parkes, Martin Taylor, David Lucas, Tony Varcoe, Doug Robinson, Fiona Smith, Chris Cook, Andrew Burns, Nathan Wong, Barry Traill, Marjorie Grant, Rosemary Lowry: information and advice on the terrestrial chapter.

Yung En Chee, Juliet le Feuvre, Jamie Pittock and Peter Wilson: information and advice on the freshwater chapter.

Brendan Sydes, Gabrielle Tipple, Nicola Rivers, Elizabeth McKinnon and David Clarke: information and advice on the governance chapter.

George Mansour, Grimaldo Villanueva, Kelly Arbon, Richard Hughes, Emil Skender, Maree Platt, David Lees, Lyn Murray, Jeremy Alcorn, Geoff Bullock, Christine Connelly, Tony Faithfull, Heidi Weiser: assistance with spatial data and GIS technical advice.

Steve Mathews, Geoff Carr and Andrew McMahon of Ecology Australia, Matt Edmunds, S Mustoe, K Stewart, E Sheedy and J Ong of Australian Marine Ecology, Laura Wiliams, Robin Hale, Paul Reich and Sam Lake of Monash University, David Endersby of Sinclair Knight Merz, Chris Smyth, Don Garden, Yung En Chee of University of Melbourne: authors of the commissioned reports.

The Department of Environment and Primary Industries, the Department of Planning and Community Development, the Growth Areas Authority, Victorian Environmental Assessment Council, ERIN within the Federal Department of Environment, Trust for Nature (Victoria), The Wilderness Society and the Merri Creek Management Committee: provision of data.

Numerous anonymous people: information, advice and review.

The VNPA Nature Conservation Review 2014 was generously supported by The Dara Foundation.

Traditional Owners

The Victorian National Parks Association acknowledges the many Traditional Owners of Victoria's natural areas.

Aboriginal people occupied Victoria for tens of thousands of years before their communities were decimated by European occupation.

Their relationship to the land was both profound and clever. They used fire to clear pathways, hunt animals and promote the abundance of useful plants, significantly changing some natural systems in local areas. They promoted the growth of many food plants, and in places transformed natural waterways to harvest eels and other foods. Their links to the land were driven by spirituality as well as practicality, and they were strongly protective of the natural world.

This fourth VNPA nature conservation review 2014 acknowledges the long history of Indigenous occupation, and respects the ongoing roles and responsibilities of Victoria's Traditional Owners in caring for country.

The review concentrates on the period since European occupation.

Foreword

What an amazing place we live in! Deserts, grasslands, heathlands, dry forests, tall wet forests, alpine meadows, reefs and seagrass meadows are but some of the hundreds of the beautiful and diverse ecosystems we are custodians of. The coastline is dramatic and we have the highest density of waterways on the mainland.

VNPA Nature Conservation Review 2014 draws on scientific, government and community sources to document the values of our natural heritage and the threats. It analyses conservation gaps and priorities and, most importantly, proposes thoughtful solutions to many of our most pressing problems.

Initiated in 2008, this report builds on previous nature conservation reviews, undertaken by the VNPA in 1971, 1987 and 2001. Compared to these earlier reviews, this report is broader in scope and more detailed. It is a reflection of how far we have come in understanding the complexity of our natural heritage, and it also highlights the complexity of the laws, rules, institutions and programs aimed at managing our impacts on the environment.

This review starts with an historical perspective, for many of today's problems are legacies of the past. This is not to lay blame, but to recognise that conserving Victoria's natural heritage is not just about managing the impacts of what we do now, but also the dramatic impacts 'European' settlement has had in the past. This ecological debt is profound in Victoria and one we need to address, particularly in the face of a changing climate, if future generations are to enjoy the bush as we do.

Importantly, the report dedicates a whole chapter to environmental governance: the system of laws, implementation mechanisms, accountability regimes, and institutional arrangements needed to manage these challenges. There is no doubt that, while Victoria has made progress since the first nature conservation review in 1971, our current system of environmental stewardship is failing and we still have a huge amount of work to do. To address the gaps and flaws in this system, we have made 163 recommendations, some detailed, some big picture, focused primarily at the state level. Our aim is to encourage debate and action.

As a community-based organisation, the VNPA has been a voice for nature in Victoria for over 60 years. This report was a major undertaking, and could not have been completed without the generous support of the Dara Foundation and our many members and supporters. It has also benefited from many hours of volunteer input from scientists, community members and others. As with previous reviews it will guide our work, and hopefully the work of others, for at least the next decade.

Matt Ruchel
Executive Director
Victorian National Parks Association

Contents

APPENDICES: (PUBLISHED AS SEPARATE DOCUMENTS)

1. Victoria – Setting the Scene

A GUIDE TO CHAPTER 1

This chapter is backward and forward looking, providing historical context and a focus on major drivers and trends that will influence Victoria's future. Section 1.1 provides introductory information about the review. Section 1.2 outlines the history of environmental decline and protection in Victoria. Although the environment has been influenced by tens of thousands of years of Aboriginal management, the historical focus is limited to the past 200 years since European colonisation. Section 1.3 outlines three major drivers of environmental change in Victoria – climate change, population growth and land use intensification. Section 1.4 provides some background to Victoria's national park and conservation system, and explains the terminology used in this report for protected area categories.

Topics covered

1.1 Introduction to the review

1.2 A short environmental history

- European colonisation, 1800-1970
- VNPA nature conservation reviews, 1971-2001
- Progress since 2001

1.3 Environmental drivers and trends

- Climate change
- Population growth
- Land-use intensification

1.4 Victoria's national park and conservation system

1.5 Sources

1.1 Introduction to the review

This is the fourth nature conservation review published by the Victorian National Parks Association (VNPA). When the first review was published 43 years ago, just 1.2% of Victoria's land area was protected (to a limited extent) for conservation, there were no marine parks, the management budget for parks was $141,000 and little was known about Victoria's biodiversity assets. 'There has never been an official corps of fully trained biologists able to assess the biological content of the State in a systematic fashion,' the 1971 reviewer Judith Frankenberg wrote. We know a great deal more now (although still surprisingly little about many aspects of biodiversity such as invertebrates), and about 5% of the marine environment and 14% of land area are in the national park estate. But pressures on nature have also grown, far exceeding the progress made, and on current trajectories they condemn our seas, lands and waters to growing biological poverty and ecological dysfunction.

The first three reviews – in 1971, 1987 and 2001 – were each done by one or two experts, in consultation with many other experts and with reference to the scientific literature. For this fourth review, VNPA commissioned the following seven expert reviews – of Victoria's environmental history and conservation issues in marine, coastal, terrestrial and freshwater ecosystems.

Title	Authors	Institution	Date	Chapter	Appendix
Phases of Ecological Impact of the European Occupation of Victoria	Don Garden	Melbourne University	2012	1	1
VNPA Nature Conservation Review: Marine Conservation Priorities and Issues for Victoria	Matt Edmunds, Simon Mustoe, Kim Stewart, Elizabeth Sheedy, Joyce Ong	Australian Marine Ecology	2010	2	2
The Coast is Unclear: An Uncertain Future for Nature Along the Victorian Coast	Chris Smyth		2014	2	3
VNPA Nature Conservation Review: Terrestrial Ecosystems	Steve Matthews, Geoff Carr, Andrew McMahon	Ecology Australia	2011	3, 5	4
Terrestrial Biodiversity Review: Bioregional Vegetation Summaries	David Endersby	Sinclair Knight Merz	2010	3	5
Nature Conservation Review: Freshwater-dependent Ecosystems	Yung En Chee	Melbourne University	2010	4	6
Ecological Benefits of Riparian Restoration with Particular Application to Victoria	Laura Williams, Robin Hale, Paul Reich, Sam Lake	Monash University, Arthur Rylah Institute	2010	4	7

This report synthesises those reviews, supplemented by information from a wide range of other sources. An expert reference group guided the process and assisted with the development of recommendations. The objectives were to:

- review new information, knowledge and approaches to nature conservation and their applicability to Victoria
- identify priority areas for nature conservation and national parks
- review threatening process and identify reforms to protect biodiversity and conserve nature in Victoria.

Although the report ranges across many different topics, it is not comprehensive, for it focuses on areas most relevant to VNPA's nature conservation mission.

The focus of policy analysis and recommendations is primarily the state government. While the federal and local governments and many non-government institutions also have vital roles, the state government has primary responsibility for the laws, policies and programs that most influence people's actions in the Victorian environment. The recommendations involve a wide array of conservation tools, including laws, policies, stewardship programs, and land and sea management. Protected areas are a core focus, as they offer the greatest potential for dedicated conservation management and threat mitigation. Many types of properties are called 'protected areas' but only properties with a secure and perpetual conservation tenure and primarily managed for conservation are genuinely protected. In this report, these properties are referred to as the 'national park and conservation system' (see section 1.4 for an explanation). Public properties receiving the highest level of protection are referred to as the 'national park estate'.

Chapter overviews

Chapter 1 is both backward and forward looking. Understanding the current state of the Victorian environment and its challenges requires knowledge of the past. The long Aboriginal history with this part of Australia has been influential in shaping its ecology (and is important for its future as well), but the focus in this chapter is limited to the past two centuries. Section 1.2 outlines the major eras of European colonisation from an environmental perspective up to 1970 and then summarises VNPA's past three nature conservation reviews, which cover major conservation issues since 1971. As well as dealing with the legacies of a destructive past, Victoria must prepare for a more difficult future. Section 1.3 outlines major drivers and trends – rapid changes in climate, population and land use – that will shape the environment of the future and that increase the urgency of reforms to strengthen protections for nature. Section 1.4 explains what is referred to in this report as the Victorian 'national park and conservation system' – the network of protected areas that meet VNPA's criteria for secure and permanent protection.

Chapter 2 focuses on marine and coastal ecosystems, in recognition of their tight ecological links and the need for integrated management. The area of focus is waters under state jurisdiction (to 5.5 kilometres seaward from the high water mark) and land within 500 metres of the shoreline. Sections 2.1 to 2.3 discuss the values, characteristics and state of marine and coastal ecosystems and the threats to them. Sections 2.4 and 2.5 focus in on each of the five marine bioregions and ten coastal subregions, identifying values and conservation gaps, particularly in the national park and conservation system. Sections 2.6 and 2.7 identify gaps in and priority reforms for state-wide policies and programs affecting marine and coastal systems. The priority areas for reform are improving knowledge, developing a comprehensive, adequate and representative national park and conservation system and strengthening institutions, laws and policies for integrated management of coastal and marine systems.

Chapter 3 focuses on terrestrial ecosystems, particularly on vegetation and protected areas. Sections 3.1 to 3.4 discuss the values, characteristics and state of terrestrial ecosystems, the adequacy of protection afforded by the national park and conservation system, and the threats to terrestrial habitats. Sections 3.5 and 3.6 identify gaps in and priority reforms for policies and programs affecting terrestrial systems. The priority areas for reform are developing a comprehensive, adequate and representative national park and conservation system, strengthening protection of native vegetation and improving management of bushfire and invasive species threats to nature.

Chapter 4 focuses on freshwater ecosystems – those associated with rivers and streams, riparian areas, wetlands, floodplains and groundwater systems. Sections 4.1 to 4.4 discuss the values, characteristics and state of freshwater ecosystems and the threats to them. Sections 4.5 and 4.6 identify gaps in and priority reforms for policies and programs affecting freshwater ecosystems. The priority areas for reform are restoring environmental flow regimes, protecting and restoring riparian habitats, establishing freshwater protected areas and strengthening wetland protection and catchment management.

Chapter 5 focuses on environmental governance issues that underpin problems faced across all Victorian environments. Section 5.1 outlines governance flaws and section 5.2 identifies governance reform priorities in laws, institutional structures, climate change adaptation, planning funding, and knowledge. Section 5.3 describes VNPA's five priority cluster areas for conservation work and section 5.4 lists priority reforms, including a proposed new structure for environmental institutions.

Chapter 6 is a compilation of recommendations from each of the preceding chapters.

1.2 A SHORT ENVIRONMENTAL HISTORY

Understanding the Victorian environment requires knowledge of its past and how it has been shaped by humans. The following history is short in two respects: it is only a sketch (a summary of four reports), and it focuses only on the two centuries since European colonisation – a brief but tumultuous period in ecological terms, and representing less than 1% of the more than 40,000 year duration of Aboriginal history with this part of Australia. Section 1.2.1 is a summary of *Phases of Ecological Impact of the European Occupation of Victoria* by Don Garden,[1] and section 1.2.2 a summary of the three previous VNPA nature conservation reviews.

1.2.1 European colonisation, 1800-1970

'The ecological impact of colonial and post-colonial exploitation can be seen to have occurred in a number of chronological phases. These phases essentially reflect four factors…: the number of humans inhabiting Victoria; the level/volume of their consumption; the principal economic activities they pursued; and the technologies available to them.'

Don Garden, 2012[2]

Early European colonists were not drawn to Victoria. Naval explorers had reported a coast of mainly dense low forest and sandy wetlands, lacking in timber, fertile soils and large rivers. The first European settlement, in 1803 at Sorrento, was abandoned after a few months due to lack of water and fertile soils.

But the colonisers' view of Victoria changed in the 1830s when sheep graziers sought more land. Explorers and potential pastoralists encountered abundant grasses, often shoulder high, amid scattered trees and tree stands. 'I entertain the most promising expectations of the fertility of the regions we are now traversing,' said NSW's Surveyor General Thomas Mitchell in 1836 of the place that would become Swan Hill.

1800s–1840s: sealing and whaling

The discovery of large fur seal colonies in the late 1700s brought sealers from Sydney and Van Diemen's Land to exploit valuable fur and oils. But the industry drove itself to extinction by the 1830s, after almost total extermination of seals. A similar pattern was followed by the whaling industry, which killed mostly right whales migrating each winter from Antarctica. It was a major shore-based industry in the first three decades of the 19th century, with local vessels joined by dozens from Europe and North America. The industry ceased to operate from Victorian stations in the 1840s after whale populations crashed.

1834–1851: pastoral settlement

Sheep grazing became the major industry in eastern Australia in the 1830s and 40s due to demand from British textile industries. The first pastoralists and permanent settlers moved from Tasmania to Portland in 1834. By the late 1840s, sheep and, to a lesser extent, cattle were grazing over much of central and western Victoria. Only the arid country of the Wimmera and Mallee, the dense Gippsland rainforests and the Alps were not occupied. The Port Phillip District gained a population of nearly 100,000 Europeans.

Early pastoralists periodically burned the land to clear it of scrub and promote fresh grasses. John Robertson gave a graphic account in 1853 of rapid damage from sheep grazing in the Casterton area. When he arrived in 1840 it was 'splendid country' with excellent grasses (he counted 37 species) – 'all the landscape looked like a park with shade for sheep and cattle'. But native herbs and grasses soon began to disappear and weeds invaded; 'deep-rooted grasses that held our strong clay hill together have died out; the ground is now exposed to the sun, and it has cracked in all directions, and the clay hills are slipping in all directions'.[3]

1851–1870: the gold era

Days after Victoria became a separate colony in 1851, gold was discovered, triggering a great rush. A host of gold towns sprung up, the population surged in 20 years from less than 100,000 to almost three-quarters of a million in 1871, and gold took over from wool as the principal export industry. Victoria became one of the wealthiest places in the world, with high standards of living.

Initially, mining was of alluvial gold. Vegetation was removed, soil and rock were dumped, and streams were diverted. From the late 1850s, the focus shifted to gold-bearing quartz, which required deep shafts, sophisticated technology and great volumes of water. Many creeks were dammed and diverted, arsenic-contaminated tailings accumulated, and vast woodlands in central Victoria were stripped for timber. Concern about timber losses drove the first efforts at forest conservation in the 1860s, and close to 1 million acres of timber reserves and state forests were set aside by 1874. Later in the century, new techniques for gold mining involved huge, steam-driven water hoses blasting away creek banks to give access to alluvial deposits. Large dredges worked their way down creeks, digging up and processing soil as they went, causing irreparable damage to water systems and spreading large areas of mullock that grew little more than weeds.

Because of the much increased demand for food, agriculture expanded, leading to large-scale clearing. With arable land converted to crops, sheep and cattle grazing was pushed into drier areas. In the 1850s, a commercial fishing industry established. New plants and animals were introduced – cats, dogs, foxes and rabbits. Manufacturing industries were established, and roads, telegraph lines and railways carved up the countryside. Australia's first large dam, the Yan Yean reservoir, was built in the upper reaches of the Plenty River in 1857 to service Melbourne. As the Yarra was no longer needed for potable water, it was made available as Melbourne's main drain for effluent.

1870–1901: selection laws, agriculture and marvellous Melbourne

A series of Selection Acts were passed in the 1860s to 1880s, to take land from pastoral licence holders and make it available for small farms, to provide food and employment, and create a yeoman society of small farmers. By the turn of the century almost half of Victoria's land area had been privatised. Rural life was regarded as morally and socially superior to urban life, and other industries were needed to employ people as gold mining declined. Large parts of the Northern Plains, Goulburn Valley, Gippsland and the Wimmera were subdivided, and millions of hectares of native vegetation were cleared. But fragile soils, limited fertility and irregular climate made survival tenuous. The 1870s were quite wet, encouraging more people onto the land. But dry times in the following decades – including the Federation Drought from 1895 until 1902 – ruined many small farmers. Compounding the environmental damage was a great plague of rabbits, which destroyed vegetation and caused erosion over vast areas. Rabbit extermination and trapping for human consumption became new industries.

Irrigation was promoted as the solution for a dry climate. In 1884 Parliamentarian Alfred Deakin headed a Royal Commission on irrigation, and under the resulting laws in 1886, the government took control of all waters and planning for large reservoirs and canals. The first project was the Goulburn reservoir near Nagambie. There was also large-scale drainage of wetlands, including the 50km^2 Carrum Carrum Swamp and the even larger Koo Wee Rup Swamp.

Victoria became increasingly urban, and Melbourne reached a population of half a million. Known as 'Marvellous Melbourne' during these prosperous times, it also earned the nickname of 'Smellbourne', as low-lying areas along the Yarra River became polluted slums and the site of noxious industries, and the Maribyrnong River around Footscray hosted animal processing and other polluting industries. Industrial and human wastes poured into open drains that flowed into the Yarra and Maribyrnong Rivers. A Royal Commission in 1888 resulted in the construction of a deep sewer system, with effluent pumped to the Werribee Treatment Farm.

Victoria's first conservation reserve of 600 hectares at Tower Hill near Warrnambool was established in 1866 and others followed at Fern Tree Gully in 1882, and Mount Buffalo and Wilsons Promontory in 1898. In 1892 Tower Hill became Victoria's first national park, although in name only, for by then it had lost most of its natural vegetation. The status and objectives of early reservations make it problematic to identify Victoria's first true national park.[4]

1901–1945: closer settlement, irrigation, forestry

Punctuated by two world wars and major economic depression in the 1930s, the first 45 years of the 20th century were not an easy time. Under various closer settlement and soldier settlement schemes, large areas were cleared. Spurred by a belief that dry land could be made productive by adding water, there were renewed efforts to develop irrigation. The 1905 Water Act established the State Rivers and Water Supply Commission to take control over inland waterways. Over time, it allocated rights to considerably more water than was available. Between 1914 and 1940 the area under irrigation increased from about 40,500 hectares to 240,000 hectares. The overall area under cultivation more than doubled to 3.8 million hectares by 1931, with wheat the main product. When wheat prices fell in the 1920s, there was pressure on farmers to grow more, and many over-worked their land. The 1930s brought dust storms and made dust bowls of lands bare and vulnerable due to clearing, rabbit plagues and damaged soils. Victoria lost large volumes of its 'soil capital'.

Melbourne's population exceeded one million by the end of the 1920s, making up about 57% of the state population. Timber cutters worked their way into the hills and mountains to the north and east of Melbourne to meet the demand for construction. A Forests Act was passed in 1907, establishing a Department of State Forests under a minister for forests. Major transformations came with brown coal mining in 1920 for electricity generation and the rapid adoption of motor vehicles. The availability of cheap energy enabled Victoria to maintain its position as a major industrial and manufacturing centre. Commercial fishing had spread well beyond Port Phillip, to port towns such as Port Fairy, Portland, Warrnambool, Lakes Entrance and San Remo. At first it was mainly coastal fishing, but then ocean-going vessels moved well into Bass Strait and beyond.

The increasing exploitation caused mounting concern among a minority of the population and stimulated early conservation advocacy. Some of the earliest habitat protection came from the establishment of timber reserves on crown lands, to provide for future timber use or protect water catchments. The protection of birds became popular, with the 1901 establishment of the Royal Australian Ornithologists Union, followed by the Gould League of Bird Lovers in 1909, which was organised through Victoria's education department to encourage school children to value birds. Bushwalking was a favoured activity from about the 1880s and boomed in the interwar years. Bushwalking and naturalist clubs lobbied the government to preserve wilderness areas, and were instrumental in the establishment of national parks. In 1906 the 'national park' at Wilsons Promontory was upgraded, its grazing licences cancelled and a management committee appointed.[5] In 1909 more-remote areas were reserved at Wingan Inlet, Wyperfeld and Mallacoota, although they had only limited protection until 1956.

1945–1970: prosperity, technology and environmentalism

After the second world war came more-intensive development and environmental degradation, but also a growing movement for environmental protection. A large-scale immigration program and a baby boom caused the Victorian population to jump from 2 million in 1945 to 3.5 million in 1971. New reservoirs were built in the hills and mountains east of Melbourne to try to meet water demand. Agriculture intensified, with more soldier settlement schemes and technologies such as bulldozers and chainsaws that made land clearing and timber felling easier and cheaper, subsidised by a taxation system offering deductions for 'improvements'. The application of trace elements, chemical fertilisers and pesticides and systematic damming or diversion of most of the state's rivers greatly boosted production.

Demand for timber increased, initially mostly for the housing boom, but governments also began to licence the export of wood chips to Japan for papermaking. Loggers pushed further into Gippsland and East Gippsland. Concern about forests led to the establishment in 1944 of a professional organisation, the Save the Forests Campaign, which in 1951 morphed into the Natural Resources Conservation League of Victoria. In 1952 the Victorian National Parks Association was created by a federation of organisations concerned about these issues. As a result of advocacy led by the VNPA, a National Parks Act was passed in 1956 that more clearly defined and protected national parks. The Australian Conservation Foundation, based in Melbourne, was formed in 1965.

Probably the single most important trigger in the rise of environmental consciousness in Victoria was the Little Desert controversy in the 1960s. An area of sandy and partly saline Mallee country in far western Victoria, the Little Desert had remained Crown Land because it was considered too poor for agriculture. In the late 1950s and 1960s proposals to subdivide the land for farms were unsuccessful. But in 1967, the government proposed to set part of it aside as a national park and open the majority to farming. The legislation to do so was passed in 1969. But there was strong opposition, both locally and in Melbourne, including by the Melbourne *Age*. In Melbourne, scientists and concerned citizens formed the Save Our Bushland Action Committee. Eventually, for a mixture of political and environmental reasons, the government abandoned the scheme and most of the Little Desert was eventually declared a national park. In 1969, energised by the successful Little Desert campaign some citizens and organisations formed the Conservation Council of Victoria (now Environment Victoria), and with other campaigns such as that to protect the Lower Glenelg in south-western Victoria from development, environmental issues became prominent as never before.

The watershed Little Desert campaign also triggered reforms to make land management decision-making 'both scientific and a public concern'.[6] In 1971, the government formed the Land Conservation Council (now the Victorian Environmental Assessment Council) to 'carry out investigations and make recommendations to the government with respect to the use of public land in order to provide for balanced land use in Victoria'. It fostered research to develop a knowledge base for the ecological evaluation of Victorian landscapes and resulted in the declaration of many national parks. Another response to mounting environmental concern was an extension of government policies, authorities and actions, including the 1971 establishment of the Victorian Environment Protection Authority and a department responsible for conservation.

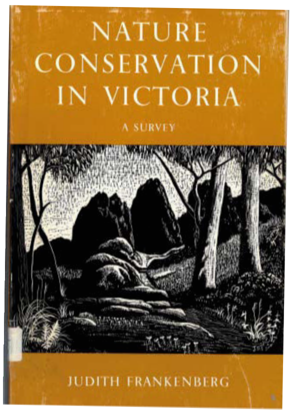
1.2.2 VNPA nature conservation reviews, 1971-2001

In 1971 the Victorian National Parks Association published a small book with a large impact, entitled Nature Conservation in Victoria – a survey … The information assembled and presented established a baseline from which successive governments and the community have moved to develop further a nature conservation reserve system for Victoria.

Doug Frood and Malcolm Calder, 1987

The three previous VNPA nature conservation reviews – in 1971, 1987 and 2001 – tell the more recent history of European impacts on Victoria's environment, and are also themselves part of that history because of their influence on conservation reforms.

1971 review: Nature Conservation in Victoria: A Survey by Judith Frankenberg, edited by John Turner[7]



It is shown that from the point of view of wildlife conservation the present system of reserves is entirely inadequate. At the same time there is sufficient suitable unalienated Crown land to allow the establishment of a state-wide system of reserves which would protect the majority of our plant and animal communities and prevent the further loss of indigenous species.

Judith Frankenberg, a recent Masters graduate from Melbourne University's Botany School, was appointed in 1966 to conduct a 2-year survey, the objects to 'assess the extent and value of the various kinds of nature reserve now existing in Victoria and to assess the current deficiencies in the field of nature conservation by an examination of those parts of the ecosystem for which no adequate conservation measures have yet been taken'. John Turner, the head of the Botany School, edited the manuscript.

Only about 1% of Victoria's land area was then protected in conservation reserves and, apart from birds, little was known of their values. The National Parks Act, which established the National Parks Authority, was just a decade old. Prior to that most of Victoria's national parks and nature reserves were managed by local committees, which often had to lease areas for grazing and timber harvesting to finance any management.

There was no detailed vegetation map of the state and little had been done to assess the status and biology of the state's flora and fauna. The basic ecological work necessary for defining ecological communities was still in progress.

In 1971, in a pivotal move for Victorian conservation, after the successful campaign to protect the Little Desert from an agricultural scheme, the state government established the Land Conservation Council to advise on the most appropriate uses for public land, then about 38% of Victoria's land area. By highlighting conservation priorities, the review was to prove of great value to inform and influence the work of the Land Conservation Council.

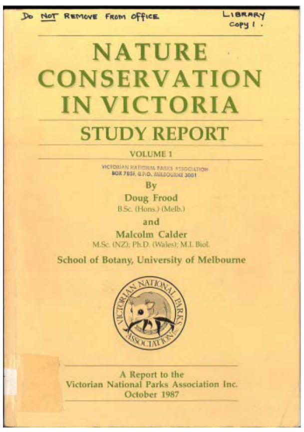
To assess the adequacy of the reserve system, Frankenberg compiled the first systematic characterisation of vegetation communities in Victoria, listing 62 'vegetational alliances' and recording their distribution in vegetation provinces.[8] They were the basis of her assessment of the adequacy of the reserve system, the first such assessment in Victoria and one of the first in Australia. Of the 62 alliances, about 25 (40%) were assessed as 'reasonably well protected in some form of reserve' while the remaining 37 had 'poor to inadequate' protection. Seventeen alliances (27%) required 'urgent measures for conservation'. Frankenberg warned that it could be difficult to locate 'relatively undamaged examples' of some communities, especially the grasslands, and their regeneration would be difficult.

Frankenberg also assessed the adequacy of the reserve system for species conservation and compiled the first list of Victoria's flora and vertebrate fauna and their likely conservation status. She found that 39% of Victoria's native plants and 5% of birds were not recorded in any reserve. There was insufficient knowledge of other groups to assess the extent of their protection in reserves. She highlighted threats to species due to fire, fertilisers, alien species, pollution, spear fishing, river improvement schemes, dams, and grazing in alpine areas.

Frankenberg concluded that if 'examples of what remains of Victoria's wildlife and plant communities are to survive, the basis of a State-wide conservation system must be laid down within the next few years.' She found that in most cases the selection of reserves had been soundly based, 'although their promulgation as reserves was acceptable only because no other use for them could then be envisaged'. She advocated reserving areas larger than 100 acres and stressed the importance of conserving 'the more common widespread species and communities ... as 'those characteristic of this part of Australia, giving Victoria its distinctive appearance and providing habitat for the common and characteristic animal species'.

The review recommended the establishment of large reserves in 11 regions, the conservation of 11 other areas, extensions to eight national parks and the establishment of eight multiple-use national parks. It also advocated the establishment of marine reserves, particularly in coastal waters. 'In the whole spectrum of flora and fauna of Victoria the life of the coastal waters is the largest group completely lacking conservation measures and among those needing it most.'

1987 review: *Nature Conservation in Victoria: Study Report* by Doug Frood and Malcolm Calder, University of Melbourne[9]



In this State we are still working actively towards the provision of an adequately comprehensive and representative system of reserves ... [It] is sadly true that much has been lost.

The 1987 review was a 20 month desk-top study to prepare a database from which a rational assessment of the adequacy of the reserve system could be made, and to identify species and communities in need for further protection.

Progress since the 1971 review

The Land Conservation Council had completed the first round of regional studies and made over 4000 recommendations to reserve public land for a wide range of purposes. Many areas with high conservation values had been protected, including most identified in the 1971 review (but with important exceptions such as mountain ash forests in the Central Highlands). There was 'wide acceptance' of most recommendations by the Land Conservation Council, although several 'generated heated and polarised debate'. Between 1971 and 1987 the area of national parks and other protected areas (those on the schedules to the National Parks Act) expanded from 0.2 million hectares to more than 1.4 million hectares, comprising 30 national parks, 2 wilderness parks, 25 state parks and 19 other parks and reserves. Important national park and wilderness park additions include the following (a complete list is in appendix 8).

1978	North-eastern Victoria	Burrowa-Pine Mountain
1979	Eastern Victoria	Baw Baw, Croajingolong, Snowy River, Tingaringy
1979	Mallee	Big Desert
1980	Mallee	Hattah-Kulkyne
1981	Otways	Otway
1981-82	Victorian Alps	Bogong, Wonnangatta
1984	South-western Victoria	Grampians
1986	South Gippsland	Tarra-Bulga National Park
1986	Gippsland	Mitchell River
1987	Victorian Alps	Avon

A new management structure had been established for reserves. Under administration by the Department of Conservation, Forests and Lands, public land management was devolved to 16 regional groups. Frood and Calder were uncertain how successful it would be. The major vegetation 'alliances' of Victoria were being mapped at a 5 minute grid scale, and a Victorian bird atlas and mammal atlas were to be undertaken. There had been major advances in ecological knowledge.

Focus of 1987 review

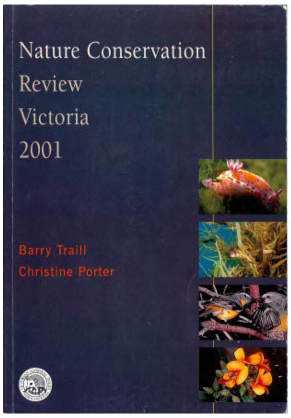
The 1987 review was important for its analysis of conservation concepts and approaches. For example, Frood and Caldwell emphasised the importance of genetic conservation: 'A different way of looking at species is required – not as a single genetic entity, but as a collective description for a range of genetic forms which have a lot in common with each other. When any of these forms are lost, it is a permanent loss of genetic diversity (the product of millions of years of evolution). ' They defined the conservation ideal as each genetic entity retaining its presence within the ecosystem, 'with some kind of long-term viability to this process'. Frood and Caldwell also emphasised the importance of maintaining ecological processes

Over 60% of the state had been cleared by this stage, including 95% of private land. About 1% of remnant bushland was being cleared each year and 'patterns of formerly piecemeal alteration [were] merging together'. Of forests, 50% had been cleared and 70% of the remainder severely modified. More than 35% of wetlands had been drained and close to 80% of rivers and wetlands had been substantially modified. Most (95%) native grassland communities had been eliminated or modified. About one in six native vertebrate animals and vascular plants were in need of 'careful protection'. Frood and Calder described major land uses and the extent of alteration in each of the vegetation provinces. They reviewed major management issues – in particular fire regimes, timber harvesting, grazing, introduced species, and disturbance factors. The issues and dilemmas they discussed still largely apply today. Of fire, they said, 'Appropriate fire-regimes vary between localities and vegetation-types within localities. The ecological effects of fire regimes (particularly as applied via fire-reduction burning) are inadequately known... '

Frood and Calder compiled lists of Victorian plants and vertebrate animals, assessed their conservation status and considered the ecological requirements of each group.

They identified opportunities to increase the representativeness of the reserve system. They found broad-scale deficiencies in the protection of plant communities and biases towards land that was not productive for agriculture. The reservation of grasslands and grassy woodlands had not greatly improved since the 1971 survey by Frankenberg, and only small fragments remained. They noted that the 'required size and spacing of reserves is a contentious issue on which more information is badly needed.' Lowland grasslands, grassy woodlands, mallee woodlands, saltbush shrublands, wetlands and riparian communities were in urgent need of conservation.

2001 review: *Nature Conservation Review Victoria 2001* by Barry Traill and Christine Porter[10]



Many gains have been made but local and regional extinctions are continuing.

The aim of the 2001 review was to identify gaps in conservation and in the reserve system and make recommendations to slow and reverse biodiversity losses.

Progress since the 1987 review

Considerable progress had been made in the 14 years since the previous review – particularly with new measures for biodiversity conservation, vegetation protection, catchment management and marine conservation. But the review found that extinction processes were nonetheless continuing largely unabated.

The Flora and Fauna Guarantee Act had been enacted, providing a process to identify and protect threatened species and communities and to address threatening processes. But implementation was being stymied by lack of adequate funds and prioritisation of commercial interests.

In 1997, the Victorian biodiversity strategy was launched, setting out the state of biodiversity and broad mechanisms for conservation. Traill and Porter commented that although 'it could be criticised for its lack of policy specifics, it nonetheless sets out a clear vision of what is sought for nature conservation.' Whether it would be successful would depend 'on the preparedness of government to enact the vision set out in the strategy and to provide the necessary political will and funding'.

Clearing controls on private land were introduced in 1989, which reduced rates from an estimated 15,000 hectares to 3000 hectares annually. There had been great progress on mapping of terrestrial ecosystems, and developing better structures for protecting native vegetation. A state vegetation framework and regional vegetation plans were in preparation. Catchment management authorities had been set up to help administer policy and to provide for better mechanisms 'to confront the increasing scale and complexity of problems such as salinity'. There was 'a significant and increasing number of landholders willing as individuals to manage land for conservation', including those who purchased land solely to protect conservation values and others seeking a lifestyle block.

There was a long overdue focus on marine ecosystems. An environmental inventory had been under way since 1992 to classify Victoria's marine ecosystems, and the Land Conservation Council and its successor, the Environment Conservation Council, had been conducting the marine, coastal and estuarine Investigation since 1991 to recommend the establishment of a representative system of protected areas and areas suitable for marine aquaculture.

Since 1987, the extent of protected areas (on the schedules to the National Parks Act) had more than doubled, to nearly 3.1 million hectares. By the end of 2001 there were 36 national parks, 3 wilderness parks, 31 state parks and 22 other parks and reserves on the schedules to the Act. Important additions to the national park estate include the following.

1988	Western Victoria	Little Desert expansion
1988	Northern plains	Terrick Terrick State Park
1988	East Gippsland	Coopracambra, Errinundra, Snowy River expansion
1988	Coastal	Point Nepean
1989	Victorian Alps	Alpine
1991	Mallee	Murray-Sunset, Wyperfeld expansion
1992	Wilderness	Wilderness areas expansion
1995	Central Highlands	Yarra Ranges
1997	Coastal	Coastal parks: Bay of Islands, Cape Conran, Cape Liptrap
1999	Northern plains	Terrick Terrick

Focus of 2001 review

Traill and Porter reviewed the status of Victoria's marine systems and described the major threats including habitat loss and alteration, declining water quality, overexploitation of resources, introduced species and pathogens, and global warming. The extent of threats was 'largely unknown'. They assessed data limitations and high priority research and management needs, which included identifying rare and threatened species, mapping their distribution and identifying habitat requirements, and mapping breeding aggregations and nursery areas for a wide range of species.

At the time of the 2001 review, only 600 hectares of Victoria's marine waters were protected (other areas covering 53,500 hectares were labelled as such but they permitted exploitation such as fishing). The Environment Conservation Council had developed draft recommendations for a system of protected areas that Traill and Porter recommended VNPA support 'in principle'. However, they criticised the process as having been too influenced by economic considerations and inadequate to protect variation within bioregions. They recommended that 20% of each major marine habitat by area be included within highly protected marine protected areas, that a minimum of two marine national parks in each bioregion be urgently established, and that funding for management be increased. They also advocated the integration of marine national parks within a framework of coastal zone management.

Traill and Porter reviewed the state of terrestrial biodiversity and primary threats: habitat loss and degradation, environmental weeds (after habitat destruction, probably 'the single most important cause of habitat loss and degradation'), feral animals, logging and firewood removal, overgrazing, salinity, greenhouse effect ('the potential to be the greatest threat to nature conservation in Victoria'), and changes to water flows.

Although expanding, Victoria's reserve system had been 'disproportionately occurring in the land types which are not desired for human exploitative uses'. Based on an assessment of the extent of reservation of ecological vegetation communities, the review found 'very poor achievement of target levels'. Of 632 ecological vegetation classes (vegetation types based on ecological and physical features) mapped in Victorian bioregions, just 19% were adequately reserved, 76% were not adequately reserved, and others lacked data or were extinct. More than half were threatened or extinct.

High priority recommendations were to protect all vegetation remnants in highly fragmented landscapes and establish major new park systems for protection of south-western Victoria, riverine forests and woodlands, the Strzelecki Ranges, and box–ironbark woodlands and forests. There were also recommendations to address invasive species and climate change and threats to freshwater systems.

1.2.3 Progress since 2001

Although the majority of recommendations from the 2001 review have not yet been achieved, some important progress has been made.

In 2001, a native vegetation management framework was introduced with the goal of achieving a net gain in the extent and quality of native vegetation, given force through local government planning provisions. The approach had flaws but in 2013 the goal of net gain was abandoned and the regulations were considerably weakened, so clearing rates are expected to rise again.

In 2002 a world-first representative system of marine protected areas was created to protect 5.3% of state waters (about 53,000 hectares). There was an increase in the terrestrial national park estate by about 300,000 hectares, and the creation of 13 new national and state parks.

For the first time in Victoria, Aboriginal people's struggle for land was recognised with the creation of a national park board of management with majority Indigenous membership at Barmah, one of the new red gum national parks created in 2010.

Important additions to the national park estate include the following.

2002	Box-ironbark forests and woodlands	4 new national parks: Chiltern-Mt Pilot, Greater Bendigo, Heathcote-Graytown, St Arnaud Range. 2 new state parks. Additions to existing national & state parks.
2002	Marine	13 marine national parks, 11 marine sanctuaries
2005	Otways	Great Otway
2008	South-western Victoria	Cobboboonee
2010	River red gum forests	4 new national parks: Barmah, Gunbower, Lower Goulburn, Warby-Ovens. Additions to existing national and state parks.
2010	East Gippsland (old growth forest)	Additions to Croajingolong, Errinundra and Snowy River
2012	East Gippsland	Lake Tyers State Park

Since the 2010 election of the Liberal/National government, many environmental reforms have been undone or abandoned, including a 2009 white paper for reversing environmental decline and protecting biodiversity under climate change, prepared at the end of a four-year process (*Securing Our Future: A White Paper for Land and Biodiversity at a Time of Climate Change*). Controls on land clearing, forestry, firewood collection and planning have been weakened, and national parks are being opened to damaging exploitation. The government reneged on creating Murray River Park, a string of crown lands along the Murray River between Mildura and Yarrawonga, in favour of allowing ongoing cattle grazing.

1.3 Environmental drivers and trends

Human-mediated environmental impacts are now so extensive and pervasive that many consider that the planet has entered a new geological epoch – the Anthropocene.

Christoph Kueffer & Christopher Kaiser-Bunbury, 2014[11]

There are many continuities in this nature conservation review with the findings of the three previous reviews. Victoria is still a long way from having a comprehensive, adequate and representative national park and conservation system, a core element of any effective nature conservation strategy. Most major threats to nature identified in the past reviews, many initiated in the early days of settlement, are still very much with us – habitat loss and degradation, invasive species, harmful fire regimes, over-grazing, modified water flows and over-exploitation of natural resources. Several have intensified, and the speed, magnitude and types of change are increasing. Three interrelated major drivers of these changes – climate change, population growth and agricultural intensification – will profoundly shape Victoria's future.

1.3.1 Climate change

Already significantly affecting life in Victoria, climate change will drive multiple escalating and cascading changes – in temperature and rainfall patterns, extreme weather events, sea level rise and ocean acidity – and exacerbate many other threats, particularly severe fire events and invasive species. Since the 2001 nature conservation review, Victorians have experienced the longest, hottest and driest period since European colonisation. During the 13 years of the millennium drought (1997–2009) rainfall totals were the lowest on record.[12] Fourteen of the past 17 years have recorded below-average rainfall and every year has been warmer than the 1961-1990 mean (Figure 1.3).[13] Six of the 10 hottest years recorded in Victoria have been in the past 20 years and eight have been since 1980 (Table 1.1).

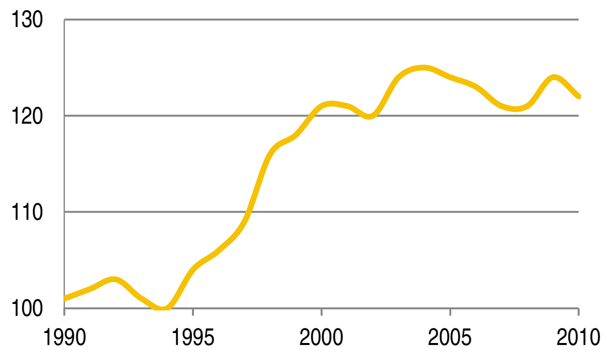
Table 1.1 Victoria's ten warmest recorded years[14]

2007
1988
2013
1914
1961
1981
2000
2005
1999
2001

Severe fires in eastern and alpine Victoria in 2003, in eastern Victoria in 2006 and 2007, and to the north and east of Melbourne in February 2009 caused catastrophic damage. Although individual weather events cannot be attributed to climate change, the extremes of recent times are consistent with climate change and some patterns of change can only be explained by factoring in anthropogenic warming.[15]

Victoria is among the world's worst greenhouse gas emitters, with its heavy use of fossil fuels and emissions increases of more than 20% since 1990 (Figure 1.2).[16]

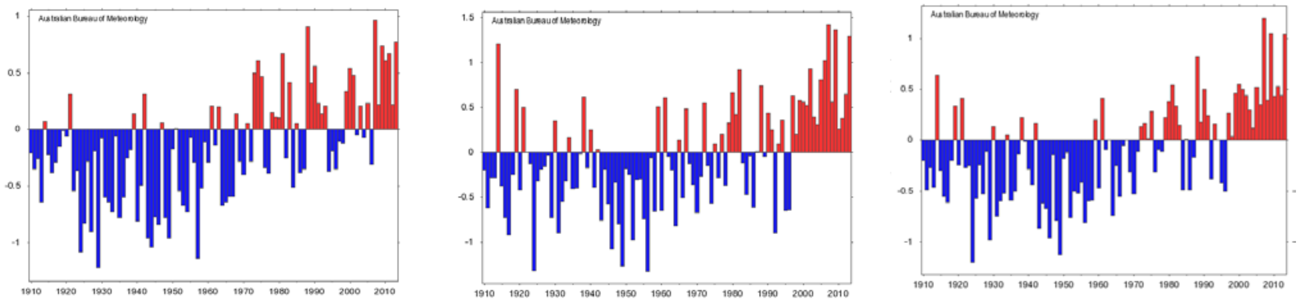
Figure 1.1 Victoria's greenhouse gas emissions[17]



Data source: Victorian government. Note: The units are CO_2-equivalent (million tonnes), excluding land use, land use change and forestry

With the global failure to arrest greenhouse gas emissions and continued warming inevitable, there needs to be a concerted effort to optimise the resilience of ecological and human communities and their potential for adaptation. Mitigating other threats to nature and expanding the national park and conservation system have become even more important. Adapting to climate change will surely be Victoria's greatest challenge in the near-term future.

Figure 1.2 Annual temperature anomalies, Victoria 1910-2013: annual minimum temperatures (left), annual maximium temperatures (middle) and annual mean temperatures (right)[18]



Source: Bureau of Meteorology. The graphs shows variations from 1910 to 2013 around the annual minimum (left), maximum (middle) and mean (right) temperatures based on a 30 year climatology from 1961-1990.

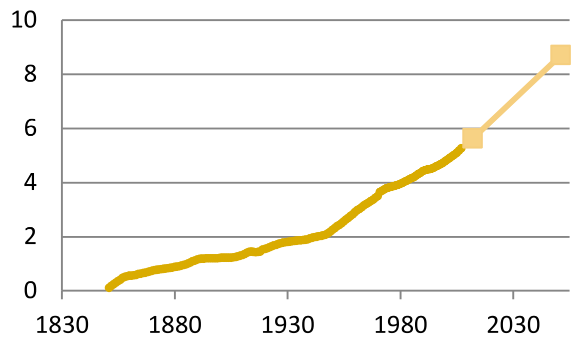
1.3.2 Population growth

Victoria's burgeoning human population is the driver of many threats. Precious habitat remnants are being bulldozed for urban expansion or paved for roads. More people are emitting more greenhouse gases, consuming more natural resources (water and firewood for example) and introducing more invasive species for gardens or pets or through increased travel and trade. Victorians consume several times their equitable share of planetary resources. Some forms of recreation – fishing for example – are also taking a heavy toll on nature. At the same time, a more sedentary and indoor lifestyle is increasingly severing many Victorians from nature, undermining health and wellbeing as well as support for conservation.

Victoria's population has grown by almost a million over the past decade, reaching 5.8 million in 2013. About three-quarters (4.1 million) live in Melbourne, compared to about 40% in 1900. Recent increases have been driven by a 'mini baby boom' and immigration from overseas. It is projected that by mid-century the population will increase by almost 60% to reach 8.7 million (6.5 million Melbourne) (Figure 1.4).[19] Victoria is Australia's most densely populated state, and by 2030, Melbourne is expected to become Australia's largest city.[20]

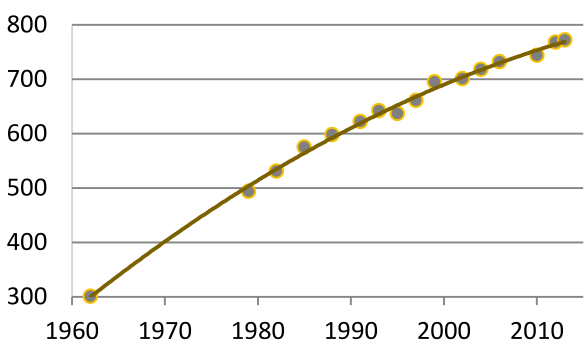
Population growth over the next three decades is predicted to require more than 300,000 more dwellings, which will add enormously to pressures on biodiversity in the urban fringes.[21] The impacts of a burgeoning population are exacerbated by increasing consumption, such as higher vehicle ownership (Figure 1.5).

Figure 1.3 Victoria's population (millions) since European colonisation and projected to 2050[22]



Source: Australian Bureau of Statistics

Figure 1.4 Vehicles per 1000 population in Victoria[23]



Source: Australian Bureau of Statistics

1.3.3 Land-use intensification

The fundamental challenge … is to develop farming systems that are more intrinsically Australian: that are resilient in the face of extreme weather and extreme seasonal variability; that are miserly with water and conserving of energy; that maintain groundcover and are kind to the soil; that sit lightly on the landscape and don't displace native wildlife or habitat; that are highly profitable in good seasons and don't lose money in bad seasons; that preserve and build their natural, human and financial capital; that recover quickly from shocks and stress…

Andrew Campbell, 2008[24]

The majority of land in Victoria, and much of the sea as well, is subjected to intense human exploitation. A major driver of change is increasing intensification of land-use, primarily agriculture. The spread of urban areas is also a form of intensification in some places.

Although Victoria has just 3% of Australia's total farm area, it produces about 25% of the value of national agriculture output.[25] Close to 60% of Victoria's land area, about 12.7 million hectares, is used for agriculture and about 80% of this area has been cleared. Conventional farming practices – clearing, cultivation, irrigation, grazing, spraying, fertilisation – have caused the greatest ecological damage in Victoria, and any intensification of these practices is likely to have further conservation consequences.

Agricultural intensification involves a 'simplification of the agroecosystem' and increased inputs (fertilisers, pesticides or water).[26] In Victoria, it has included the conversion of grazing lands to crops, the planting of 'improved' pastures (using introduced, often invasive, plants and applying fertiliser) pastures, the use of new technologies such as centre pivot irrigation (for which paddock trees and small buloke remnants are removed) and basalt rock crushing on the Victorian Volcanic Plains.

The number of farms in Victoria has more than halved in the past four decades (from almost 70,000 in 1963-64 to about 32,500 in 2012) but the average farm size has almost doubled (from about 210 to 390 hectares).[27] Since the turn of the century, the area of crops in Victoria has increased by about 1 million hectares to more than 4 million hectares, close to a fifth of Victoria's land area.[28] Terms of trade for agriculture have declined, putting pressure on farmers to increase productivity.[29] Agricultural businesses not in the top 10% of productivity are generally subject to chronic unprofitability and rising debt.[30] Aspirations to increase Australia's food exports are likely to drive greater intensification. On current trends, global food consumption is expected to be 75% higher in 2050 than in 2007, and the 2013 national food plan has a target to increase agriculture and food-related exports by 45% by 2025.[31]

Some of the major recent changes in land use are captured in the following five-fold classification of Victoria's landscapes by Neil Barr (Figure 1.6).[32]

Production landscapes (26 statistical local areas) are mostly in northwest Victoria and have larger farms with broadacre cropping or grazing. They have achieved productivity increases that match or exceed the long-term decline in agricultural terms of trade. (A statistical local area is a classification used by the Australian Bureau of Statistics.)

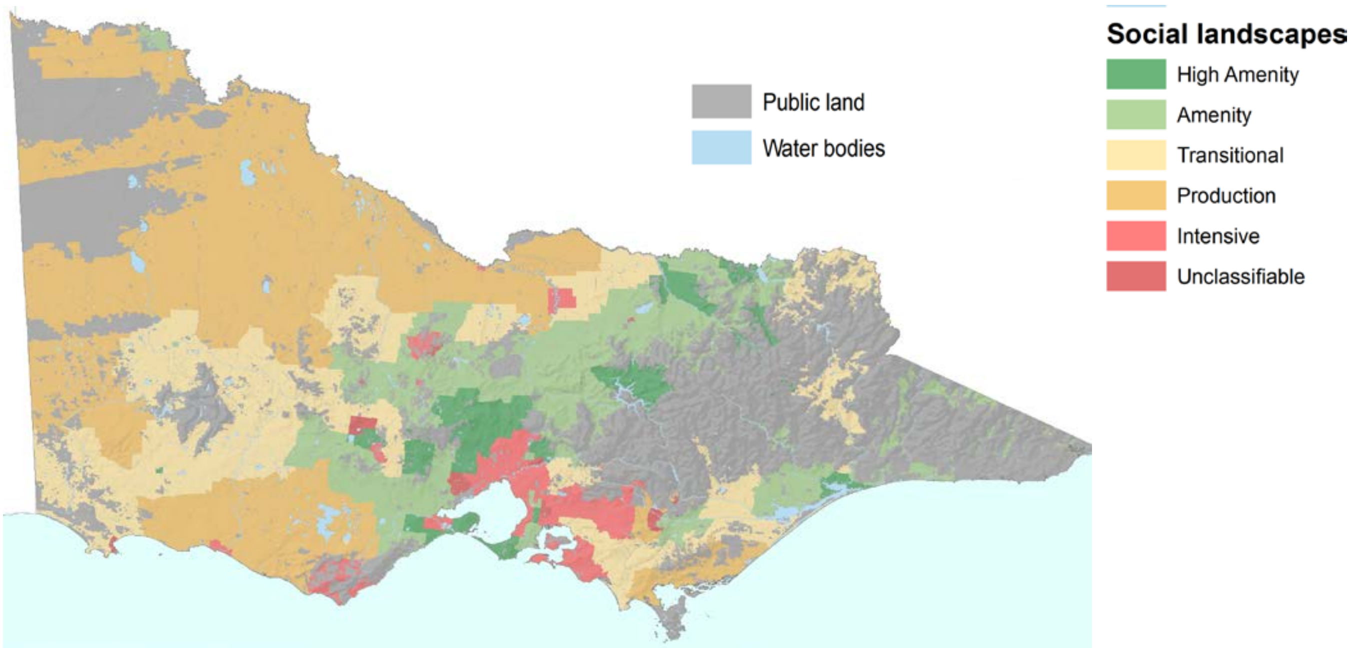
Transitional landscapes (25 statistical local areas) are mostly areas where agricultural industries such as sheep farming have declined in profitability and are gradually being replaced by more profitable forms of broadacre agriculture, blue gum plantations and small boutique crops or animal production. Some wool producers have diversified to 'prime lamb production'. Some land has been bought for conservation restoration.

Amenity farming landscapes (35 statistical local areas) are in areas with high scenic qualities but beyond the Melbourne commuting zone, where land is being bought for its residential value, often as weekenders. In many local government areas, 30% to 50% of properties have non-resident ratepayers. The small number of farms that have prospered have often done so by intensification. Others are run by ageing farmers who are not under pressure to increase productivity to pay a mortgage.

High amenity landscapes (19 statistical local areas) are mostly on the outskirts of Melbourne or major provincial centres; a few are in mountain tourism destinations. Two-thirds of rural property purchases in these landscapes are made by people living outside the district and land price is determined by location and scenic qualities rather than agricultural potential. Farms are smaller than elsewhere and have been shrinking. Agriculture plays a minor role in the local economy.

Intensive agriculture landscapes (20 statistical local areas) are mostly located on the outskirts of Melbourne, Bendigo and Ballarat. In common with amenity landscapes, they have high population growth, high land values and a significant part-time farming community. They also have a flourishing intensive farming sector that produces chicken meat, vegetables, mushrooms, pork, eggs and wine.

Figure 1.5 The social Landscapes of Victoria



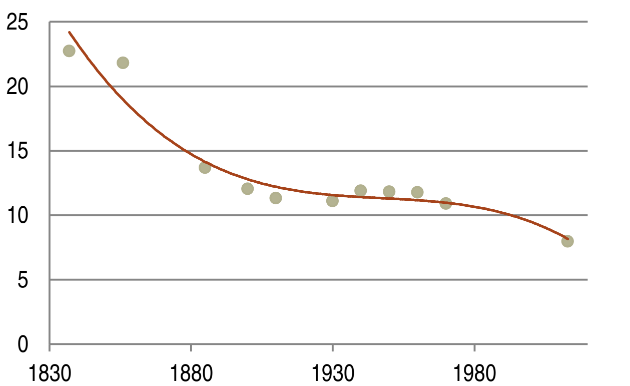
Map: VNPA. Data source: Rural Social Landscapes datasets compiled by Neil Barr (2008).

1.4 Victoria's national park & conservation system

The greatest progress in Victorian conservation has come from providing public lands and waters with a high level of conservation security in the national park estate. As the history in section 1.2 makes clear, the rapid development of Victoria and large-scale land clearing was given strong impetus by the selling (alienation) of crown land. Changes in land tenure from public to private ownership have preceded most damaging land uses. Some early and fortuitous intervention came with decisions in the late 1800s to reserve in public ownership the unalienated sections of coastal foreshore and river frontages, to support water transport and land access.[33]

About two-thirds of Victoria's land area has been alienated (close to 15 million hectares, Figure 1.7), leaving about 8 million hectares of land in public ownership.[34] (All marine waters are in public ownership.) Most national parks have been created by upgrading the tenure of public lands, about half of which are now managed primarily for conservation (Table 1.2).

Figure 1.6 Progressive alienation of public (crown) land in Victoria (millions of hectares)[35]



Sources: Judith Frankenberg, Department of Environment and Primary Industries. The increase in public land area after 1930 was due to forfeitures.

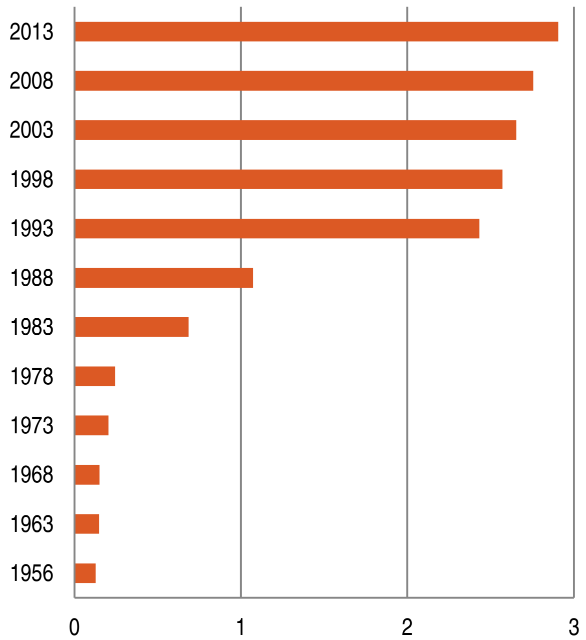
The cornerstone of biodiversity conservation in Australia and internationally is the establishment and effective management of a comprehensive, adequate, and representative system of protected areas.[36] 'Comprehensive' requires protecting examples of the full range of ecosystems within and across bioregions, 'adequate' requires protecting areas sufficient to maintain the viability and integrity of populations, species, and communities, and 'representative' requires protecting the variability of habitats within ecosystems.[37]

Although Victoria's terrestrial national park estate is fairly extensive, it is far from comprehensive, adequate or representative, mainly because of the early alienation of public land in the most productive landscapes for agriculture (chapter 3). For different reasons, the marine national park estate also does not meet these protected area goals (chapter 2).

For the past four decades, Victoria has had the great benefit of independent public bodies to investigate and recommend the protection of crown land for conservation and other public purposes. This began with the Land Conservation Council in 1971, replaced by the Environment Conservation Council in 1997, which was replaced by the Victorian Environmental Assessment Council in 2002.

Figure 1.8 shows the growth in Victoria's national parks since the first National Parks Act (see appendix 8 for details). More recently, private land and Aboriginal land have become a small but growing part of the national park and conservation system.

Figure 1.7 Growth of Victoria's terrestrial national parks, 1956-2013 (millions of hectares)



Sources: Annual reports for the National Parks Act.

1.4.1 Defining the national park and conservation system

Although many types of tenure or legal agreement imply some form of conservation protection, only properties that are securely and permanently protected and managed primarily for conservation are genuinely protected (Box 1.2 explains these criteria). In this report, marine and terrestrial properties that meet these criteria are referred to as the 'national park and conservation system'. They are a subset of what governments refer to as 'protected areas' or 'reserves'.

Properties with the highest level of protection are referred to in this report as the 'national park estate'. They are properties listed under the National Parks Act in schedules 2, 2A and 2B (national parks, state parks, wilderness parks) and schedules 7 and 8 (marine national parks, marine sanctuaries) or they are reference areas under the Reference Areas Act. The terrestrial national park estate covers about 3.3 million hectares and the marine estate about 54,000 hectares (Table 1.2).

A second tier of protected areas that are also part of the national park and conservation system ('other conservation properties') includes properties listed under schedule 3 of the National Parks Act and private properties with a perpetual covenant under the Victorian Conservation Trust Act (Trust for Nature covenants). They are securely and permanently protected but have less rigorous legal requirements for conservation management than the national park estate. They are typically also smaller properties, averaging 150 hectares. They total about 600,000 hectares (Table 1.2).

Other tenure types that are typically called 'protected areas' or 'reserves' but do not meet the criteria for the national park and conservation system include properties such as those listed in schedule 4 of the National Parks Act (marine and coastal parks, marine reserves, marine parks) and wildlife reserves that permit hunting. Their protection may be insecure (able to be easily changed) or temporary or there is no specified primary management intent for conservation.

Table 1.3 outlines the protected area categories used in this report, including the legislation under which they are enacted.

Table 1.2 National park and conservation system[38]

Category	Number	Area (hectares)	% of state
Marine – national park estate			
Marine national parks	13	52,241	5.2
Marine sanctuaries	11	864	0.1
Marine total	24	53,776	5.3
Terrestrial – national park estate			
National parks	45	2,901,284	12.8
State parks	26	157,825	0.7
Wilderness parks	3	200,699	0.9
Reference areas(1)	54	25,392	0.1
Subtotal	128	3,274,528	14.4
Terrestrial – other conservation properties			
Public: eg nature conservation reserves	2,775	526,041	2.3
Private: Trust for Nature properties & covenants	1,330	93,456	0.4
Subtotal	>4,000	595,033	2.7
Terrestrial total	>4,000	**3,901,941**	17.2

Sources: Federal Department of the Environment (CAPAD 2012), Victorian Department of Environment and Primary Industries (Public Land Management spatial data 2013), Trust for Nature (2014). Note: (1) There are additional reference areas that overlap with other protected area categories.

Box 1.1 Criteria for the national park and conservation system

Three criteria must be met for an area to qualify as genuinely protected and part of the national park and conservation system: the conservation agreement is secure and permanent and the primary focus of management must by law be biodiversity conservation.[39]

- Security – protected areas are secure if their status is under control of an act of parliament (one focused on conservation) and requires a parliamentary process to extinguish the protected area or excise portions from it, or if they are under a secure contract, covenant, agreement or other legal instrument that has similar security.
- Permanence – ideally, protection should be in perpetuity; 99 years is a minimum.
- Primary management intent – biodiversity conservation must be the primary management goal. It is important to distinguish between a requirement to pro-actively manage for biodiversity conservation, and a lesser (insufficient) requirement to simply restrict particular uses which may impact negatively on biodiversity.

Table 1.3 Protected area categories: Victoria's national park and conservation system, as defined by VNPA

Tenure / mechanism	Legislation	PROTECTED AREAS[1]: National park & conservation system [2]: National park estate[3]	PROTECTED AREAS[1]: National park & conservation system [2]: Other conservation properties	PROTECTED AREAS[1]: Not in the national park and conservation system
PUBLIC LANDS (LAND STATUS DEPENDENT ON ACT)	National Parks Act[4]	Schedule 2: National park Schedule 2A: Wilderness park Schedule 2B: State park Schedule 7: Marine national park Schedule 8: Marine sanctuary	Schedule 3: other parks & reserves: ▪ Coastal park ▪ Flora & fauna reserve ▪ Park Schedule 4: selected reserves: ▪ Nature conservation reserve	Schedule 4: miscellaneous parks & reserves: ▪ Marine & coastal park ▪ Marine reserve ▪ Marine park
	Crown Lands (Reserves) Act		Nature conservation reserves: ▪ Flora & fauna reserve ▪ Wildlife reserve (no hunting) ▪ Flora reserve ▪ Nature conservation reserve Natural features reserves: ▪ Scenic reserve ▪ Geological reserve ▪ Bushland reserve ▪ Natural features & scenic reserve ▪ Streamside reserve ▪ Cave reserve ▪ Geological & geomorphological features area Phillip Island nature parks[5]	Natural features reserves: ▪ Wildlife reserve (hunting) ▪ River Murray reserve
	Fisheries Act			Fisheries reserve (if used for critical habitat) (not in use)
PRIVATE LANDS	Victorian Conservation Trust Act		Perpetual covenant[6] Trust for Nature nature reserve[7]	
	Conservation, Forests & Lands Act			Section 69 agreement in perpetuity[8]
	Wildlife Act		Wildlife sanctuary	
	Private agreements			Land management cooperative agreement with Alcoa[9]
INDIGENOUS LANDS	National Parks Act	Jointly managed schedule 2, 2A, 2B reserve (as above)[10]	Jointly managed schedule 3 or 4 reserve (as above)	Jointly managed schedule 4 reserve (as above)
	EPBC Act (federal)[11]			Indigenous protected area agreements to manage natural and cultural values
OVERLAYS	Reference Areas Act	Reference area		
	National Parks Act		Schedule 6: ▪ Remote natural area[12]	
	Wildlife Act[13]		State wildlife reserves: ▪ State game refuge ▪ State faunal reserve Nature reserve Wildlife sanctuary	State wildlife reserves: ▪ Game reserve (hunting)
	EPBC Act (federal)			Critical habitat (not in use)
	Flora & Fauna Guarantee Act			Critical habitat (not in use)

Explanatory notes for Table 1.4

(1) Most of these tenures are those recognised as protected areas by the Victorian Government in its provision of information to the 2012 Collaborative Australian Protected Area Database (CAPAD),[40] and thus are recognised by the IUCN, the Convention on Biological Diversity, Australia's National Reserve System and National Representative System of Marine Protected Areas. However, Trust for Nature covenants and reserves and section 69 agreements are not recognised in the CAPAD. Areas designated under the Forests Act, such as special protection zones, special management zones and Section 50 reserves, are not considered secure enough to be regarded as protected areas since they can be easily altered.

(2) Properties in this category are regarded as 'conservation reserves' by the Victorian Environmental Assessment Council. Other reserves placed in this category by the Victorian Environmental Assessment Council (but not in the national park and conservation system as defined in this review) include marine reserves, marine parks and national heritage parks (under the National Parks Act)

(3) These areas are largely exempt from mining by virtue the Mineral Resources (Sustainable Development) Act (section 6).

(4) The historic park and national heritage park reserve categories are protected under the National Parks Act but are not regarded as part of the national park and conservation system.

(5) The crown lands that make up Phillip Island Nature Parks were reserved for the conservation of areas of 'natural interest', 'ecological significance', 'natural beauty and historic interest', 'recreation and amusement' or other public purposes.

(6) Covenants are not recognised in the CAPAD 2012 but they are included here as part of the national park and conservation system because their protection is permanent and they are required by law to be managed for conservation. A few covenanted areas are used for production and therefore not regarded as part of the national park and conservation system.

(7) For example, Ned's Corner. These are not recognised in CAPAD 2012 as protected areas but are permanently and securely protected.

(8) Not recognised in CAPAD.

(9) Agreement on 8 November 2000 to manage Anglesea Heath.[41]

(10) Title is held by Indigenous owners, the land is subject to an agreement under the Traditional Owner Settlement Act, a management board with majority Indigenous owner representation is established and the land is managed in accordance with the National Parks Act.

(11) EPBC Act is the 1999 federal Environment Protection & Biodiversity Conservation Act.

(12) All remote natural areas created to date lie within the national park estate, which offers additional protection.

(13) Each reserve type overlays an equivalent wildlife reserve (either hunting or no hunting) under the Crown Lands (Reserves) Act.

1.5 Sources

Endnotes

[1] Garden (2012)
[2] Garden (2012)
[3] Robertson (1898)
[4] Garden (2013)
[5] Garden (2013)
[6] Robin (1998)
[7] Frankenberg (1971)
[8] Frood & Calder (1987) defined a vegetational alliance as 'a series of climax plant communities which have the same structural characteristics, related species as dominants in the uppermost stratum and possibly the same or related species in the understorey'.
[9] Frood & Calder (1987)
[10] Traill & Porter (2001)
[11] Kueffer & Kaiser-Bunbury (2014)
[12] Department of Sustainability and Environment (2012)
[13] Bureau of Meteorology (2014a)
[14] Department of Sustainability and Environment (2008); Bureau of Meteorology (2014a).
[15] CSIRO (2012). The South Eastern Australian Climate Initiative research has demonstrated that an expansion of the tropics, indicated by the Hadley Circulation expanding at about 50 km per decade, is pushing mid-latitude storm tracks further south and leading to reduced winter rainfall across southern Australia. Climate modelling shows that this observed expansion can only be reproduced if human influences (such as greenhouse gases, aerosols and stratospheric ozone) are included in the models, providing evidence that observed changes in large-scale atmospheric circulation patterns affecting south-eastern Australia are at least partly attributable to climate change.
[16] Department of Climate Change and Energy Efficiency (2012)
[17] Department of Climate Change and Energy Efficiency (2012)
[18] Bureau of Meteorology (2014b)
[19] Department of Transport Planning and Local Infrastructure (2013); Department of Planning and Community Development (2012)
[20] Department of Planning and Community Development (2010)
[21] Department of Planning and Community Development (2009)
[22] Australian Bureau of Statistics (2008); Department of Planning and Community Development (2012)
[23] Source: Australian Bureau of Statistics various databases
[24] Campbell (2008)
[25] Australian Bureau of Statistics (2012)
[26] Maron & Fitzsimons (2007)
[27] Campbell (2008), citing DPI (2008); Australian Bureau of Statistics (2013)
[28] Australian Bureau of Statistics (2004); Australian Bureau of Statistics (2013)
[29] Barr (2009)
[30] Campbell (2008)
[31] Department of Agriculture Fisheries and Forestry (2013)
[32] Barr (2008)
[33] Public Record Office of Victoria (2005)
[34] Victorian Environmental Assessment Council (2011); Department of Environment and Primary Industries (2013a, Trust for Nature (2013)
[35] Frankenberg (1971); Department of Environment and Primary Industries (2013a)
[36] Natural Resource Management Ministerial Council (2009)
[37] Natural Resource Management Ministerial Council (2009)
[38] Department of the Environment (nd); Department of Environment and Primary Industries (2013b)
[39] Fitzsimons (2006)
[40] Department of the Environment (nd)
[41] Parks Victoria (2002)

References

Australian Bureau of Statistics (2004) *Agricultural Commodities 2002-03.* Australian Government Australian Bureau of Statistics

Australian Bureau of Statistics (2008) *Australian Historical Population Statistics, 2008 (3015.0).* Australian Government Australian Bureau of Statistics

Australian Bureau of Statistics (2012) *Value of Agricultural Commodities Produced* Australian Government Australian Bureau of Statistics

Australian Bureau of Statistics (2013) *Land Management and Farming in Austraila, 2011-12.* Australian Government Australian Bureau of Statistics

Barr N (2008) The Social Landscapes of Rural Victoria. Landscape Analysis and Visualisation In *Lecture Notes in Geoinformation and Cartography*, pp. 305-32

Barr N (2009) *The House on the Hill: The Transformation of Australia's Farming Communities* Melbourne: Halstead Press.

Bureau of Meteorology (2014a) *Annual climate statement 2013.* Australian Government Bureau of Meteorology

Bureau of Meteorology (2014b) *Australian Climate Variability & Change: Trend Maps.* http://www.bom.gov.au/climate/change/#tabs=Tracker&tracker=trend-maps. Accessed March 2014

Campbell A (2008) *Paddock to Plate: Food, Farming and Victoria's Progress to Sustainability.* Australian Conservation Foundation

CSIRO (2012) *Climate Variability and Change in South-Eastern Australia. A Synthesis of Findings from Phase 2 of the South Eastern Australian Climate Initiative.* . CSIRO

Department of Agriculture Fisheries and Forestry (2013) *National Food Plan: Our Food Future.* Australian Government Department of Agriculture, Fisheries and Forestry

Department of Climate Change and Energy Efficiency (2012) *Australian National Greenhouse Accounts. State and Territory Greenhouse Gas Inventories, 2009–10.* Australian Government Department of Climate Change and Energy Efficiency

Department of Environment and Primary Industries (2013a) *Managing Crown Land.* http://www.dse.vic.gov.au/property-titles-and-maps/managing-crown-land/managing-crown-land-fact-sheets/managing-crown-land-fact-sheet-managing-crown-land.

Department of Environment and Primary Industries (2013b) Public Land Management (PLM25). ed. VGDoEaP Industries

Department of Planning and Community Development (2009) *Victoria in Future 2008: Victorian State Government Population and Household Projections 2006-2036.* Victorian Government Department of Planning and Community Development

Department of Planning and Community Development (2010) *Melbourne 2030 – Planning for Sustainable Growth.* Victorian Government Department of Planning and Community Development

Department of Planning and Community Development (2012) *Victoria in Future 2012. Population and Household Projections for Victoria and its Regions 2011–2031.* Victorian Government Department of Planning and Community Development

Department of Sustainability and Environment (2008) *Climate Change in Victoria: 2008 Summary.* Victorian Government Department of Sustainability and Enviroment

Department of Sustainability and Environment (2012) *Report on Climate Change and Greenhouse Gas Emissions in Victoria.* Victorian Government Department of Sustainability and Environment

Department of the Environment (nd) *CAPAD 2012.* http://www.environment.gov.au/node/34737. Accessed November 2013

Department of Transport Planning and Local Infrastructure (2013) *Victorian Population Bulletin.* Victorian Government Department of Transport, Planning and Local Infrastructure

Fitzsimons J (2006) Private protected areas? Assessing the suitability for incorporating conservation agreements over private land into the National Reserve System: A case study of Victoria. *Environmental and Planning Law Journal* 23: 365-85

Frankenberg J (1971) *Nature Conservation in Victoria: A Survey* Victorian National Parks Association.

Frood D, Calder M (1987) *Nature Conservation in Victoria: A Study Report.* Victorian National Parks Association

Garden D (2012) *Phases of Ecological Impact of the European Occupation of Victoria.* Melbourne University

Garden D (2013) *Conservation Histories: A Short History of VNPA.* Victorian National Parks Association

Kueffer C, Kaiser-Bunbury CN (2014) Reconciling conflicting perspectives for biodiversity conservation in the Anthropocene. *Frontiers in Ecology and the Environment* 12: 131-37

Maron M, Fitzsimons J (2007) Agricultural intensification and loss of matrix habitat over 23 years in the West Wimmera, south-eastern Australia *Biological Conservation, 135 (4).* 135: 587-93

Natural Resource Management Ministerial Council (2009) *Australia's Strategy for the National Reserve System 2009–2030.* Australian Government

Parks Victoria (2002) *Anglesea Heath Management Plan.* Parks Victoria and Alcoa World Alumina Australia

Public Record Office of Victoria (2005) *Function VF 236, Coastal management.* ttp://www.access.prov.vic.gov.au/public/component/daPublicBaseContainer?component=daViewFunction&breadcrumbPath=Home/Access%20the%20Collection/Browse%20The%20Collection/Function%20Details&entityId=236.

Robertson J (1898) 26 September 1853 In *Letters from Victorian Pioneers: Being a Series of Papers on the Early Occupation of the Colony, the Aborigines, etc.* , ed. TF Bride. Melbourne: Government Printer

Robin L (1998) *Defending the Little Desert: The Rise of Ecological Consciousness in Australia.* Melbourne University Press.

Traill B, Porter C (2001) *Nature Conservation Review Victoria 2001* Victorian National Parks Association

Trust for Nature (2013) *The Statewide Conservation Plan for Private Land in Victoria.* Trust for Nature

Victorian Environmental Assessment Council (2011) *Remnant Native Vegetation Investigation.* Victorian Environmental Assessment Council

2. Marine & Coastal Ecosystems

Guide to chapter 2

This chapter focuses on marine and coastal environments in recognition of their tight ecological links and the need for integrated management. The area of focus is waters under the jurisdiction of the Victorian government, which extend 5.5 kilometres seaward from the high water mark, and land within 500 metres of the shoreline. Some issues relevant to the coast are covered in chapters 3 and 4 on terrestrial and freshwater ecosystems.

Section 2.1 describes the high natural, social and economic values of Victoria's marine and coastal ecosystems and the major habitat types. Section 2.2 outlines the status of biodiversity and protected areas, and the condition of bays, inlets and estuaries. Major threats to marine and coastal nature – particularly climate change, coastal development, invasive species and fishing – are described in section 2.3. Section 2.4 is a summary of a gap analysis of Victoria's marine protected areas, which identifies bioregional priorities for new and expanded marine national parks and sanctuaries. Similarly, for coastal subregions, section 2.5 summarises an analysis of values, threats and priorities for upgrading the national park and conservation system. Finally, in sections 2.6 and 2.7, policy gaps and high priority reforms are identified in three major areas: improving knowledge, creating a comprehensive, adequate and representative national park and conservation system, and integrating and strengthening management of marine and coastal environments.

Topics covered

2.1 Values

The wild beauty of Victoria's southern edge draws millions of visitors each year – to stroll on beaches and peer into rock pools, to watch seabirds riding coastal breezes and shorebirds probing sand and mud for prey to fuel up for their flight to the northern hemisphere, to surf and paddle, to explore underwater reefs and sponge gardens. The multiple attractions reflect the great diversity of habitats – sandy and muddy flats, estuaries, saltmarshes, cliffs, rocky reefs, seagrass meadows, kelp forests, among the many – inhabited by a multitude of life forms, many unique to Victoria.

Although less celebrated than tropical reefs, Australia's southern waters host many more unique species, and have the world's greatest diversity of red and brown seaweeds, sea mosses, crabs, shrimps and sea squirts.[1]

Victoria's coastline winds and wriggles for more than 2000 kilometres – about 1900 kilometres along the mainland and 600 kilometres around islands.[2] The terrestrial coastal ribbon (to 500 metres inland) covers about 1100 square kilometres and state waters (to 5.5 kilometres seaward) cover almost 7000 square kilometres, in combination close to 4% of Victoria's land-sea surface area.

Because of the many physical, climatic and biological factors overlapping where land and waterways merge into ocean, coastal habitats are inherently dynamic. Twenty thousand years ago, as the last ice age was drawing to a close, Bass Strait did not exist, Port Phillip Bay was part of the Yarra River floodplain and the sea level was about 100 metres lower. The shoreline has been fairly stable for about 6000 years.

The natural dynamism of these environments is both intensified and undermined by human activity: the rate of change has accelerated but coastal resilience has been compromised, reducing the capacity of natural systems to adapt to change. Victoria's marine and coastal environments are straining under the pressure of unsustainable human development, biological dysfunction due to species introductions, over-exploitation and climate change. Much of what lures people to the coast is at risk.

2.1.1 Biodiversity

Our southern marine communities are as distinctively Australian as our terrestrial marsupials and other flora and fauna.

Environment Conservation Council, 2000[3]

The biological richness and uniqueness of Victoria's marine environments derive from 80 million years of geological isolation restricting gene flow from other geographical regions, a lack of mass extinction events, and regional variability in geology, topography, oceanography and climate fashioning multiple habitats over a relatively small area. [4] Several currents and oceanic influences intersect in Victorian waters – the warm East Australian Current, the temperate South Australia Current, and northern Bass Strait and cold subantarctic surface waters. They place Victoria at the confluence of three marine biogeographic provinces, reflected in the mix of species shared with western, eastern and southern areas.[5]

The coarsest measure of Victorian diversity is at the bioregional level, each bioregion 'a cluster of interacting ecosystems that are repeated in similar form throughout' sharing similarities in physical and biological features.[6] Under a national classification scheme, there are six marine bioregions around Victoria: five in state waters (out to 5.5 kilometres) – four along the open coast and one grouping bays and inlets – and one outside state jurisdiction (Central Bass Strait).[7] Although Victoria's state waters account for less than 0.1% of Australia's exclusive economic zone, 8% of bioregions are represented there, a reflection of its habitat diversity. In this report, the five state bioregions have been further divided into 20 biounits to represent finer scale regional diversity, based on work by Australian Marine Ecology (see section 2.4).[8]

Victoria's coast also has high habitat diversity featuring parts of six terrestrial bioregions and 10 subregions, based on a national classification scheme.[9] At a finer scale, the coast (the area within 500 metres of the shoreline) features 95 vegetation types, known as ecological vegetation classes, almost one-third of Victoria's total (at the bioregional level) (Box 2.1). They include scrubs, shrublands, heathlands, forests, woodlands, grasslands, lagoons, wetlands and marshes. Thirty-four vegetation classes (more than 10% of Victoria's total) are unique to the coast. The wetlands, sandflats and mudflats merging with beaches, sand dunes, cliffs and shore platforms on Victoria's coastline provide many different habitats for plants and animals, including strongholds for shorebirds. Some of the three dozen migratory shorebird species that spend part of the year in Victoria and travel thousands of kilometres to the northern hemisphere to breed undertake 'the longest known journeys in the natural world'.[10]

Australia's southern waters, particularly in the southeast, are more species-rich than most other temperate seas worldwide and host many more unique species than the more celebrated Great Barrier Reef. The level of endemicity (uniqueness) in many marine groups is close to 90%.[11] Victoria's marine diversity is particularly high in:[12]

- seaweeds (large marine algae),
- marine sediment infauna (animals living in soft sediments on the sea bottom, usually in tubes or burrows),
- hydroids (plant-like animals related to jellyfish, sea anemones and corals, usually living in colonies attached to rocks or plants),
- sea mosses (bryozoans – small colonial animals), and
- sponges (animals that lack true tissues and organs, with bodies full of pores and channels).

Southern Australia has the highest level of seaweed endemism (62%) of any region globally, as well as the highest species richness, with more than 1150 species.[13] The exceptional endemism of southern seaweeds is due to long stability and isolation of the Australian continent – 30 million years from Antarctica and 80 million years from other land masses – because seaweeds rarely disperse across ocean basins. It is also due to the extent and diversity of rocky habitats in southern Australia (seaweeds need something firm to attach to). Seaweeds have additional high value because, along with seagrasses, they are the main primary producers in marine waters – 'in some areas producing far more plant material than the richest agricultural land' – and they serve as food, habitat and predator protection for many animals.[14]

Sponge diversity and endemism is also exceptional, with Victorian waters hosting 523 of Australia's 1416 described species.[15] Port Phillip Heads Marine National Park has at least 115 sponges endemic to the park,[16] and the bay is rich in many other species as well: a combination of seagrass meadows, sponge gardens, wetlands, sandflats, mudflats and subtidal and intertidal reefs provide habitats for about 300 fish species and hundreds of species of molluscs, crustaceans, seaweeds, bristle worms and cnidarians.[17]

One vertebrate marine mammal is endemic to southern Australian waters, the Burrunan dolphin, described as a species in 2011 and known primarily from Port Phillip Bay and Gippsland Lakes.[18] It is endangered (according to the Victorian government's advisory list), although not formally listed.

Much marine and coastal biodiversity has become rarer due to human impacts (section 2.2.1): more than 180 species on the state government's advisory lists are considered threatened (Table 2.3, Table 2.4) as are about two-thirds of coastal ecological vegetation classes (Table 2.5). Two marine ecological communities and three coastal communities are formally listed as threatened. But the conservation status of most biodiversity, particularly in the marine environment and particularly marine invertebrates, is unknown.

2.1.2 Social and economic values

[The] value of Victoria's non-commercial coastal ecosystem services ($8.4 billion per year) is similar to the value of commercial coastal activities ($9.8 billion per year). ... The results demonstrate the need for decision makers to consider the tradeoffs between the benefits of healthy functioning ecosystems and those associated with expanding use and development.

WorleyParsons, 2013[19]

The coast is extremely popular with Victorians. A 2012 survey found that 84% had made at least one trip to the coast in the previous year, and the average was 23 trips.[20] The most common activities were walking or hiking (63% spent time doing this), swimming (52%) and nature-based activities/appreciation (31%). The survey found that the top three things contributing to a good coastal or marine experience for respondents were clean water, a lack of rubbish, and an unspoilt/undeveloped natural environment.

There is increasing recognition of the extremely high value of ecosystem services (benefits for humans and other species due to natural functions of ecological systems) provided by marine and coastal environments. There has long been appreciation of the value of natural products, such as fish, but only very recently has there been any attempt to identify and value other services by nature, which include the following for coastal habitats: [21]

Provisioning services: raw materials for agriculture, food (such as fish), oil and gas, wind and wave power, and tourism and recreational sites

Regulatory services: flood control, carbon storage, water treatment, erosion control and protection from extreme weather events, nutrient cycling

Habitat services: places for animals and plants to live, fish nurseries, and a diverse genetic pool that may provide the raw materials for developments in provisioning services such as food

Cultural services: places for recreation, aesthetic appreciation and spiritual experiences.

A 2013 evaluation commissioned by the Victorian Coastal Council found that the value of Victoria's coastal commercial activities arising from 'provisioning ecosystem services' is about $9.9 billion a year, due mainly to petroleum, tourism and commercial ports. A subset of non-commercial coastal services, including storm protection, flood and disease control, habitat, biodiversity, recreation and passive enjoyment, were valued at $8.4 billion per year, with the highest value services provided by beaches (for recreation), estuaries/rivers and seagrass (Table 2.1).[22]

Table 2.1 Estimated values of some non-commercial ecosystem services provided by Victoria's coastal habitats, 2013[23]

Habitat type	Area (ha)	Unit value ($/ha/yr)	Value/year ($ million)
Beaches (recreation)			2,385
Forest	252,627	1,518	383
Grassland/heathland	65,844	363	24
Wetlands/marshes	48,422	4,265	207
Estuaries/rivers	71,264	35,768	2,549
Mangrove	71,264	38,750	320
Seagrass	61,961	29,771	1,845
Other marine	806,141	904	729
Total			**8,441**

Source: WorleyParsons

2.1.3 Important places

National park and conservation system

The 5.3% of Victoria's marine waters formally and securely protected for nature conservation include sites with exceptional natural values. In 2002, following a decade of campaigning led by the Victorian National Parks Association and the Marine and Coastal Community Network, Victoria became the first place in the world to seek to implement a biologically representative system of marine protected areas, declaring 13 marine national parks and 11 marine sanctuaries (the marine national park estate), covering about 54,000 hectares. A greater although less representative proportion of the coast is also securely protected, with about 37% of the coastal zone (to 500 metres inland) included in the 'national park and conservation system' (see section 1.4 for an explanation of this term and the protected area criteria).

Ramsar wetlands

Of 11 Victorian wetland sites of global significance recognised under the Ramsar Convention, five are found on or near the coast.[24]

Corner Inlet is a marine embayment and tidal mudflat that supports more than 390 native plant species and 160 native animal species. It is internationally significant for migratory wading birds and its barrier islands are nationally significant for the botanical biogeography and geomorphology.

Gippsland Lakes support more than 540 plant species and 300 native animal species including more than 60 that are rare or threatened. They include sites of international and national geological and zoological significance. Lake Reeve is one of the five most important areas for shorebirds in Victoria.

Port Phillip Bay (Western Shoreline) and Bellarine Peninsula support more than 330 native plant species and 285 native animal species, including 50% of the world population of the critically endangered orange-bellied parrot. They support large numbers of migratory shorebirds and are an important drought refuge for waterbirds.

Western Port is a large bay supporting more than 350 native plant species and 330 native animal species. It is nationally significant for migratory shorebirds and for extensive saltmarsh communities. It has sites of international and national geomorphological significance.

Edithvale-Seaford Wetlands are the last remnants of the once extensive Carrum Carrum Swamp, which was drained in the nineteenth century. They have 41 regionally significant plant taxa and regularly support more than 1% of the world population of sharp-tailed sandpipers as well as many other migratory birds.

Important bird and biodiversity areas

Twenty 'important bird areas' (IBAs) – sites that are globally significant for bird conservation – have been identified in coastal Victoria.[25] (These areas are now also known as 'important bird and biodiversity areas' in recognition of their importance to other species as well.) They provide critical non-breeding habitat for large numbers of migratory shorebirds each year.

Although the designations have no legal status, they are a reminder to land managers and planners that these areas have high conservation values and they can help guide conservation priorities. BirdLife Australia is establishing a monitoring program for Victorian sites.

Box 2.1 Criteria for important bird areas

Each area meets one of the following three criteria:

- it regularly supports threshold numbers of a threatened species
- it forms one of a set protecting 'restricted-range species' (birds with a global range of less than 5 million hectares)
- it supports greater than 1% of the world population of a waterbird (similar to the Ramsar Convention criteria) or seabird.

Anderson Inlet IBA has intertidal mudflats that attract internationally significant numbers of red-necked stints, and may also regularly support critically endangered orange-bellied parrots.

Bellarine Wetlands IBA supports orange-bellied parrots, endangered Australasian bitterns and more than 1% of the world populations of chestnut teal, red-necked stints, sharp-tailed sandpipers and banded stilts.

Carrum Wetlands IBA regularly supports more than 1% of the world populations of sharp-tailed sandpipers, blue-billed ducks and chestnut teal, and is an important refuge for Australasian bitterns.

Cheetham and Altona IBA regularly supports more than 1% of the world populations of chestnut teal, red-necked stints and Pacific gulls.

Corner Inlet IBA contains the most extensive intertidal mudflats in Victoria and supports more than 1% of the world populations of red-necked stints, eastern curlews, chestnut teal, pied and sooty oystercatchers and threatened hooded plovers. It may regularly support orange-bellied parrots.

Discovery Bay to Piccaninnie Ponds IBA provides habitat for orange-bellied parrots, breeding habitat for Australasian bitterns, and supports populations of hooded plovers, restricted-range rufous bristlebirds and striated fieldwrens.

Gabo and Tullaberga Islands IBA supports more than 1% of the world population of little penguins and white-faced storm-petrels.

Gippsland Lakes IBA regularly supports more than 1% of the world population of black swans, chestnut teal and musk ducks, and substantial numbers of vulnerable fairy terns.

Lawrence Rocks IBA supports more than 10% of the world population of Australasian gannets.

Lower Brodribb River IBA supports a small breeding population of Australasian bitterns.

Nadgee to Mallacoota Inlet IBA supports an isolated southern sub-population of endangered eastern bristlebirds and a population of restricted-range pilotbirds.

Otway Ranges IBA supports populations of rufous bristlebirds as well as striated fieldwrens and pink robins.

Phillip Island IBA supports more than 1% of the world populations of little penguins, short-tailed shearwaters and Pacific gulls and small numbers of orange-bellied parrots.

Port Fairy to Warrnambool IBA regularly supports orange-bellied parrots and a breeding population of hooded plovers.

Shallow Inlet IBA supports more than 1% of the world's double-banded plovers and red-necked stints.

Swan Bay and Port Phillip Bay Islands IBA supports significant numbers of orange-bellied parrots and fairy terns, and more than 1% of the world populations of blue-billed ducks, chestnut teal, Australian white ibis, straw-necked ibis, red-necked stints and silver gulls.

Werribee and Avalon IBA supports orange-bellied parrots, and more than 1% of the world populations of blue-billed ducks, Australian shelducks, freckled ducks, Australasian shovelers, chestnut teal, musk ducks, pink-eared ducks, hoary-headed grebes, red-necked stints and sharp-tailed sandpipers.

Western Port IBA regularly supports small numbers of orange-bellied parrots, fairy terns, and more than 1% of the world populations of eastern curlews, red-necked stints and pied oystercatchers.

Wilsons Promontory Islands IBA supports more than 1% of the world populations of short-tailed shearwaters and Pacific gulls, and possibly also of black-faced cormorants.

Yambuk IBA supports orange-bellied parrots, Australasian bitterns, and a breeding population of hooded plovers.

2.1.4 Major habitat types

The typology of marine and coastal habitats in Table 2.2 and their description below is a summary of work by Australian Marine Ecology.[26]

Table 2.2 Marine and coastal habitats

Habitat Level 1	Habitat Level 2	Habitat Level 3	Habitat Level 4
Coastal	Coastal	Coastal sand	Dune
		Coastal vegetation	Grasses
			Heaths
			Moonah
			Woodland
		Structural habitat/processes	Islands
	Artificial	Structural habitat/processes	Artificial habitats (wood/rock)
Intertidal	Sheltered littoral (estuaries and wetlands)	Coastal vegetation	Saltmarsh
		Marine sediment	Mudflats
			Sandflats
		Marine vegetation communities	Mangrove
			Ruppia/estuarine grass
			Seagrass
		Structural habitat/processes	Bird roosts
	Exposed littoral	Coastal sand	Beach
			Dune
		Reefs	Intertidal reef
Subtidal shallow	Sheltered subtidal (bays and estuaries)	Marine non-vegetation communities	Pyura
			Sponge clump
		Marine sediment	Sediment beds
		Marine vegetation communities	Caulerpa
			Drift weed
			Seagrass
		Reefs	Subtidal reef
		Structural habitat/processes	Channels
	Exposed subtidal	Marine sediment	Sediment beds
		Reefs	Subtidal reef
Subtidal	Subtidal to state limit	Marine non-vegetation communities	Pelagic fauna aggregations
			Plankton and nekton
			Sponge clump
		Marine sediment	Sediment beds
		Marine vegetation communities	Seagrass
		Reefs	Deep reef
			Intermediate reef
			Subtidal reef
		Structural habitat/processes	Pinnacle/Canyon
			Upwellings
Non specific	Non specific	Marine non-vegetation communities	Pelagic fauna aggregations
			Plankton and nekton
			Sponge clump

Coastal and exposed supralittoral dunes: Wind-blown sand often accumulates as dunes between the high tide line and established coastal vegetation. Colonisation by hardy grasses can stabilise dunes, allowing other vegetation to take hold. Many estuaries and wetlands are protected from storm surge flooding by coastal dune systems.

Coastal dune grasses, heaths, moonah, scrub and woodland: With sandy, infertile soils and exposed to strong, salt-laden winds and sea spray, coasts are tough environments for plants. Coastal vegetation usually occurs in bands parallel to the shore: foredunes inhabited by dune grasses and succulents grade to low, salt affected scrub, with a ground layer of sedges, grasses and herbs, and then to taller shrubs behind the primary dunes, where there is some protection from wind, and then to low woodland. In swales between dunes and behind primary dunes, the tea-tree moonah (*Melaleuca lanceolata*) may occur as a scrub or low forest. Highly diverse heath communities often grow on headlands. Coastal habitats are foraging, breeding and roosting habitat for birds, small mammals and reptiles, many of conservation importance. They are under increasing pressure from urban sprawl, coast development, weed invasion, disease, recreational activities and changing fire regimes. Many habitats have become highly fragmented and some, such as coastal moonah woodland, exist only in a small portion of their pre-settlement range.

Coastal islands: Island communities are often unique, and their relative isolation has helped to conserve more pristine habitats than on the mainland. Many function as sanctuaries, free from introduced predators and competitors, such as cats, foxes, rabbits and rodents. Coastal islands are home to breeding colonies of fur seals and seabirds, including Australasian gannets, little penguins and short-tailed shearwaters.

Saltmarsh and mangrove communities: These communities often inhabit the intertidal sand and mudflats of protected bays and estuaries in parallel zones, with saltmarsh growing inshore of mangroves. Saltmarsh vegetation includes succulent shrubs and herbs, grasses and sedges, and in Victoria is often dominated by a few plant species, particularly glassworts. Mangroves are at the southern limit of their range and just one species, grey mangrove, grows in Victoria. Saltmarshes and mangroves are foraging and nursery habitat for diverse marine and estuarine fauna. The endangered orange-bellied parrot is dependent on saltmarshes for winter food. Mangrove and saltmarsh habitats trap and stablise coastal sediments and protect against coastal erosion, as they form a barrier against the effects of flooding, currents, waves and storms. Victoria has suffered extensive loss of saltmarsh and mangrove habitats. Weeds have invaded saltmarshes, and mangroves were cleared for land reclamation and port development. Swamp drainage for agriculture has caused decline in these communities by increasing freshwater runoff and reducing salinity.

Seagrass and estuary grass: Seagrasses (flowering plants) grow in shallow coastal waters, some as meadows in bays and estuaries and others in sheltered areas along the open coast. In Victoria, the main seagrasses are eelgrasses (*Heterozostera tasmanica*, *H. nigricaulis* and *Zostera muelleri*), sea-nymph (*Amphibolis antarctica*), paddlegrass (*Halophila australis*) and strapweed (*Posidonia australis*). Estuary grass (*Ruppia megacarpa*) is related to seagrass and provides similar habitat in shallow estuaries, coastal lagoons and salt lakes. Seagrass communities are important to ecological processes, including primary productivity, nutrient cycling and trophic pathways. They provide surfaces for the attachment of algae and sessile invertebrates, and refuge for mobile invertebrates. Seagrass beds are primary habitat for many pipefishes, seahorses and sea dragons, and important fish nurseries. There have been dramatic declines in seagrass habitat stemming from population pressures in the coastal zone.

Estuaries: Estuary habitats are subject to influences from both marine and riverine environments. Estuaries provide a wide variety of sheltered habitat types, including intertidal and subtidal reef, channels, seagrass, *Ruppia*, mangroves and saltmarshes. They are dominated by intertidal sandflats and mudflats, and subtidal sediment beds, which have diverse and productive infaunal invertebrate communities that provide productive feeding grounds for local and migratory shorebirds. They also serve as fish nurseries.

Exposed littoral beach: As the interface between ocean and coast, beaches are mobile and unstable. Beach organisms must survive wave action, sand deposition, erosion, high and low temperatures, regular inundation with sea water and exposure to desiccation. They have an important role in cycling nutrients between coastal and near-shore environments. Accumulations of deposited marine algae support diverse microbes and invertebrate fauna, an important food source for many fish. Beaches are important foraging and breeding habitat for shorebirds, some of high conservation status, such as hooded plover.

Intertidal reefs: Occurring mostly around headlands and points, and often isolated from each other by stretches of beach, intertidal reefs are inhabited by specialist intertidal species adapted to extreme environmental variability due to alternate tidal inundation and exposure. A thin layer of microscopic algae growing on rock surfaces is an important food source for grazing molluscs. Larger algae such as the mat-forming Neptune's necklace provide food and refuge at low tide. Gastropod molluscs are the dominant fauna, and there are also small crustaceans such as barnacles and crabs, the seastar *Parvulastra exigua* and tubeworm *Galeolaria caespitosa*. They are important foraging habitats for shorebirds at low tide and for fish at high tide. Because of their accessibility, intertidal reefs are vulnerable to human pressures, including collection of animals for fishing bait and food, trampling and pollution.

***Pyura* and sponge clumps**: *Pyura stolonifera* is a seasquirt that inhabits hard and soft surfaces in intertidal and subtidal habitats and provides a surface for attachment by many other organisms. In subtidal soft sediment habitats, *Pyura* beds are important habitat for sponges, other sessile invertebrates and algae, which in turn provide surfaces for further attachment, forming large clumps of biogenic reef (generated by living organisms). *Pyura* beds also provide habitat for mobile invertebrates such as brittlestars, seastars and sea urchins. Species richness is often higher in *Pyura* bed habitats than in comparable seagrass or bare sediment habitats. The recovery of *Pyura* beds after disturbance is slow or non-existent, so they are a high priority for protection.

Caulerpa: This diverse genus of green algae grow on shallow and intermediate reefs and in sediments. They are fast growing and can quickly spread into adjacent areas by vegetative growth. They can form dense meadows that exclude other algae. *Caulerpa* are important to ecological processes, including habitat provision, primary productivity, nutrient cycling and trophic pathways. *Caulerpa taxifolia* is an invasive species from the Mediterranean Sea, now widespread along the Australian coast.

Drift weed: Many large algae do not need to be attached to the sea bottom to survive and, carried by tides and currents, they can form vast mats. In Port Phillip Bay, drift algae sometimes cover up to 90% of the seabed along the northwest shore, probably benefiting from discharge from the Western Treatment Plant. Drift algae are important to local ecological processes, including primary productivity, nutrient cycling, trophic pathways and biogenic habitat.

Channels: Soft sediment channels are prevalent in sheltered bays and inlets. Major Victorian embayments, including Port Phillip Bay, Corner Inlet, Nooramunga and especially Western Port, are dominated by intertidal and subtidal sand and mud flats interwoven with deeper channels. The tidal currents that create channels also carry food particles. Many species occur only in channel habitats and species assemblages are often unique. Brachiopods and some molluscs are locally abundant within Western Port channel habitats but have very restricted ranges, so these populations are of particular conservation importance.

Subtidal reefs: Kelp and other seaweeds provide the dominant habitat structure on subtidal reefs. The robust bull kelp dominates on reefs that are most exposed to wave and swell, and large brown algae, such as the common kelp and crayweed form a canopy 0.5-2 metres high in less exposed reefs. Smaller kelps and filter-feeding sessile invertebrates (sponges, corals, bryozoans, hydroids and ascidians) form an understory 5-30 centimetres high. A hard layer of pink crustose coralline algae encrusts the rocks of most subtidal reefs. As depth increases, kelps become less dominant and other algae and sessile invertebrates make up a greater proportion of the cover. Seaweeds and sessile invertebrates provide important habitat structure for other organisms on the reef. Gastropods, crustaceans, echinoderms and fishes inhabit these communities. Shallow reefs have high biological complexity, species diversity, biomass and productivity. Dense seaweed beds are among the most productive habitats in the world.

Intermediate depth reefs (15-30 metres depth): Kelps become less dominant as depth increases and other algae, particularly thallose red algae make up a greater proportion of the cover. Sessile invertebrates, including bryozoans, ascidians and sponges also become more abundant. There have been few surveys of intermediate depth communities in Victoria.

Deep reefs: The difficulties of working at depth have limited the ecological study of deep reef habitats. Recent technological advances have made this environment somewhat more accessible and there are currently numerous Victorian deep reef studies in progress. The biota is dominated by sessile invertebrates, particularly sponges, cnidarians, ascidians and bryozoans. Most of the invertebrate species on the reefs are suspension feeders, capturing small plankton and detritus from the water. They may filter up to hundreds of litres of ocean water per square metre of reef every day, and are therefore a potentially vital link for the cycling of nutrients and energy in the marine ecosystem. Small crustaceans, echinoderms and molluscs are commonly found in the spaces created by the sessile invertebrates. Fishes are also abundant in deep reef areas, taking refuge within the reef structure or feeding on the wide range of organisms. The importance of deep reef biota in supporting high trophic-level carnivores is unknown.

Pinnacles and canyons: Pinnacles (steep-sided peaks) and canyons (steep-sided gorges) provide vertical and overhanging surfaces inhabited by highly diverse, filter-feeding, sessile invertebrate communities, typically dominated by sponges, and supporting a high diversity of mobile invertebrates, including molluscs, crustaceans, polychaetes and echinoderms, as well as fish. They are associated with high density aggregations of seabirds, whales and dolphins and often have high fish densities. Pinnacle and canyon communities are often small in area and endemic, having evolved in isolation from other such habitats. It means they are particularly vulnerable to disturbance, as an entire patch is likely to be affected and there will be little potential for recolonisation and recovery.

Upwellings: Important upwellings occur in Discovery Bay (Bonney Upwelling) and along east Gippsland (Bass Canyon Upwelling). Seasonal winds drive warm, nutrient-depleted surface water away from the coast, which draws deeper, colder, nutrient-rich water to the sunlit surface, where it sustains high rates of phytoplankton growth.

Plankton: Organisms that drift in the water column, plankton are important in carbon, nitrogen and other nutrient cycles. Photosynthetic plankton, such as diatoms and dinoflagellates, are highly productive – they are responsible in Port Phillip Bay for at least two-thirds of primary production. Concentrations are often highest in estuaries and river mouths, where there are nutrient inputs from terrestrial runoff. Phytoplankton are preyed on by zooplankton, small floating animals including amoeboids, crustaceans, jellyfish, invertebrate larvae and fish larvae.

Nekton: In Victoria, actively swimming pelagic (open sea) organisms, nekton, are mostly fish and cephalopods (eg. octopuses, squid, cuttlefish), but also include mammals, penguins and crustaceans (e.g. krill). Nekton play an important role in trophic pathways, facilitating the transfer of energy from plankton, through lower trophic levels, to higher order predators. High abundances are often associated with areas of high phytoplankton productivity, such as upwellings.

Pelagic fauna aggregations: Many pelagic (open sea) fish school for protection against predators or converge in favourable habitats. Orange roughy, for example, aggregate around seamounts, pinnacles and canyons. Seabirds, predatory fish and marine mammals congregate where there is a reliable food supply, such as nutrient-rich upwellings. Aggregations provide opportunities for courtship and breeding for species that are normally scattered. Blue whales congregating along the Bonney coast to feed also engage in courtship. Species that aggregate are more vulnerable to recreational and commercial fishing pressures, diseases and localised environmental disturbances.

Artificial habitats: Although artificial habitats are less ecologically complex than natural systems they can be ecologically important if their primary purpose is for conservation. Popes Eye and South Channel Fort, artificial islands in Port Phillip Bay, provide reef habitat for a diverse fish fauna, as do shipwrecks, particularly in the Ships' Graveyard area between Port Phillip Heads and Torquay, with about 50 wrecks. White-faced storm petrels nest on South Channel Fort, Australian fur seals haul out regularly at the purpose-built Chinaman's Hat, and little penguins breed on the breakwater built at St Kilda. The largest winter-breeding population of pied cormorants in Victoria nests in and around Lake Borrie at Melbourne Water's Western Treatment Plant, which is the primary source of nutrients into Port Phillip Bay and the Geelong Arm in winter.

2.2 State of marine and coastal ecosystems

Even in the face of skepticism about climate change, there is overwhelming evidence of rapid physical changes in the environment and that habitats are having to adapt, resetting an ecological balance that has been mostly stable for thousands of years.

Australian Marine Ecology, 2010[27]

2.2.1 Biodiversity and native vegetation

Threatened species

More than 180 species in coastal and marine environments are considered threatened (listed in the Victorian government's advisory lists) (Table 2.3 and Table 2.4). These advisory lists are not statutory: unless species are formally listed under the Flora and Fauna Guarantee Act, there are no legal requirements to protect them beyond what is required for any other native species. Only about half the threatened marine and coastal species on the advisory lists have been formally listed, and only about half of these listed species have action statements (which set out actions needed for their recovery) (see chapter 5). There are many more species identified in the advisory lists as near threatened or as too poorly known to determine their conservation status. Information is particularly lacking for marine invertebrates.

Two marine and three coastal ecological communities are listed as threatened under the Flora and Fauna Guarantee Act (Box 2.2) and two-thirds of ecological vegetation classes on the coast have been assessed as threatened in at least one of the subregions in which they occur (Table 2.7). With no equivalent to the ecological vegetation class classification, and many marine habitats not mapped, the conservation status of marine ecological communities is mostly unknown.

Table 2.3 Marine threatened species (based on Victorian government advisory lists)[28]

Group	Critically endangered	Endangered	Vulnerable	Total threatened	Extinct
Marine fish	0	0	2	2	0
Catadromous fish(1)	2	0	2	4	1
Seabirds	0	2	8	10	0
Mammals	2	1	2	5	0
Reptiles	1	0	0	1	0
Invertebrates	0	0	17	17	0

Source: State government advisory lists. Catadromous species are born in the sea, but live much or all their adult life in freshwater.

Table 2.4 Coastal threatened species, in government advisory lists, formally listed and with action plans[29]

Group	Critically endangered	Endangered	Vulnerable	Total threatened (advisory)(1)	Listed FFG Act(2)	Action plan
Fish	2	1	4	7	7	4
Birds	4	20	32	56	33	17
Mammals	1	4	3	8	5	3
Reptiles	1	2	2	5	3	3
Frogs	1	0	2	3	1	0
Invertebrates	1	2	1	4	4	1
Plants	NA	27	49	76	34	17

Notes: (1) State government advisory lists: vertebrates (2013), invertebrates (2009), plants (2005). (2) Listed under the Floral and Fauna Guarantee Act. There is some overlap with Table 2.3 (marine threatened species) for coastal species that use marine environments, such as fish that have freshwater and marine stages, and shorebirds. Some of the coastal species are also found further inland (so there are overlaps with threatened species discussed in chapters 3 and 4).

Box 2.2 Threatened marine and coastal ecological communities

The San Remo marine community, at the eastern entrance to Western Port, occurs over a nine hectare area of patchy basalt, sand and mud, and is dominated by opisthobranch molluscs (marine slugs) and bryozoans (moss animals). It is subject to potential threats from dredging, invasive species and coastal development.[30]

The Port Phillip Bay entrance deep canyon marine community is highly diverse, with many endemic species. It is restricted to the 120 hectare canyon between the Port Phillip Heads, and subject to threats from rock dredging and invasive species, as well as potential shipping accidents and sub-sea infrastructure developments.[31]

Coastal moonah woodland is a scattered forest, woodland or shrubland community occurring on calcareous dune systems in central southern Victoria in the Gippsland and Otway Plains bioregions. More than 90% has been cleared or highly fragmented, and weeds and recreational activities threaten what is left. It usually occurs on hind dunes, and is important for preventing erosion and as habitat for several threatened species.[32]

Warm temperate rainforest (coastal East Gippsland) occurs on relatively dry coastal sites, usually in shallow gullies and on abandoned sea cliffs, on or near the Gippsland Lakes (especially Lakes King and Tyers) and at the mouth of the Snowy River near Marlo. It has been severely depleted by clearing for agriculture and grazing, and is threatened by weed invasion and fires of high intensity and frequency.[33]

Plains grassland (South Gippsland) ranges from closed tussock grassland to seasonal wetlands on the South Gippsland coastal plain between Seaspray and Welshpool and the head of Western Port, on grey, often seasonally waterlogged soils.[34] More than 99% has been lost to clearing and degradation, and what remains is threatened by weed invasion and inappropriate fire regimes.

Coastal native vegetation

Close to two-thirds of the coast (to 500 metres inland) still has remnant vegetation, 57% of which is protected (Table 2.6). Vegetation loss increases with distance from the coast. Within the zone out to five kilometres from the coastline, half the vegetation has been cleared and 52% of what remains is protected (Table 2.6).

Victoria's plants communities have been mapped as ecological vegetation classes based on their structure, ecology and floristic and environmental associations. Their conservation status has been assessed within each bioregion and subregion, based on a comparison with their estimated pre-1750 extent (Box 2.3). Of 300 ecological vegetation classes described for Victoria's bioregions, 95 occur within 500 metres of the state's shoreline (Table 2.7). Thirty-four are found only on the coast, while the other 61 have largely inland ranges.[35]

Almost two-thirds (62%) of ecological vegetation classes within 500 metres of the shoreline are threatened within at least one subregion in which they occur (Table 2.7). The losses have been greatest for hinterland vegetation in the Warrnambool Plains, Otway Plains, Victorian Volcanic Plains and Gippsland Plains subregions, for they were settled early in Victoria's colonial history to graze sheep because of their relatively fertile soils and ease of clearing. Other vegetation losses have resulted from forestry and urban settlements. Table 2.7 shows the extent of remnant vegetation, fragmentation and threatened ecological vegetation classes found within 500 metres of the shoreline in each of the 10 coastal subregions. Swamp and coastal scrubs, grassy woodlands, herb-rich woodlands and forests, estuarine wetlands and saltmarshes are the most consistently threatened vegetation types across the ten subregions (Table 2.5).

Table 2.5 Threatened ecological vegetation classes (EVCs) in coastal subregions

EVC	Number of subregions		
	E(1)	V(2)	NT(3)
Coastal EVCs			
Estuarine wetland	4	0	3
Coastal headland scrub	0	6	2
Coastal tussock grassland	0	5	1
Coastal alkaline scrub	2	1	2
Hinterland EVCs			
Damp sands herb-rich woodland	1	6	0
Herb-rich foothill forest	0	5	1
Swamp scrub	5	1	0
Damp heath scrub	2	1	0
Plains grassy woodland	3	0	0
Plains grassland	3	0	0
Shallow freshwater marsh	3	0	0
Grassy woodland	4	0	0

Data source: Trust for Nature. Notes: (1) Endangered. (2)Vulnerable. (3) Non-threatened, including least concern, rare or data deficient.

Table 2.6 Coastal remnant vegetation protected in the national park and conservation system

Distance from coastline	Remnant vegetation (hectares)	Remnant vegetation (%)	Wetlands (hectares)	Wetlands (%)	Reserves (hectares)	Reserves (%)	Remnant vegetation in reserves (%)
0-200m	36,541	71	7,439	14	20,931	41	57
0-500m	73,467	65	12,683	11	41,727	37	57
0-1km	121,477	60	18,568	9	68,656	34	57
0-5km	440,011	49	43,746	5	228,286	26	52

Data: VNPA analysis of data from the Department of Environment and Primary Industries.

Box 2.3 Victoria's ecological vegetation classes (EVCs)[36]

EVCs are the basic mapping units used for biodiversity planning and conservation assessment at landscape, subregional and bioregional scales in Victoria. They are used in this review, mostly at the subregional scale, as the main basis for determining priorities for completing the national park and conservation system (unfortunately, there is no equivalent system for the marine environment).

The state government has classified the state's native vegetation into EVC units based on ecological characteristics (eg dominant species, vegetation structure) and physiographic variables (eg aspect, elevation, geology and soils, landform, rainfall, salinity and climate). Each EVC represents one or more plant communities that occur in similar types of environments. The communities in each EVC tend to show similar ecological responses to fire and other environmental factors. The EVC system includes EVC complexes, mosaics and aggregates for situations where specific EVCs cannot be identified at the spatial scale used for vegetation mapping.

The conservation status of each EVC has been assessed – as endangered, vulnerable, depleted, rare or least concern – as a measure 'of the current extent and quality of each EVC compared to its pre-1750 extent and condition and with consideration of threatening processes' in each bioregion or subregion in which it occurs. The pre-1750 extent is estimated from predictions derived from existing vegetation, a variety of physical environmental attributes, and expert knowledge.

Table 2.7 Remnant vegetation and ecological vegetation classes (EVCs) in coastal subregions[37]

Subregion	Remnant vegetation (%)	Fragmentation (%)	Coastal EVCs (number)	Coastal EVCs threatened	Coastal EVCs threatened (%)
Victorian Volcanic Plain	16	100	17	17	100
Warrnambool Plain	17	100	19	17	89
Gippsland Plain	26	100	63	43	68
Strzelecki Ranges	31	100	5	4	80
Otway Plain	32	96	22	15	68
Glenelg Plain	46	100	9	6	67
East Gippsland Lowlands	62	33	18	7	39
Bridgewater	68	100	13	10	77
Otway Ranges	76	68	19	8	42
Wilsons Promontory	91	2	20	1	5

Data: VNPA and Smyth (2014) analysis of data from the Department of Environment and Primary Industries.

2.2.2 National park and conservation system

Victoria's marine and coastal national park and conservation system includes 5% of state waters and 37% of coastal land (to 500 metres inland) (Table 2.8).

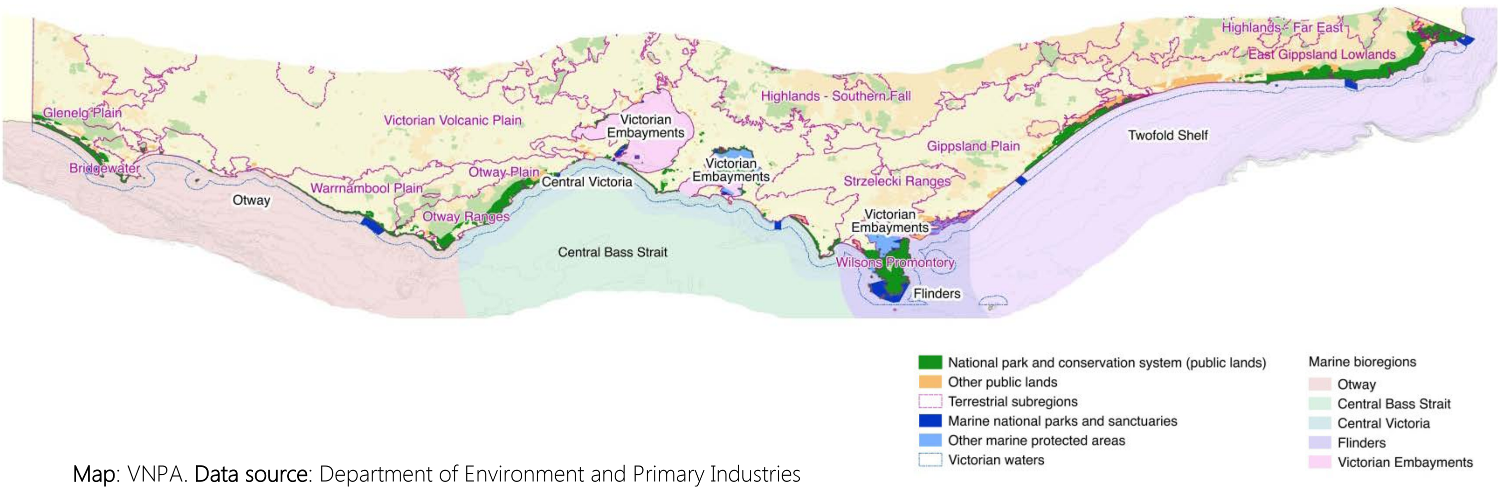
The marine national parks and sanctuaries were all declared in 2002 following a statewide investigation by the Land Conservation Council initiated in 1991. They include the near-shore environment, seabed and marine waters out to 5.5 kilometres (the state limit), islands, and the foreshore up to 200 metres inland from the high water mark. Extractive and damaging activities such as dredging, waste disposal, aquaculture, mining, and commercial and recreational fishing are prohibited, but a loophole allows petroleum exploration.[38]

Close to a quarter of coastal land (23%) is in the national park estate (mainly national and state parks) and 14% is in other securely protected conservation properties (eg coastal parks and nature conservation reserves). The area of private land protected under perpetual conservation covenants is very small, just 0.2% of the coastal area.

Coastal protection has been greatly assisted by an 1881 decision by the Victorian government to reserve all unalienated land within one-and-a-half chains [30 metres] of the colony's 'rivers, rivulets, creeks, channels, aqueducts, lakes, reservoirs, swamps, inlets, loughs and straits'.[39] All but 4% of land abutting the high water mark is still in public ownership, although under multiple management arrangements, some incompatible with conservation. Many stream and river frontages are also in public ownership (chapter 4). The privatised proportion of land increases with distance from the shoreline: three-quarters of the land area to 200 metres from the shoreline is in public ownership but only half of the land from 200 to 500 metres is.[40] Squeezed between sea and development, many conservation properties and other public lands are exceedingly narrow, and set to be further squeezed as sea levels continue to rise. Their shape makes conservation management very challenging, for they are subject to severe edge effects and impacts from adjoining land uses.[41]

Other marine sites and many dozens of coastal properties called protected areas or reserves are not sufficiently secure or managed for conservation to meet the VNPA criteria for the national park and conservation system (section 1.4). These insufficiently protected tenures include marine parks, marine reserves, and marine and coastal parks in which various forms of exploitation (eg fishing) are allowed and which do not require a strong focus on conservation management. As noted by the Victorian Environmental Assessment Council, the environmental management required in multiple-use marine parks 'is generally the same as that of the surrounding marine environment'.[42] There are also marine protected areas in Commonwealth waters adjacent to Victorian waters, all of them multiple use reserves that permit fishing, so not part of the national park and conservation system (Box 2.4).

Figure 2.1 Victoria's marine and coastal national park and conservation system



Map: VNPA. **Data source**: Department of Environment and Primary Industries

Table 2.8 Victoria's marine and coastal national park and conservation system

Marine national park estate	Marine bioregion	Area (hectare)
Twelve Apostles Marine National Park	Otway	7,500
The Arches Marine Sanctuary	Otway	45
Merri Marine Sanctuary	Otway	25
Discovery Bay Marine National Park	Otway	2,770
Mushroom Reef Marine Sanctuary	Central Victoria	80
Bunurong Marine National Park	Central Victoria	2,100
Barwon Bluff Marine Sanctuary	Central Victoria	17
Point Danger Marine Sanctuary	Central Victoria	25
Point Addis Marine National Park	Central Victoria	4,600
Eagle Rock Marine Sanctuary	Central Victoria	17
Marengo Reefs Marine Sanctuary	Central Victoria	12
Wilsons Promontory Marine National Park	Flinders	15,550
Cape Howe Marine National Park	Twofold Shelf	4,050
Point Hicks Marine National Park	Twofold Shelf	4,000
Beware Reef Marine Sanctuary	Twofold Shelf	220
Ninety Mile Beach Marine National Park	Twofold Shelf	2,750
Corner Inlet Marine National Park	Victorian Bays and Inlets	1,550
Yaringa Marine National Park	Victorian Bays and Inlets	980
French Island Marine National Park	Victorian Bays and Inlets	2,800
Churchill Island Marine National Park	Victorian Bays and Inlets	670
Point Cooke Marine Sanctuary	Victorian Bays and Inlets	290
Jawbone Marine Sanctuary	Victorian Bays and Inlets	30
Ricketts Point Marine Sanctuary	Victorian Bays and Inlets	115
Port Phillip Heads Marine National Park	Victorian Bays and Inlets	3,580
Total area (marine)		53,776
Coastal national park estate	**Subregion**	
Port Campbell National Park	Warrnambool Plain	1,069
Point Nepean National Park	Gippsland Plain	357
Mornington Peninsula National Park	Gippsland Plain	1,110
French Island National Park	Gippsland Plain	2,235
Great Otway National Park	Otway Ranges Warrnambool Plain	3,712
Wilsons Promontory National Park	Wilsons Promontory	7,619
Croajingolong National Park	East Gippsland Lowlands	9,697
Cape Nelson State Park	Glenelg	112
Subtotal		25,910
Other coastal conservation properties		**Area**
Nature conservation reserves etc (tenures identified in Table 1.3)	All	15,402
Trust for Nature covenants	All	261
Subtotal		15,633
Total area (coastal)		**41,543**

Table 2.9 Public land tenures on the coast (0 to 500 metres from the high water mark)

Land category	Area (hectares)	Coastal land (%)
National park estate		
National park, state park	25,911	
Marine national park, marine sanctuary	419	
Subtotal	26,330	23
Other conservation properties		
Schedule 3 parks	11,652	
Nature conservation reserves	1,490	
Flora and fauna reserves	203	
Wildlife reserve (no hunting)	688	
Natural features reserves	109	
Phillip Island Nature Parks	1,260	
Subtotal	15,402	14
Other public land		
Schedule 4 parks or reserves	10,141	
Historic reserves	62	
Lighthouse reserves	332	
Wildlife reserves (hunting)	1,545	
Proposed NP Act	381	
Coastal reserve	7,277	
Commonwealth land	1,250	
Metropolitan park	363	
State forest	278	
Port & coastal facility	40	
Other or unclassified	6,757	
Subtotal	28,426	25
Totals		
Total public land	71,599	63
Total coastal area	113,639	

Analysis: VNPA. Data sources: Department of Environment and Primary Industries.

Box 2.4 Commonwealth marine protected areas adjacent to Victorian state waters

The following Commonwealth marine protected areas are all multiple use zones with fishing permitted, and so do not meet the VNPA criteria for the national park and conservation system:

- East Gippsland Commonwealth Marine Reserve covers 413,700 hectares, and contains representative samples of an extensive network of canyons, continental slope and escarpment in depths from 600 metres to deeper than 4000 metres.
- Beagle Commonwealth Marine Reserve, covering 292,800 hectares within the shallow Bass Strait (mostly 50 to 70 metres), has its north-western edge abutting Victorian waters to the south-east of Wilson’s Promontory.
- Apollo Reserve, off Apollo Bay on Victoria's west coast in shallow waters (80 to 120 metres) on the continental shelf, covers 118,400 hectares.

2.2.3 Bays, inlets and estuaries

'There remains little data available on the ecological condition of estuaries, although it is evident that most of Victoria's estuaries have been degraded. It is estimated that as many as half of Victoria's major estuaries are significantly modified.'

State of the Environment Victoria 2013

The many wriggles in its coastline and a high density of coastal waterways have endowed Victoria with a multitude of diverse bays, inlets and estuaries of immense value to both humans and wildlife. There are more than 123 bays and inlets greater than one square kilometre in area.

At the intersection of freshwater and sea water, estuaries are a dynamic transitional environment, linking catchments to marine environments and affected by conditions both in local catchments and far upstream. Biological information has been collected for very few Victorian estuaries, and usually only over a short time. A 2008 assessment of threats noted that data of 'sufficient quality or spatial and temporal extent to measure the condition of Victoria's estuaries' is lacking.[43] The majority of Victoria's estuaries have been modified and degraded by human activity (Table 2.10) due to:[44]

- land uses and degradation of catchments
- changes to freshwater inflows
- coastal urbanisation (including increased recreational and commercial use and physical modification of waterways)
- modification of estuary entrances or opening of estuary mouths.

Victoria's only 'near-pristine' estuaries are located in the far east, and 'largely unmodified' estuaries occur around South Gippsland, along the Great Ocean Road and along the south-west coast.

More than half of Victoria's estuaries are naturally closed by sand bars from time to time, the frequency and duration of which is affected by altered land uses and water flows. Closure may render them more vulnerable to human threats because flooding around closed estuaries can lead to pressure for artificial opening, the consequences of which (such as large fish kills) can be 'catastrophic'.[45]

Table 2.10 Condition of Victoria's estuaries[46]

Subregion	Estuary condition				
Bridgewater	Glenelg River				
Warrnambool Plain	Merri River	Fitzroy River	Moyne River	Port Campbell River	Surry River
	Hopkins River	Curdies Inlet	Gellibrand River	Sherbrook River	Lake Yambuk
Otway Plain	Aire River	Barham River	Port Phillip	Skeleton Creek	Aireys Inlet
	Anglesea River	Spring Creek	Thompson Creek	Barwon River	Anderson Creek
	Swan Bay	Limeburners Bay	Little River	Werribee River	Wild Dog Creek
Otway Ranges	Skenes Creek	Grey River	Kennett River		
	Erskine River	Jamieson River	St George River		
Victorian Volcanic Plain	Kororoit Creek	Laverton Creek	Port Phillip		
Gippsland Plain	Gippsland Lakes	Western Port	Anderson Inlet	Corner Inlet	Merriman Creek
	Patterson River	Port Phillip	Powlett River	Shallow Inlet	Jack Smith Lake
Wilsons Promontory	Tidal River	Darby River			
East Gippsland Lowlands	Snowy River	Sydenham Inlet	Yeerung River	Thurra River	
	Lake Tyers	Basby Creek	Red River	Betka River	
	Tamboon Inlet	Mallacoota	Shipwreck Creek	Benedore River	

Source: Barton et al (2008)

Near pristine	Largely unmodified	Modified	Extensively modified

Port Phillip Bay

Victoria's largest embayment is the extraordinarily diverse Port Phillip Bay (1950 square kilometres, with 250 kilometres of shoreline). It has a multitude of habitats - deep muds, sandy shores, *Pyura* beds, shallow reefs and sheltered reefs, seagrass, drift algae and estuarine habitats – and great biodiversity values, including many unique to the bay. Of more than 270 sponge species at the Heads, at least 115 are endemic to that site.[47] The bay's wildlife include about 300 fish species, and several hundred species each of molluscs, crustaceans, bristle worms and cnidarians. The west coast has internationally significant bird habitats recognised in the declaration of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site, which annually supports more than 40,000 waterbirds.

As well as extremely high conservation values, and in tension with those values, Port Phillip Bay has Australia's most densely populated catchment and one of the most urbanised coastlines in the world.[48] It has Australia's busiest port, and supports commercial and recreational fisheries and aquaculture. It is also immensely popular for recreation – swimming, beach activities, sightseeing, diving, sailing, boating and recreational fishing.[49] The bay's ecosystems are therefore under great and increasing pressure from urban and agricultural runoff, fishing and the spread of introduced marine species – it is one of the most invaded marine sites globally (section 2.3.2).[50]

Western Port

Victoria's second largest embayment, Western Port (680 square kilometres) is semi-enclosed with two large islands. Its internationally significant values have been recognised by its listing as a Ramsar wetland and designation as an important bird area. At low tide about 40% of the bay is exposed as mudflats, which are highly productive habitats for crustaceans and shorebirds.[51] It regularly supports more than 10,000 migratory shorebirds and 10,000 waterbirds.[52] Other important wildlife habitats include deep channels, seagrass meadows, mangroves and saltmarsh.[53] This diversity of habitats supports an abundant fish fauna.

But Western Port also hosts a major commercial port, with most ships carrying liquid fuel, and is popular for recreational fishing. Extensive vegetation clearing within the catchment (leaving less than one-quarter of the catchment with native vegetation), draining of the large Koo Wee Rup swamp and the growth of agriculture, industry and urban areas have wrought major ecological changes.[54] From 1971 to 1984, about 70% of Western Port's seagrass meadows were lost (from 250 to 72 square kilometres) due to physical smothering of the leaves and reduced light levels. There has been some recovery since then, to about 154 square kilometres in 2000. The losses and limited recovery are 'symptomatic of nutrient and sediment loads exceeding the system's capacity to process and assimilate them', and the bay is susceptible to further losses due to increased sedimentation or nutrients resulting from urbanisation, catchment and coastal development or climate change.[55] Of 38 species of aquatic birds that have been regularly counted over about four decades, 25 have declined, as have the total numbers of aquatic birds.[56]

The cessation of commercial netting has reduced the risk of overfishing in Western Port but recreational effort has been increasing with a growing human population and more sophisticated technology (echo sounders and GPS navigation systems).[57] The impacts may be particularly serious for elephant fish, due to intense targeting of breeding aggregations (the recreational catch is equivalent to the entire commercial catch of south-eastern Australia), and for gummy sharks and school sharks, for which Western Port is an important breeding area.

The Victorian government is proposing to expand the Port of Hastings to make it an international container port. This would increase shipping traffic from fewer than 100 ships a year to more than 3000 annually. This will increase the risk of oil spills and the spread of marine invasive species. It will require extensive dredging and some land clearing. According to a series of expert reports commissioned by VNPA, even a moderate-sized oil spill could reach shorelines within minutes and most high conservation value areas would be reached in less than six hours. This would be virtually impossible to stop.[58] A single oil spill could have severe and long-lasting impacts on internationally significant populations of migratory shorebirds and damage large areas of seagrass, mangrove and saltmarsh, depending on tidal and weather conditions.[59]

Gippsland Lakes

The Gippsland Lakes are under enormous pressure from catchment inputs, with nutrient levels and sediments threatening the ecological health of the Lakes by maintaining it at an eutrophic level.

Environment Protection Authority, 2013

The third-largest embayment is the Gippsland Lakes (600 square kilometres), an internationally significant (Ramsar-listed) system of coastal lagoons and marshes separated from the sea by a barrier system of sand dunes fringed by Ninety Mile Beach. Once an intermittently open system of brackish (primarily freshwater) lagoons, the Gippsland Lakes have been extensively modified. The entrance has been permanently opened and deepened, and combined with reduced freshwater inflows (due to dams and water extraction in the catchment) has made the lakes a much more saline environment. Clearing in the catchment and land use practices have caused serious degradation, reflected in losses of fringing wetlands, bank erosion, high nutrient and sediment loads and recurring algal blooms.[60]

Coastal lagoons and seagrass, estuarine grass and saltmarsh habitats are among many different wetland habitats in the lakes system. They regularly support more than 20,000 waterbirds, and are important as a drought refuge. With about 179 fish species, the lakes provide important feeding, dispersal and spawning sites for numerous fish species.[61]

Corner Inlet

The fourth-largest embayment, Corner Inlet (600 square kilometres), is also a Ramsar wetland. It has large intertidal sand and mud flats, seagrass beds, a network of incised channels connected to Bass Strait and large sand islands. Due to the diversity of relatively undisturbed habitats, Corner Inlet supports internationally significant populations of several aquatic and semi-aquatic species. At times it hosts more than 40,000 shorebirds. The seagrass beds are highly productive for many fish and invertebrates. The fish fauna is diverse, with more than 170 species. About 390 indigenous plant species and 160 species of indigenous terrestrial animals have been recorded.

Corner Inlet has four ports servicing commercial fishers, offshore oil and gas production and boating visitors. It is one of only three estuaries or bays where commercial fishing is allowed in Victoria and is popular for recreational fishing. Threats assessed as medium to high risk include recreational boating (eg boat wash, anchor damage), modified flow regimes, sediment and nutrient pollution, future infrastructure development, oil spills, habitat loss due to seawalls and urban development and climate change.[62]

The proposed expansion of Port Anthony to cater for coal exports from Latrobe Valley is a potential threat to Corner Inlet. It would involve construction of a one-kilometre conveyor belt and channel dredging to allow the entry of larger ships.

2.3 Major threats

Victoria's marine and coastal ecosystems are under pressure from a multitude of human-driven extinction processes. Listed under the Flora and Fauna Guarantee Act, for example, are seven 'potentially threatening processes' specific to marine and estuarine habitats and another 30 or so directly affecting coastal habitats or their catchments. Following is an outline of threats in four major categories: climate change, habitat loss and degradation (eg coastal development), dysfunction of biological interactions (eg invasive species and algal blooms) and overexploitation (fishing). [63] Threats in a fifth major category, changes to disturbance regimes (eg fire and hydrological regimes), are covered in chapters 3 and 4. Most threats discussed in chapters 3 and 4 are relevant to coastal habitats, and many are also relevant to marine habitats, with catchment degradation typically compromising the condition of coastal marine habitats.

Many long-term threats – coastal development and invasive species, for example – are undiminished or intensifying as the potentially overwhelming threat of climate change builds. Information about many threats is inadequate, particularly those involving biological interactions, such as the loss of top predators and impacts of introduced species, and there is uncertainty about region-specific climate change predictions.

As well as directly affecting specific sites and species, major marine and coastal threats disrupt natural ecological processes, 'all the physical processes and the plant and animal activities which influence the state of ecosystems and contribute to the maintenance of their integrity and genetic diversity, and thereby their evolutionary potential'. [64] There are seven categories of ecological processes (described in section 3.3), all relevant to marine and coastal ecosystems:[65]

- climate, eg storm frequency, light climate, seasonal changes in water temperatures
- primary productivity, eg benthic nutrient cycling
- hydrological processes, eg tides, river flows
- formation of biophysical habitats, eg the formation of biogenic habitats such as *Pyura* and sponge clumps
- interactions between organisms, eg predation, competition between species
- movements of organisms, eg migration from marine to freshwater habitats
- natural disturbance regimes, eg fire regimes, storm frequency

Actions to protect particular species, habitats, sites or communities are unlikely to be effective unless the ecological processes sustaining them are also maintained.[66] So, to protect a fish species on which a fishery depends is likely to require measures to protect its habitat, its prey and their habitats, and all associated components of a healthy ecosystem, which may require management of impacts far away, including on land.

2.3.1 Climate change

A major question for several coastal ecosystems is whether they are likely to face a threshold with modest climate change beyond which they will flip into a less desirable state.

Climate Change Risks to Australia's Coast, 2009[67]

Human interference with the global climate system will inevitably bring dramatic change. For good reason, most accounts of climate change start off by emphasising the immense complexity of potential impacts, for the effects of accumulating greenhouse gases are driving multiple changes – in temperatures, rainfall, storms, currents, sea levels, sea chemistry etcetera – which in turn drive multiple cumulative and synergistic changes at many different scales of space and time. Many climatic changes are inevitable, but their extent and consequences will depend on whether human actions over the next few years increase or decrease the potential for species and ecosystem to adapt.

Victorian waters have been rapidly warming in recent decades. The greatest warming measured in Australia's oceans has been in the western Tasman Sea, where increases in sea surface temperatures have been more than 0.2°C per decade, much higher than the global average (due to the shifting East

Australian Current).[68] Coastal regions have experienced temperature rises, a decline in autumn to winter rainfall and sea level rises (at an increasing rate, Table 2.11).[69]

The following environmental changes in recent times are probably partly due to climate change:[70]

- increased salinity in Port Phillip Bay due to drought conditions
- persistent decline of seagrass beds in southern Port Phillip Bay
- almost complete loss of string kelp forests
- the westward spread of long-spined sea urchins.

Table 2.13 summarises climatic changes predicted for 2070, with examples of likely impacts on marine and coastal environments. The levels of uncertainty for some of these predictions are high due to the complexity of interactions. It is not only averages (in temperature, rainfall, sea level rise, for example) that will change but variability too, and many of the most severe impacts are likely to come from more extreme and more frequent extreme events. Many of the changes will be cumulative or synergistic. Coastal inundation risks, for example, are due to a combination of higher sea levels, storm surges and high rainfall events.

Of the three main types of climate changes (physical, biophysical and chemical, see Table 2.12), the most readily resisted will be physical changes due to increased storm frequency and sea level rise. Biophysical changes due to increased ocean temperatures and El Niño frequency are much more difficult to manage, and there is no potential at all to control chemical changes due to ocean acidification, which are almost certainly irreversible and one of the tipping points that will lead to ecosystem collapse unless global greenhouse gas emissions are limited to a 'safe' level (Box 2.5).

In the short-term, protecting against physical threats will require conserving and restoring habitats that stabilise coastal soils, absorb wave energy and disperse flood waters. The 'first line of defence' habitats include saltmarsh, mangroves, seagrass, and any coastal vegetation. If they are not protected, there are likely to be significant feedback effects that will reduce resilience in other habitats as well.

Biophysical changes are likely to be too rapid for many species to adapt to through natural selection and evolution. Adaptation will have to be at the level of ecological communities, and is most achievable in relatively natural habitats with complex trophic (food web) interactions. Areas of high biodiversity value are potential sources of ecological resilience. Protecting and restoring ecological processes will be critical to providing biodiversity with the greatest adaptation potential (chapter 5).

Table 2.11 Sea level rise experienced and projected[71]

	1961-2003	1993-2003	1990-2100
Increase	7.5 cm	3 cm	26-59 cm
Rate of increase	1.8 mm/year	3 mm/year	up to 5.4 mm/year

Source: Hennessy et al (2008)

Table 2.12 Options for building resilience to the threats of climate change[72]

Threats	Type of change	Options for building resilience
Increased storm frequency Sea level rise	Physical	Protect and restore physical coastal features and processes.
Increased ocean temperature Increased El Niño frequency (and associated changes in nutrient regime)	Bio-physical	Very difficult to manage. May depend on restoring population structures and ecological complexity, providing ecosystems with flexibility to adapt to change. May require considerable intervention to maintain species and processes.
Ocean acidification	Chemical	No options. Total ecosystem collapse. Irreversible.

Source: Australian Marine Ecology

Table 2.13 Predicted 2070 climatic changes and potential impacts on marine and coastal environments[73]

Climatic change	Changes for 2070 compared to 1990	Examples of predicted consequences
Rises in mean atmospheric temperatures	1 to 2.2 °C (low emissions scenario) 1.9 to 4.2 °C (high emissions scenario)	Changes in growth rates, abundance and distribution of plankton Changes in photosynthetic and respiration rates of marine seagrasses and macroalgae Increased distribution of mangroves Losses of giant kelp forests Species distribution shifts, including invasive species and pathogens
Rises in mean sea temperature	Sea surface: 1- 2 °C 500 m depth: 0.5-1°C	
Rises in sea level	0.18 to 0.59 metres	Inundation of low-lying coastal areas (intertidal areas, mangroves and wetlands) Erosion of cliffs, beaches and foreshores Loss of habitats that are constrained from movement due to coastal development
Strengthening of the warm East Australia Current (but depends on changes to the El Niño–Southern Oscillation)	20% (by 2100)	Altered population dynamics and distributions of many native species Dispersal of some harmful invasive species Impacts due to warmer water
Increased ocean acidity, leading	pH reduced by 0.2 units	Reduced growth and calcite production by dominant calcifying phytoplankton Deterioration of the shells of holoplanktonic molluscs
Greater stratification in ocean layers & a shallower mixed surface layer	Mixed layer shallower by about 1 metre	Reduced nutrient inputs from deeper waters Lower production, biomass and sinking export of phytoplankton Changes in the distribution and abundance of zooplankton
Increased solar radiation	2 to 7 watts/square metre	Increased photosynthetic efficiency in plants such as phytoplankton, seagrass, kelp Reduced photosynthesis in mangroves past a certain level of radiation Damage to phytoplankton, intertidal animals, zooplankton, seagrass due to UV radiation
Increased sea surface winds & water column turbulence	0 to 1 metres/second	Destruction of sensitive plankton Enhanced or suppressed nutrient upwelling, affecting productivity positively or negatively Increased sediment suspension, reducing water clarity and productivity
Reduced annual rainfall & runoff	6 to 11 % less rainfall	Impacts on coastal plankton, organisms in intertidal areas, mangroves Changes in stratification of the water column & nutrient supply, affecting productivity & nutrient cycling
Increased severity and frequency of storms & coastal flooding		Losses of seagrass & macroalgae due to destruction or increased turbidity Destruction of mangroves in fierce storms Erosion of beaches, foreshores & cliffs Pollution from sewer overflows

Box 2.5 Ocean acidification[74]

The current rate of carbon dioxide release 'stands out as capable of driving a combination and magnitude of ocean geochemical changes potentially unparalleled in at least the last ~300 [million years] of Earth history'.

Bärbel Hönisch & others, 2012[75]

About a third of carbon dioxide released has been absorbed by oceans, making them more acidic. Seawater is already 0.1 pH units lower than in pre-industrial times and is projected to drop another 0.2 to 0.3 units by 2100. An increasing CO_2 concentration in oceans will have many physical, chemical and biological effects. For example, it is likely to reduce the availability of iron and nitrogen for phytoplankton, and fundamentally alter nitrogen cycling in the sea.[76] It will reduce the concentration of carbonate ions, which are used by a wide variety of marine organisms (plankton, coralline algae, crustaceans, echinoderms, fish and molluscs) to construct their shells and skeletons (made of calcium carbonate). Experiments have shown that acidification reduces the growth rate and calcite production of dominant phytoplankton, and causes shell deterioration in holoplanktonic molluscs.[77] 'If this occurs on a large scale, it will have irreversible and catastrophic consequences for both the terrestrial and marine environments, with incalculable human cost.'[78]

Box 2.6 Shores and shorebirds under climate change

By the end of the century, according to recent projections, sea levels could rise by an average 75 to 190 centimetres relative to 1990 levels.[79] South-eastern Australia is projected to experience greater sea-level rises than the global average because the warming East Australian Current is moving further south.

One-in-100 year events are used as a benchmark for assessing extreme risk. Even if sea levels rise just 0.5 metres in the 21st century, current 1-in-100 year events could occur several times a year and 1-in-10 year events would happen about every 10 days.[80]

Rising sea levels in combination with extreme events will inundate and erode coastal ecosystems. About three-quarters of the Victorian coastline is sandy or soft, so is vulnerable to erosion. One simple approximation is that each centimetre rise in sea level is likely to cause sandy shoreline recession of 50 to 100 centimetres (for a 1 metre sea rise, this implies 50 to 100 metres recession).[81] This will put at risk billions of dollars of coastal housing and infrastructure. A 2009 first-pass assessment of the risks to Victoria's coastal infrastructure under a 2100 climate change scenario of a 1.1 metre rise in sea level and a 1-in-100 storm-tide predicted that from 27,600 to 44,600 residential buildings (current replacement value $6.5 billion to $10.3 billion) could be at risk of inundation. It estimated that there are 4700 residential buildings within 110 metres of erodible shorelines.[82]

To survive, coastal ecosystems such as seagrasses, mangroves and saltmarshes will need to shift landward but coastal infrastructure will prevent natural movement in many areas. Saltmarshes in particular will be trapped by a coastal squeeze, between urban development on the land side and migration of mangroves on the sea side. Loss of saltmarsh would not only compromise the future of dependent wildlife but could liberate a huge pool of carbon stored in wetland sediments. Beaches too will be lost to coastal squeeze unless buffers are created to accommodate landward migration.

The loss of saltmarsh and beach habitats will deprive many shorebirds of important habitat. Other climate change impacts on shorebirds include increased mortality and reduced breeding success due to heat stress, and alterations to the synchronised timing of shorebird migration and the abundance of food species.

2.3.2 Dysfunction of biological interactions

Processes that change interactions between species, reducing their functionality or disrupting life-cycle processes, threaten many species. The most obvious are invasions of introduced species – new predators (foxes and cats) eliminating native animals, new pathogens (myrtle rust) inflicting heavy losses on immunologically naïve species and rampant weeds outcompeting native plants. They also include native species benefiting from anthropogenic changes – altered fire regimes, climate change or assisted spread – that detrimentally affect other species. Examples are long-spined urchins spreading to new areas via the strengthening East Australia Current, and noisy miners dominating fragmented woodlands (section 3.4.2). Another major cause of dysfunction less well recognised (and not covered here) is the decline or loss of a key partner in multispecies relationships – for examples, declines of top predators (sharks and dingoes), pollinators and seed dispersers (honeyeaters, parrots, flying-foxes).

The Victorian government has listed more than 16 threatening processes, mostly invasive species, that fall into this category and affect coastal and marine environments.

Invasive species

Port Phillip Bay is one of the most invaded marine ecosystems globally, with at least 100 to 160 introduced species, representing 8 to 13% of all species, and including half of the 10 most abundant species in the bay. The number of introduced and cryptogenic species found there is higher than reported 'for a comparable body of water anywhere else in the world'.[83] The current invasion rate could be as high as three or more new benthic species yearly. Sources include hull fouling, ballast water and mariculture. The extent to which the ecological resistance of the bay has been altered by invaders is unknown, but an 'invasional meltdown' may be occurring, whereby invasions become mutually reinforcing with established species facilitating additional invasions.[84] Other sites are vulnerable to invasion from Port Phillip Bay – by natural or human means. Japanese kelp (recently found in Apollo Bay) and Pacific seastars can spread on fishing gear and boats.[85] Recreational fishers are permitted to transport live European shore crabs across the state. Although they are not allowed to be used as live bait, there is a risk that crabs will escape or will be carrying eggs.[86]

Coastal terrestrial ecosystems have been severely damaged by invasive species, with weeds invading vegetation remnants (Box 2.7), foxes and cats preying on wildlife, and rabbits, goats and other herbivores degrading habitats (chapter 3).

Native species can also be harmful if they are introduced or move to new areas, or become more abundant due to human-caused changes, a problem that will grow under climate change, exemplified by the native long-spined sea urchin denuding coastal reefs.

Box 2.7 Weeds destroying coastal saltmarsh[87]

About half the plant species in Victoria's coastal saltmarshes are exotic (118 species). Weeds have caused major degradation, shifts in the composition of saltmarshes and changes in ecosystem function. Tall wheat grass, introduced and promoted by the Victorian government for grazing on saline lands, 'is unquestionably the most serious invader because of its very broad ecological amplitude and robust life form'. A 2001 risk assessment found that it could 'destroy most upper saltmarsh in western Victoria' and it has been listed as a potentially threatening process by the government.[88] Yet, it is still promoted by the government as a pasture species and there are no restrictions on its sale or planting.

Another deliberately introduced plant of saltmarshes, also listed as a potentially threatening process, is the 'ferocious weed' cord grass (*Spartina* species), which can grow in tidal locations, including amongst mangroves. *Spartina* can colonise mudflats, destroying the feeding grounds of shorebirds and invertebrates.[89]

Feral animals too have substantially degraded saltmarshes, with rabbits having so profoundly affected the composition and structure of upper saltmarsh that 'we are unaware of the full extent and nature of their impacts'.

Aquaculture

Land-based aquaculture facilities involving seawater exchange are sited around Geelong Arm, Phillip Island and Port Fairy. The greatest risks are genetic alteration of wild animals, and the introduction or amplification of disease. An abalone disease outbreak at a Port Fairy facility in 2007 has caused substantial declines in wild abalone in the Otway bioregion (Box 2.8).

Sea-based aquaculture occurs mostly in leases within Geelong Arm, southern Port Phillip Bay, and at Flinders, Western Port, focused mostly on passive rearing of molluscs. The main risk is the accidental release of invasive species when transferring stock between farms. Other risks include organic enrichment, release of antibiotics and growth stimulants and harvesting pressure on wild species to produce food for cultivated species.

Wild 'stock enhancements'

In February 2013, 300,000 eastern king prawns bred in an aquaculture facility were released into Lake Tyers for recreational fishers to catch later in the year. Focused just on benefits for fishers, it was done without an environmental impact assessment. There are substantial risks associated with stock enhancements, including impacts on genetic diversity, trophic interactions and the translocation of disease.[90]

Box 2.8 Abalone disease outbreak

In 2006, wild abalone in Victorian waters became infected with a severe disease caused by the herpes-like abalone ganglioneuritis virus, thought to have originated from an abalone farm at Taylor Bay which discharged untreated effluent into coastal waters. The virus has spread more than 200 kilometres along Victoria's coast, causing up to 90% mortality in infected abalone populations and major economic losses in the wild abalone fishery.[91] The quota in the western region dropped from 280 tonnes in 2001-02 to 20 tonnes in 2011-12. In eastern Victoria the abalone fishery has also suffered declines due to the proliferation of long-spined sea urchins, which have denuded some reefs of vegetation creating 'barrens'. Their spread into cooler near shore waters of Victoria's eastern Bass Strait coastline is most likely due to a strengthening of the East Australian Current.[92]

Algal blooms

Phytoplankton blooms occur naturally but their frequency and severity is increased by nutrients, introduction of new species and through compromised nutrient cycling by marine plants such as seagrasses.

Blooms of conservation concern occur in northern Port Phillip Bay and Western Port, particularly of toxic dinoflagellates. Algal blooms can persist for months in Gippsland Lakes, severely affecting water quality.

2.3.3 Habitat loss and degradation

Victorians do indeed love their coast— on average they visit it more than 20 times each year—but love can be lethal. Each poor planning and management decision adds to the pressure from previous ones—death by a thousand cuts.

Chris Smyth, 2014[93]

At broad scales, habitat loss results from clearing of native vegetation or dredging of the sea bottom, but it also occurs at smaller scales by the loss of habitat elements such as hollow-bearing trees, woody debris and rocks. Degradation, caused by erosion, sedimentation, eutrophication, pollution, overgrazing and weed invasion, reduces the productivity of habitats, while fragmentation limits interactions between and within species, constrains species movements across the landscape, interrupting gene flow and recolonisation, and exacerbates degradation.[94]

The Victorian government has listed at least a dozen potentially threatening processes under the Flora and Fauna Guarantee Act that contribute to loss and degradation of coastal and marine environments, including the degradation of riparian vegetation, habitat fragmentation, input of organotoxins, petroleum and related products to marine and estuarine waters, input of toxicants to rivers and streams, loss of coarse woody debris and hollow-bearing trees, removal of woody debris from streams, discharge of human-generated marine debris and wetland loss and degradation.

Coastal development

The Victorian coastline has already suffered much damage from urbanisation, industrialisation and visitation. Much remnant habitat exists in a narrow strip, hemmed in by roads, car parks, caravan parks and buildings, and vulnerable to fragmentation, weeds, vandalism and dieback. The pressures are increasing, with the number of applications for development under the Coastal Management Act increasing by about one-third between 2003-04 and 2009.[95] Between 1980 and 2004 urban areas increased by 15%, extending from 270 to 311 kilometres, 17% of the coastline.[96] This trend will continue as Victoria's population grows. About 16% of the population lives within five kilometres of the coast, and in the decade from 2001 the coastal population grew an average 1.3% a year to 840,000.[97]

Other development pressures come from high rates of visitation, an estimated 13 million visits a year by Victorians.[98] A 2012 survey found that four of five (84%) Victorians had made at least one trip to the coast in the previous year, and the average was 23.4 trips a year. [99]

Box 2.9 Inappropriate coastal development[100]

In January 2013, the Victorian environment minister gave consent for a breakwater, boat ramp and beach road on crown land at Bastion Point, Mallacoota. In so doing, he approved the burial by concrete and asphalt of a significant landscape, the town's only safe swimming beach, archaeological sites and a rare surfing break.

Under the Coastal Management Act, ministerial consent is to be given only to proposals proven to be appropriate, and consistent with the *Victorian Coastal Strategy 2008*, the relevant coastal action plans and the purposes for which the land was reserved. There had been overwhelming opposition to it in the local community, and a safe and less costly alternative with far fewer impacts was proposed.

An independent planning panel in 2009 found that the project would have 'considerable impact on the wilderness and landscape values of Bastion Point and an overall net detriment to tourism', that the economic case for it was 'very weak', that it would impact in cultural heritage values and that it would have 'no overall societal benefit'. The panel recommended a small-scale upgrade of the existing ramp.

The then ALP environment minister rejected the panel's advice. A Supreme Court judicial review of the planning minister's decision, mounted by the Friends of Mallacoota, found that the minister's decision was 'surprising' and the panel report was 'a careful, fair, and balanced evaluation.'[101]

Box 2.10 Climatically irresponsible development[102]

Development of the coast along the Dutton Way and out to Narrawong is fraught with great risk, for this region is highly prone to erosion. For many years a special use zone froze development on land at greatest risk of erosion. In 2007 the Shire of Glenelg introduced an assessment process for house construction in this zone, which required extensive documentation by applicants. In 2008 the then planning minister, Justin Madden, gave the go-ahead for construction on 24 blocks, leaving another 525 in limbo. At the November 2010 state election the Coalition committed to removing the local government impediments to development in this zone.

This decision could be costly for Victorian taxpayers. A study commissioned by the Glenelg Shire Council in 2010 estimated that sea-level rise, shoreline erosion and increased storm intensity would result in the following:

- by 2030: shoreline recession of 43 to 63 metres and damage worth $101 million
- by 2070: shoreline recession of 124 to 146 metres by 2070, and damage worth $158 million
- by 2100: shoreline recession of 183 to 211 metres and damage worth $168 million.

The study assessed four adaptation options ranging from doing nothing to reconstructing and extending rock walls, with additional groynes, to the mouth of the Surry River at an estimated cost of $125 million. It considered four planning options that ranged from doing nothing to prohibiting further development. In response, the shire developed a decision matrix that measured the level of risk to property access and the risk of flood and erosion to guide decisions on applications for subdivision and house construction.

In 2012 the state planning minister overturned the Glenelg Shire's rejection of a rezoning application for houses on freehold coastal land west of the Surry River's mouth. The 2010 erosion study indicated this land could be partially eroded by 2070 and completely gone by 2100 due to sea level rises.

In July 2013 the Shire of Glenelg and the planning minister struck a deal to allow future coastal development between Portland and Narrawong, which would 'exclude council's liability for the area and enforce a build-at-your-own-risk policy'.[103] This will create an incentive for future construction of a seawall. The development will also facilitate weed and feral animal invasion of the narrow coastal crown land reserve, stymie movement of plants and animals as the sea rises, and prevent revegetation to improve habitats for coastal wildlife.

Ports, harbours and shipping

There is also industrial development on the coast in the form of ports and harbours. Threats include dredging, oil spills, land reclamation and modification of estuarine habitats, pollution, establishment of marine pests and recreational fishing. Shipping threats include oil spills, groundings, litter/rubbish and effluent dumping at sea, translocation of marine pests and release of toxic antifouling substances. Shipping is increasing as population and trade increase.

In April 2013, the state government announced funding for the design and environmental assessment of a fast-tracked expansion of Port of Hastings as a major container port, which would involve channel dredging, land reclamation and upgrading road and rail corridors. Shipping traffic is predicted to increase from 100 to 3000 ships per year, which could expose Western Port to damaging spills of heavy fuel oil and diesel from container ships and port support vessels, with terrible consequences for the sensitive habitats of the Ramsar listed wetland and internationally significant populations of shorebirds. [104] It will add to the growing pressure on the bay from the spread of Melbourne into its catchment (the city of Casey's population has been growing at 3.3% a year.

Dredging and channel deepening

Maintenance dredging occurs at most of Victoria's major ports, causing suspension of sediments, which reduces water clarity and smothers plants and animals.[105] Most ports have seagrass habitats, which are highly sensitive to turbidity. Due to a lack of studies, the specific consequences of past and present dredging activities are largely unknown. Channel deepening on the rocky seabed at the entrance to Port Phillip Bay has occurred since the late 19th century. Blasting and dredging in 2008 resulted in rubble being moved by swells and currents into adjacent canyon habitats of high conservation value.

Subsea infrastructure and discharges

Subsea structures in Victoria are mostly pipelines for effluent discharge, gas and oil transfer, and water intake and discharge (for the desalination plant), and electricity and telecommunications cables. There are also three 50 square metre reef ball style artificial reefs in Port Phillip Bay for recreational fishers, and plans for more along the Victorian Coast. They alter seabed habitat and attract aggregations of fish, some species of which are vulnerable to fishing pressure. Renewable energy projects are another emerging source of subsea infrastructure. A proposed demonstration offshore wave power station near Portland will require buoys, undersea pods and a submarine power cable. Offshore wind farms, which require subsea infrastructure to anchor turbines and connect to the electricity grid, are being built overseas and are likely to be proposed in future. Polluting discharges into coastal waters include sewage at Boags Rocks (Gunnamatta) and Black Rock (Barwon Heads) and industrial waste at Corio Bay (Geelong) and Seaspray (Latrobe Valley). When operating, the desalination plant at Wonthaggi will discharge up to 280 billion litres of brine annually. There have been substantial oil leaks in the Otway basin, with unknown impacts.

Oil and gas mining

Victoria's seas are mined for oil and gas: substantial amounts of both are extracted from the Gippsland Basin and there is a smaller but expanding gas industry in the Otway Basin. Oil production peaked in 1985 and annual production is declining, but gas production is increasing. There are considerable undiscovered gas reserves in the Gippsland and Otway Basins. Origin Energy conducted seismic testing offshore from the Bays of Islands Coastal Park in 2011 and in Commonwealth waters off the Otway coast in 2013. Other companies are also exploring for gas. Oil and gas exploration and mining causes hydrocarbon pollution from leaks, accidents and chronic discharges from process water. Seismic testing can affect sensitive marine mammals and potentially other species such as rock lobsters and abalone.[106] Often, the construction of artificial features is necessary for resource extraction, with impacts on the seabed or the coast.

Catchment activities[107]

Inherent to integrated coastal zone management is recognition that catchment activities have consequences for coastal health. The poor health of many of Victoria's catchments is highly detrimental for coastal processes. A 2005 assessment found that fewer than half of Victoria's coastal river basins had more than a third of their stream lengths in good health (Table 2.14).[108] A 2012 assessment found that rivers and streams were in poor or poor to moderate condition in three of five coastal catchments (explained in chapter 4).[109] Catchment-related threats include erosion and sedimentation due to land clearing, forestry and burning; contamination by agricultural nutrients and chemicals, and urban-derived chemicals, nutrients, litter and bacteria; the reduction of freshwater flows; and the disturbance of acid sulphate soils. There is a legacy of pesticides, heavy metals and other contaminants within the sediments of Victorian bays and inlets due to past activities. The siltation of waters flowing into Western Port has caused extensive seagrass loss (section 2.2.3).

Table 2.14 Percentage of stream lengths in good or excellent condition in coastal river basins, 2004[110]

<10%	11-30%	31-60%	61-70%	>70%
Glenelg	Weribee	Otway Coast	Tambo River	Mitchell
Portland Coast	Yarra	Latrobe	Snowy River	East Gippsland
Hopkins	South Gippsland			
Barwon	Thomson			
Moorabool				
Maribyrnong				
Bunyip				

2.3.4 Overexploitation

[While] modern-day fishing practices are generally much improved over practices used as recently as 30 years ago, the legacy effects from the intense fishdown phase of virgin stocks... are a dominant feature of the population structure of most fishable species.

Australia State of the Environment 2011[111]

Fishing, both commercial and recreational, is the major form of exploitation affecting coastal and marine ecosystems. In addition to depletion of targeted species, fishing can affect species caught for bait or incidentally (bycatch), and damage habitats.

Commercial fishing[112]

All large edible species in Victoria have suffered dramatic reductions in biomass and abundance due to historically high levels of commercial exploitation. An initial 'fish down' caused some population collapses, for example of barracouta and elephant seals, which were harvested to commercial extinction. Other species have since been maintained at or below the estimated maximum sustainable fishery production, which has probably led to other collapses – of flat oysters, scallops, pilchards and greenlip abalone.[113] Other fisheries, such as that for school shark, remain tenuous, and declines of white sharks, grey nurse sharks and blue fin tuna are also fishing related. Fishing pressure occurs at or above ecologically sustainable levels throughout all marine habitats, except for the larger marine national parks.

In addition to removal of biomass, fishing can damage habitats. Demersal and scallop trawling, operating out of Portland and Lakes Entrance, cause great damage to bottom communities.

In 2009-10, Victorian commercial wild-caught fisheries production was 4638 live tonnes based on more than 120 species: molluscs (abalone, scallops, pipis, periwinkles), crustaceans (rock lobster, crabs, prawns), cephalopods (squid, octopus, cuttlefish), echinoderms (sea urchins, sea cucumber), polychaetes (sand worms), teleosts (scale fish, more than 75 species) and elasmobranchs (sharks, chimeras, skates, rays).

The Victorian government has assessed wild catch commercial fisheries in Victoria as, 'in general, at or near capacity in terms of fishing effort', with most targeted species classified as 'fully exploited' (defined as sustainable levels of fishing and satisfactory abundance of fished species) or 'environmentally limited' (non-fishing issues are influencing productivity) (Table 2.15).[114] Such stock assessments are typically based on a target biomass of only about 40% of undepleted levels; they mostly do not account for recreational fishing, and a lack of data constrains the capacity to assess ecosystem impacts.[115]

However, improvements have been made in commercial fishing practices in Victorian marine waters in recent years. The Australian Conservation Foundation's Sustainable Australian Seafood Assessment Program assessed several Victorian wild caught fisheries as sustainable in 2011 (Table 2.16).

Table 2.15 Victorian fisheries assessments 2010[116]

Fishery	Stock status	Recreational effort
Rock lobster	Fully exploited	Moderate (eastern) Minor (western)
Giant crab	Fully exploited	Negligible
Abalone	Fully exploited	Minor
Scallop	Fully exploited	Minor
Snapper	Environmentally limited	Large
Black bream	Environmentally limited	Large
King George whiting	Environmentally limited	Large
Sea urchin	Underexploited	Minor
Calamari	Environmentally limited	Large
Garfish	Fully exploited	Large
Rock flathead	Environmentally limited	Minor
Sand flathead	Environmentally limited	Large
Dusky flathead	Unknown	Large
Australian salmon	Unknown	Moderate

Source: Adapted from Department of Primary Industries by Ford & Gilmour (2013). The status of some species was deduced from stock assessment reports. Definitions of terms: Underexploited: The fishery could potentially tolerate additional harvest pressure. Fully exploited: There are sustainable levels of fishing and satisfactory abundance of fishery stocks. Over exploited: Stock abundance is not satisfactory or overfishing is occurring. Environmentally limited: Significant non-fishing (ecosystem) issues are influencing productivity in the fishery and considered to be driving stock status.

Table 2.16 Wild-caught fisheries assessed as 'sustainable' (Sustainable Australian Seafood Assessment Program)[117]

Species	Location
Southern calamari	Corner Inlet, Port Phillip Bay
King george whiting	Corner Inlet, Port Phillip Bay
Snapper	Port Phillip Bay
Rock flathead	Corner Inlet
Silver trevally	Corner Inlet, Port Phillip Bay
Black bream	Gippsland Lakes

Recreational fishing[118]

So many people, so many places, so many methods, so many species – this is the challenge that fisheries and environment agencies face when attempting to evaluate the extent and impact of recreational fishing.

John Ford and Patrick Gilmour, 2013[119]

According to surveys in 2000 and 2009, about one in eight Victorians goes fishing for recreation each year. Because of a lack of monitoring there is little information about the environmental impacts of recreational fishing but the substantial fishing effort – combined with that from commercial fishing – implies far from benign impacts.

Whether commercial or recreational, fishing has three types of impacts: (1) direct impacts on targeted species, (2) direct impacts on non-target species (bycatch, discards, bait), and (3) general ecosystem impacts.

Fishing pressure: The main data on recreational catch from a national survey more than a decade ago (1999–2000) showed that the recreational catch of several species is similar to or exceeds the commercial catch. For example, the recreational catch of snapper was an estimated 332 tonnes, more than seven times the commercial catch (see Table 2.17 for other examples). It is likely that recreational effort has increased since then. But fisheries assessments, including for species considered 'fully exploited', do not include recreational fishing effort, and the combined commercial and recreational catch for some species may be unsustainable – Elephant Fish, for example.[120] Because recreational fishing pressure tends to be highly localised and correlated with population centres and access points, local populations may become depleted. As much as 88% of the recreational catch from Victorian bays and inlets may come from Port Phillip Bay. Recreational pressure may be maintained even when catch rates are low, which prevents recovery, whereas commercial fishers abandon unprofitable sites.

Table 2.17 Estimated recreational and commercial catch 1999–2000 of some target recreational species in Victorian marine and estuarine waters[121]

Species/group	Estimated recreational catch (millions)	Estimated recreational catch (tonnes)	Commercial catch (tonnes)	Estimated % of commercial catch
Flathead	3.32	597	151	395%
Snapper	0.47	332	47	706%
Australian salmon	0.54	271	803	34%
King George whiting	0.98	215	213	101%
Black bream	0.51	203	196	104%
Rock lobster	0.05	61	543	11%
Mullet	0.30	60	>51	<115%
Leatherjacket	0.17	50	17	294%
Trevally	0.11	38	42	90%
Garfish	0.25	26	>118	<225%
Tailor	0.06	14	13	108%
Morwong	0.03	4	>4	<100%
Abalone	0.01	3	1418	<1%
Australian herring	0.01	1	1	100%
Whiting	0.004	1	8	13%

Table 2.18 Other recreationally caught species, estimated 1999-2000 catch

Species/group	Estimated catch
Pipi	640,000
Mussels	620,000
Pike	260,000
Squid/cuttlefish	200,000
Wrasse	120,000
Barracouta	110,000
Sharks/rays	90,000
Scallops	80,000
Prawns	70,000

Bycatch/non-target catch: Recreational fishers, mostly using fishing lines, typically catch a wide range of species while targeting a few favoured species. The survival of fish returned to the water as discards or returns is variable, and discard impacts could be substantial given the magnitude of the recreational catch of some fish, particularly for low-productivity, low-abundance species vulnerable to even low levels of catch. Dive surveys of grey nurse sharks off Australia's east coast between 1991 and 2001 found that the number with embedded fishing hooks and line increased from 2% to 12%.[122]

Bait collection: Impacts on species collected as bait can be similar to those targeted for sport or consumption.

Trophic effects: Fishing of single species can have flow-on ecosystem impacts – for example by favouring competitors, reducing predator abundance, altering benthic habitat or reducing mean trophic levels.

Entanglements: Birds, turtles, fish and marine mammals become entangled in discarded hooks, lines, pots and ropes. Of 537 pelicans rescued in the Richmond River, New South Wales over nine years (1993–2002), 94% were entangled in fishing line and hooks.

Habitat impacts: Fragile habitats can be damaged by anchors or propellers (in shallow water). The use of four-wheel-drive vehicles on sandy beaches and dunes – for launching boats or for shore-based fishing – may contribute to erosion and harm nesting shorebirds.

Invasive species: Fishers can contribute to the spread of invasive species attached to their boats or in fishing gear (see above). Victorian legislation allows recreational fishers to transport live European shore crabs.

Pollution: Fishers contribute to air pollution and greenhouse gas emissions through the use of motorboats and to water pollution by waste (eg bait bags, lead sinkers, discarded or lost fishing line and nets).

2.3.5 Changes to disturbance regimes

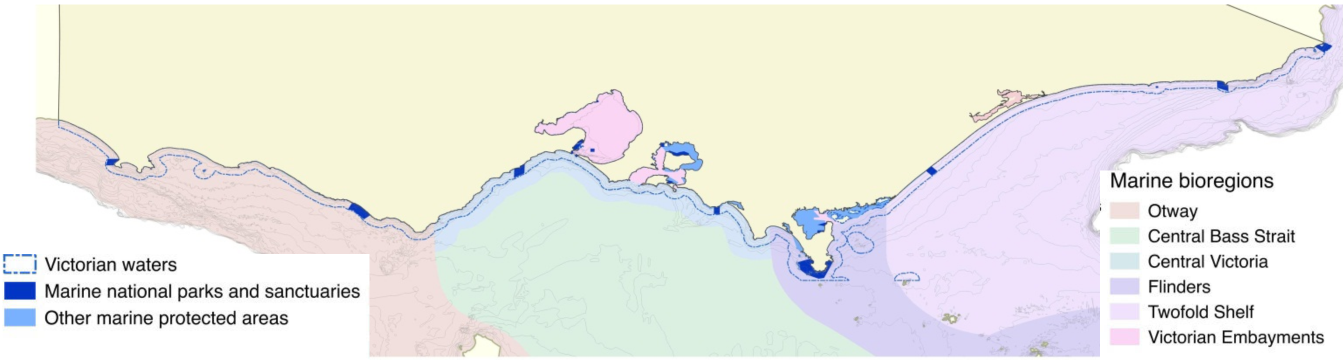
Changes to disturbance regimes – such as fire regimes and water flows - can interrupt species' life cycles or reduce the availability of food, shelter and breeding sites. Harmful fire regimes threaten remnant coastal vegetation (see chapter 3) and changes to water flows by dams and water extractions (see chapter 4) harm coastal and marine ecosystems, for example due to higher salinity levels. Alteration to the natural flow regimes and natural temperature regimes of rivers and streams, inappropriate fire regimes and high frequency fires that disrupt life cycles and compromise vegetation structure and composition are listed as potentially threatening processes.

2.4 Marine bioregional values and priorities

This section briefly summaries the features and values of Victoria's marine bioregions and the results of a gap analysis by Australian Marine Ecology of Victoria's marine protected areas, with recommendations for improving the national park and conservation system.[123] The recommendations in this section are based on the gap analysis, but are modified in a few instances from the original recommendations by Australian Marine Ecology to be consistent with VNPA's criteria for protected areas (section 1.4).[124] See Box 2.11 for the method used for the gap analysis.

Victoria's marine environment has been classified into five bioregions – Otway, Central Victoria, Flinders, Twofold Shelf, and Victorian Bays and Inlets (previously known as Victorian Embayments) – according to a nationally agreed scheme, the Interim Marine and Coastal Regionalisation for Australia.[125] A sixth bioregion – Central Bass Strait – is offshore, in Bass Strait beyond the jurisdiction of the Victorian government. The Environment Conservation Council used the five bioregions to make its recommendations for a representative marine protected area network, which resulted in the 2002 creation of 13 marine national parks and 11 marine sanctuaries encompassing 5.3% of Victorian marine waters.[126]

Figure 2.2 Victoria's marine bioregions



Box 2.11 Method for gap analysis by Australian Marine Ecology

Gaps were identified based on the principles of comprehensiveness, adequacy and representativeness. Comprehensiveness was assessed by first identifying 'provisional biounits' and ecosystems for each bioregion. The criteria for delineating biounits were:

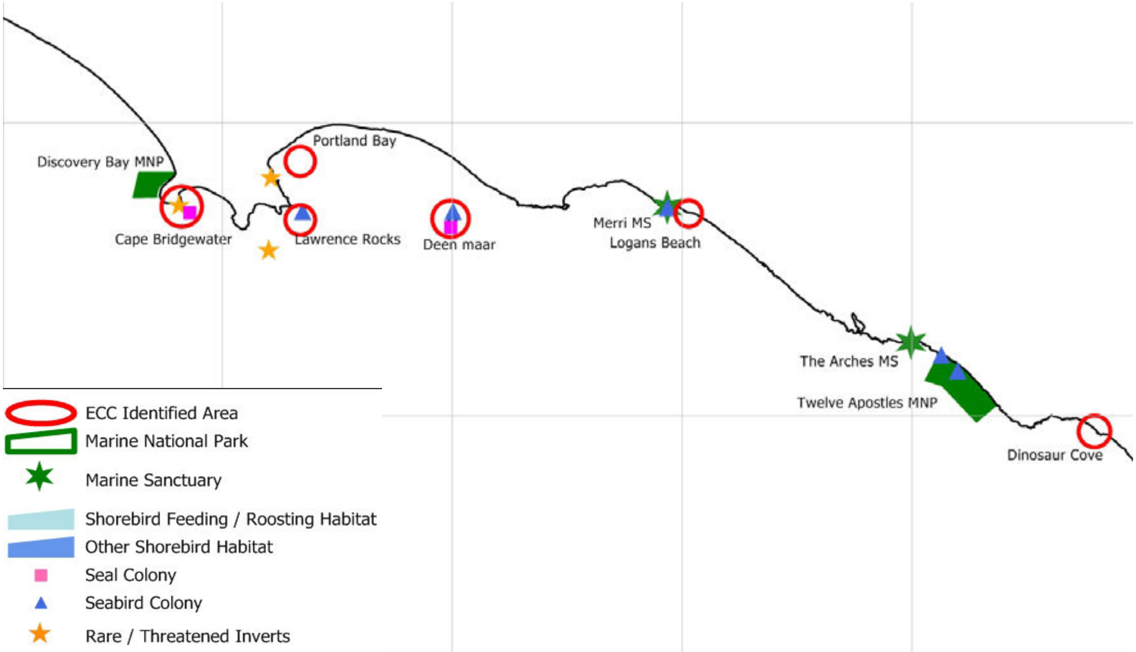
- ecologically functional structural units with recognisable natural boundaries at a scale of tens to hundreds of kilometres
- depth: above or below 30 meters
- exposure: ocean swell exposure, wind exposure, aspect
- water system: upwelling, Southern Ocean, Bass Strait, Tasman Sea
- estuarine influence: size, enclosure, barriers, tides, salinity, suspended sediments, light climate, inputs/catchment.

Adequacy was assessed by the extent to which the area, boundaries and level of protection of each marine protected area (MPA) met the ecological objectives of the MPA, as identified by the Environment Conservation Council (2000) and MPA management plans.

Using the prioritisation criteria listed above, further areas suitable as MPAs were identified and priority MPA areas were compared with the actual MPA coverage for each bioregion to determine gaps, particularly of special or unique communities and species. The existing MPAs and the MPA areas recommended by the Environment Conservation Council (2000) were included in the analysis by default. Other areas were identified from the review of conservation values for each bioregion. Tabulated results of the MPA gap analysis are provided in the appendices for each bioregion in the report by Australian Marine Ecology.[127]

2.4.1 Otway bioregion

Figure 2.3 Areas of high conservation value in Otway bioregion



This bioregion covers 37,331 square kilometres in Victoria, South Australia and Tasmania, from Cape Jaffa to slightly north of Apollo Bay and including King Island. It is characterised by cold, nutrient-rich waters and a rugged coastline of high cliffs and sand dunes lashed by powerful waves.

The Otway bioregion has a narrow continental shelf, a small barrier coast and a steeply sloping seafloor. The coast consists of headlands of volcanic outcrops, dune rock cliffs, shore platforms and offshore reefs, and sand. Seascapes include submerged volcano cones, drowned river channels, and highly eroded underwater steps and reef faces. There are extensive seaweed beds and sponge garden communities on shallow inshore reefs and deep offshore reefs, the latter still largely unexplored.

The waters are highly productive, due to nutrients welling up from deep water at the edge of the continental shelf. The Bonney Upwelling sustains large populations of seabirds, fur seals and whales, and commercially exploited species such as abalone and the southern rock lobster. The Bonney coast is one of only 13 areas globally known for frequent aggregations of blue whales, the largest animals on earth. From Warrnambool to Port Fairy is an important calving and nursery area for southern right whales.

The marine flora and fauna is typically cold temperate. The intertidal and near-shore fringes on wave-exposed coasts are dominated by bull kelp, and rocky seabed communities are dominated by large brown fucoid algae. Seagrasses carpet sheltered bays and occur in pockets in the lee of reefs. Plant species diversity is very high, particularly among the red algae, as is fish diversity.

The islands of Lawrence Rocks and Deen Maar are remnants of extinct volcanos and important breeding sites for seabirds and seals. Lawrence Rocks has the largest colony of Australasian gannets in Australia and hosts rare plants. It is a popular diving site. Deen Maar Island supports one of Australia's largest breeding colonies of Australian fur seals, and recent surveys have found unique deep reef habitats in surrounding waters. It is of special cultural significance to local Gunditjmara people and is also listed as a geological monument of national significance by the Geological Society of Australia.

Estuaries such as Yambuk Lake estuary are important nurseries for juvenile fish. Numerous wetland habitats at Yambuk Lake and along the Shipwreck Coast act as nitrogen and phosphate sinks, reducing coastal water pollution.

Table 2.19 Otway bioregion: biounits, ecological features and protected areas

Provisional biounits	Location	Protected Areas	Gaps in representation
Discovery biounit	Discovery Bay to Portland	Discovery Bay MNP	*Heterozostera* seagrass, intertidal reefs, subtidal patchy reefs, subtidal reefs
Shipwreck biounit	Portland to Cape Otway	Merri MS The Arches MS Twelve Apostles MNP	*Heterozostera* seagrass, *Amphibolis* seagrass

Gap analysis

The Otway bioregion can be divided into two biounits and has four marine national parks or marine sanctuaries (Figure 2.3, Table 2.19).

The four protected areas are generally representative of the bioregion but are inadequate in the following ways (by not according with stated objectives or values):

- Seagrass is not encompassed within any of the protected areas.
- The Discovery Bay Marine National Park does not encompass intertidal and subtidal reef habitats and linkage to coastal habitats is poor.
- The Merri Marine Sanctuary does not adequately encompass subtidal reef biota.
- There is no survey data to properly assess the adequacy of The Arches Marine Sanctuary.

Recommendations

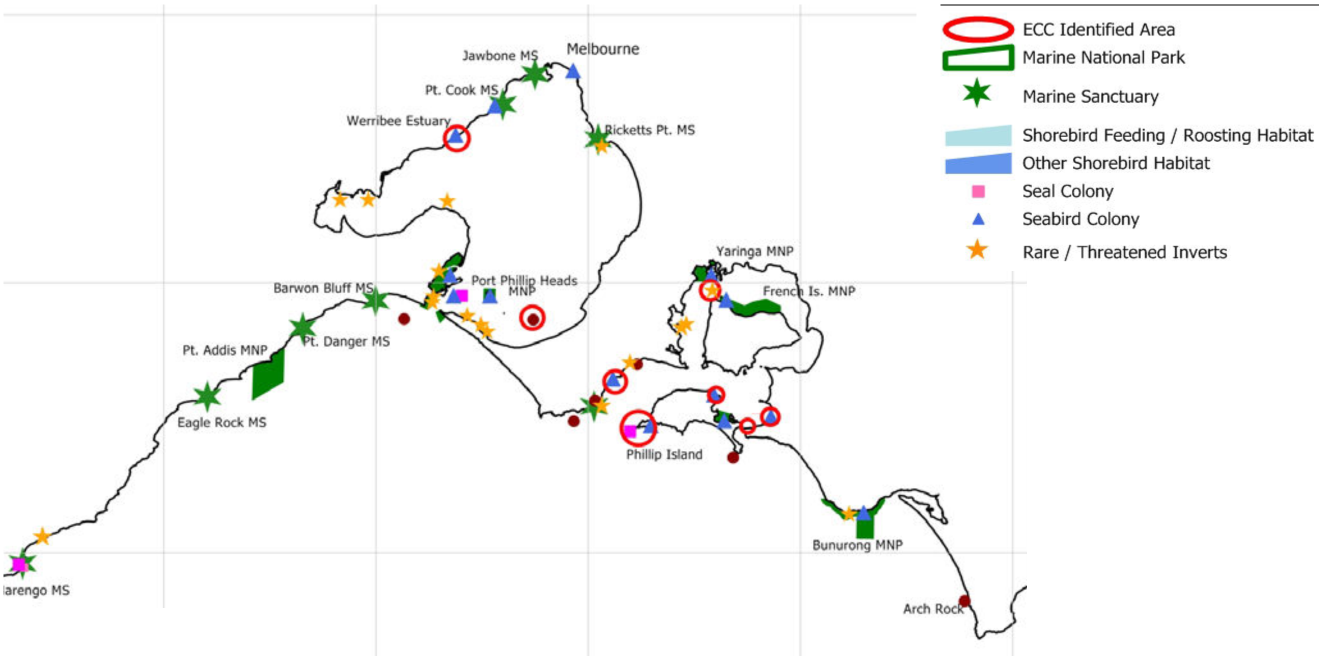
Increase the extent of protected areas in the Otway bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Dutton Bay: to protect seagrass beds and the rare seaweed *Cystophora cymodocea*.
  - Deen Maar Island and deep offshore habitats: to protect breeding sites for Australian fur seals and seabirds, white sharks, seaweed habitats and offshore deep reefs.
  - Bridgewater Bay: to protect a seal haulout, seagrass and a listed crustacean.
  - Lawrence Rocks: to protect bird breeding sites and unique flora.
  - Logans Beach: to protect a southern right whale calving and nursery area.
  - Moonlight Head or Cape Otway: to protect intertidal communities.

- Expand the following protected areas:
  - Discovery Bay Marine National Park: by removing the 500 metre excision between the park and Cape Duquesne and by extending the westward shore boundary, to increase protection of intertidal and subtidal reefs and link to shorebird and wetland habitats.
  - Merri Marine Sanctuary: by extending the southern boundary 200-300 metres seaward to improve protection of subtidal biota, including algae.

2.4.2 Central Victoria bioregion

Figure 2.4 Areas of high conservation value in Central Victoria bioregion



This bioregion covers 444,700 hectares from Cape Otway to west of Wilsons Promontory. It features coastal headlands interspersed with sandy beaches, underwater sandy plains and extensive offshore reefs of diverse types. During the Pleistocene (lasting from about 2.6 million to 12,000 years ago), the sea intruded on and regressed from the coastal plain multiple times. Each regression left a coastal dune field, the oldest of which have consolidated to form limestone ridges. Ridges above sea level are mostly dune covered and those below sea level have formed reefs. Limestone outcrops feature as occasional rocky cliffs and headlands, and as small near-shore islands. The flora and fauna are mostly of southern Australian affinity, but there are also west coast and tropical elements.

A prominent seascape feature is the three kilometre long, 100 metre deep canyon reef complex at Port Phillip Heads. It supports an endemic sessile (fixed) invertebrate community known as the 'sponge garden', which contains 271 sponge species, including 112 known only from Port Phillip Heads. There are also hydroid corals, soft corals, gorgonian corals, crustose and aborescent bryozoans, colonial and solitary ascidians. The Port Phillip Bay entrance deep canyon marine community is listed as threatened under the Flora and Fauna Guarantee Act.

Unique sessile invertebrate and rhodolith (coralline plant) communities occur offshore from Point Addis, and other significant communities are likely to occur in deep areas yet to be surveyed at Apollo Bay, Cape Schanck, Phillip Island (southeast pinnacle) and Cape Liptrap.

Other significant communities include bull kelp beds in the Apollo Bay region and at Barwon Bluff, a high diversity (96 species) of sea slugs (opisthobranchs) at Point Danger, high fish diversity and abundance at Popes Eye, unique reef habitat at Portsea Hole, and seagrass (*Amphibolis antarctica*) beds at Port Phillip Heads, Flinders and Bunurong. Forests of string kelp were once prevalent, but since 1998 this habitat type has almost disappeared.

The Barham River Estuary is a regionally significant saltmarsh and estuary system, providing nesting, roosting and feeding habitat for many bird species. A large fur seal colony lives on Seal Rocks, Phillip Island.

From Apollo Bay to Torquay, long sandy beaches, backed by dunes, offer some of the world's best surfing, and provide habitat for many seabird species. Coastal heathland and scrub are dominant vegetation types, including the threatened coastal moonah woodland community.

Table 2.20 Central Victoria bioregion: biounits, protected areas and gaps

Provisional biounits	Location	Protected areas	Gaps in representation
Surf Coast biounit	Cape Otway to Barwon Heads	Marengo MS Eagle Rock MS Point Addis MNP Point Danger MS	
Mornington biounit	Barwon Heads to Coal Point	Barwon Bluff MS Port Phillip Heads MNP Mushroom Reef MS	Offshore sediments, intermediate reefs, deep reefs
Canyon biounit	Port Phillip Heads Canyon	Port Phillip Heads MNP	
Heads biounit	Port Phillip Heads and Western Port entrances	Port Phillip Heads MNP	
Bunurong biounit	Coal Point to Sandy Point	Bunurong MNP	

Gap analysis

The Central Victoria bioregion can be divided into five biounits and has 10 marine national parks or sanctuaries (Figure 2.4, Table 2.20).

The 10 marine protected areas are considered representative of the bioregion but are inadequate in the following ways (by not according with stated objectives or values):

- The protected areas in the Mornington biounit do not adequately encompass deeper and offshore communities, in particular intermediate and deep reefs.
- Eagle Rock Marine Sanctuary only patchily encompasses subtidal reef habitat.
- Barwon Bluff Marine Sanctuary only encompasses a small area of bull kelp habitat.
- The Point Nepean section of the Port Phillip Heads Marine National Park only partially encompasses *Amphibolis* seagrass habitat, which is not adequately encompassed within any Victorian protected areas.
- Mushroom Reef Marine Sanctuary does not adequately protect fish and most other subtidal biota.
- Bunurong Marine National Park does not adequately encompass deep reef habitat or include the listed holothurian *Pentocnus bursatus*.
- The boundaries of Marengo Marine Sanctuary do not provide an adequate buffer to protect subtidal habitats.

Several areas outside protected areas warrant protection, including:

- Port Phillip Heads coastal, seagrass, subtidal reef, deep reef and canyon habitats
- Flinders intertidal reef, subtidal reef and subtidal seagrass
- Phillip Island deep reef/pinnacle habitat
- Bunurong seagrass and subtidal reef
- Western Port moderately exposed entrance habitats.

Recommendations

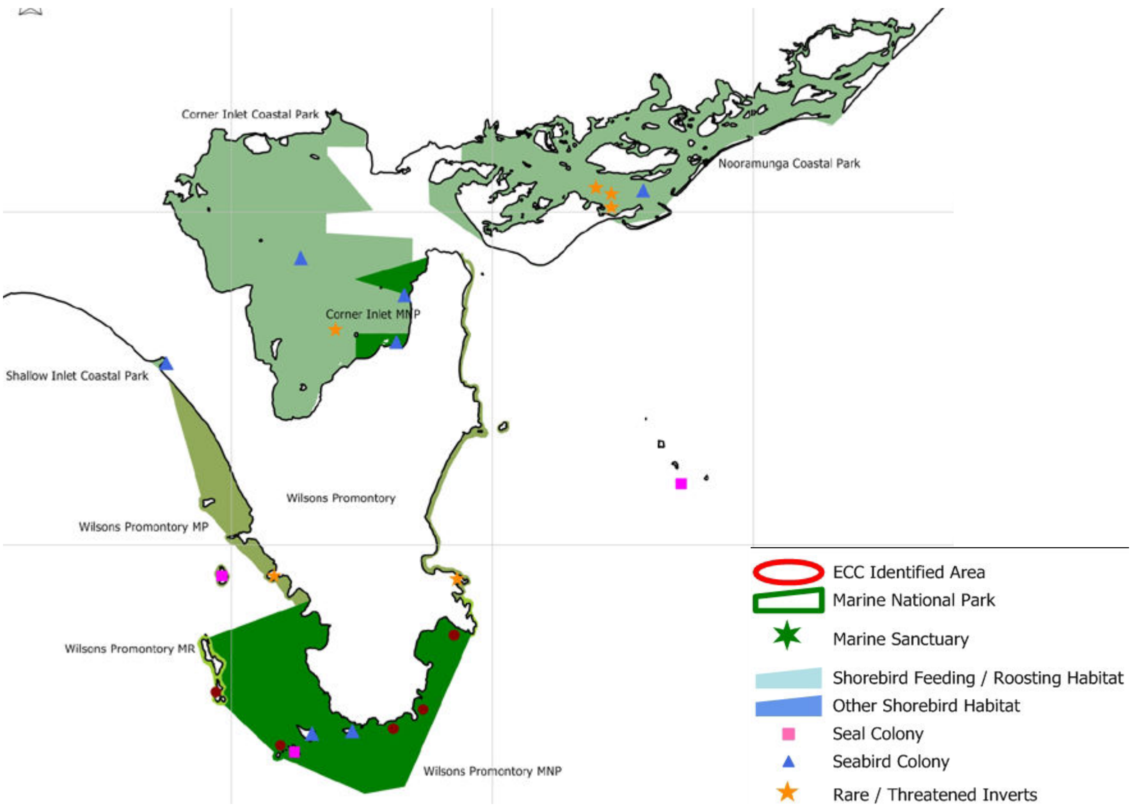
Increase the extent of protected areas in the Central Victoria bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Summerlands Peninsula and Seal Rocks: to protect the seal breeding colony, the penguin colony, white sharks, the muttonbird rookery, *Macrocystis* kelp habitat and areas of high productivity.
  - Flinders/Honeysuckle/Merricks: to protect listed species, *Amphibolis* seagrass and sea dragon colonies.
  - Cape Schanck and Phillip Island Pinnacles, to protect deep reef and offshore sediment habitat and sessile invertebrate diversity.
  - Bunurong Marine Conservation Park: to protect listed species, *Amphibolis* seagrass habitat and crevice fauna.
- Expand the following protected areas:
  - Port Phillip Heads Marine National Park: by extending it in the north to encompass the full extent of *Amphibolis* seagrass and including Tricondera Bay as a dolphin refuge.

- Marengo Marine Sanctuary: by extending it to the natural reef-sand boundaries to better protect subtidal reefs.
- Eagle Rock Marine Sanctuary: by extending the northeastern boundary to encompass continuous reef (subject to a review of the objectives of the protected area).
- Barwon Heads Marine Sanctuary: to provide a buffer for protection of bull kelp habitat (subject to a review of the objectives).

2.4.3 Flinders bioregion

Figure 2.5 Areas of high conservation value in Flinders bioregion



This bioregion covers 2.1 million hectares in Victoria and Tasmania, from Eastern Entrance to Bass Strait, including Wilsons Promontory, Flinders Island and other islands. It features long sandy beaches separated by rocky headlands and promontories, seagrass beds and diverse granitic reef communities.

The geology is mostly granite (Wilsons Promontory, Flinders and other islands) and sediments. In the south are low offshore slopes and extensive reefs while in the north around Wilsons Promontory the shores plunge steeply onto a sandy sea floor. Wilsons Promontory is the southernmost part of the mainland, part of a chain of granite mountains extending across Bass Strait, most underwater.

The waters off Wilsons Promontory are under the influence of the South Australia Current, East Australia Current, and Northern Bass Strait and subantarctic surface waters, and host many species at the edge of their ranges. The bioregion has high fish and plant diversity, mostly of cold temperate species but with a few warm temperate species more common in NSW waters like Eastern Blue Gropers.

The reefs are densely covered in seaweeds, particularly coralline seaweeds, while deeper reefs have diverse communities of sponges, sea whips and soft corals.

Small estuaries at Shallow Inlet and Tidal River and seagrass beds at Shellback Island, Glennie Island and some bays (Norman Bay, Oberon Bay, Waterloo Bay and Refuge Cove) provide important nursery areas for juvenile fish and invertebrates. Offshore islands support colonies of Australian fur seals.

The Flinders bioregion is popular for recreation – its sandy beaches, coastal and estuarine waters for recreational fishing, and its reefs for scuba diving and snorkelling.

Table 2.21 Flinders bioregion: biounits, protected areas and gaps

Provisional biounits	Location	Protected Areas	Gaps in representation
Wilson Exposed biounit	Sandy Point to Cape Wellington	Wilsons Promontory MNP	Subtidal sediments (gravel/pebble), *Amphibolis* seagrass
Wilson Moderate biounit	Cape Wellington to McLoughlins Entrance		Intertidal sediments: bare sand, subtidal sediments (beach-surf zone, inshore sand, shelly sand), *Heterozostera* seagrass, intertidal reef, subtidal reef, intermediate reef, deep reef
Flinders Offshore biounit	Seal Islands, Forty Foot Rocks		Offshore sediment, subtidal reef, intermediate reef, deep reef

Gap analysis

The Victorian component of the Flinders Bioregion can be divided into three biounits and has just one protected area (Figure 2.5, Table 2.21).

With no marine national parks or marine sanctuaries in the Wilson Moderate biounit and Flinders Offshore biounit, there are substantial gaps in representation. In the third biounit, most community types are encompassed by Wilsons Promontory Marine National Park, with the exception of *Amphibolis* seagrass and mixed brown algal communities, and it adequately encompasses the stated values and objectives for protection. Some high-value island habitats, such Norman Island, the Glennie Group and the Cliffy Group, warrant protection.

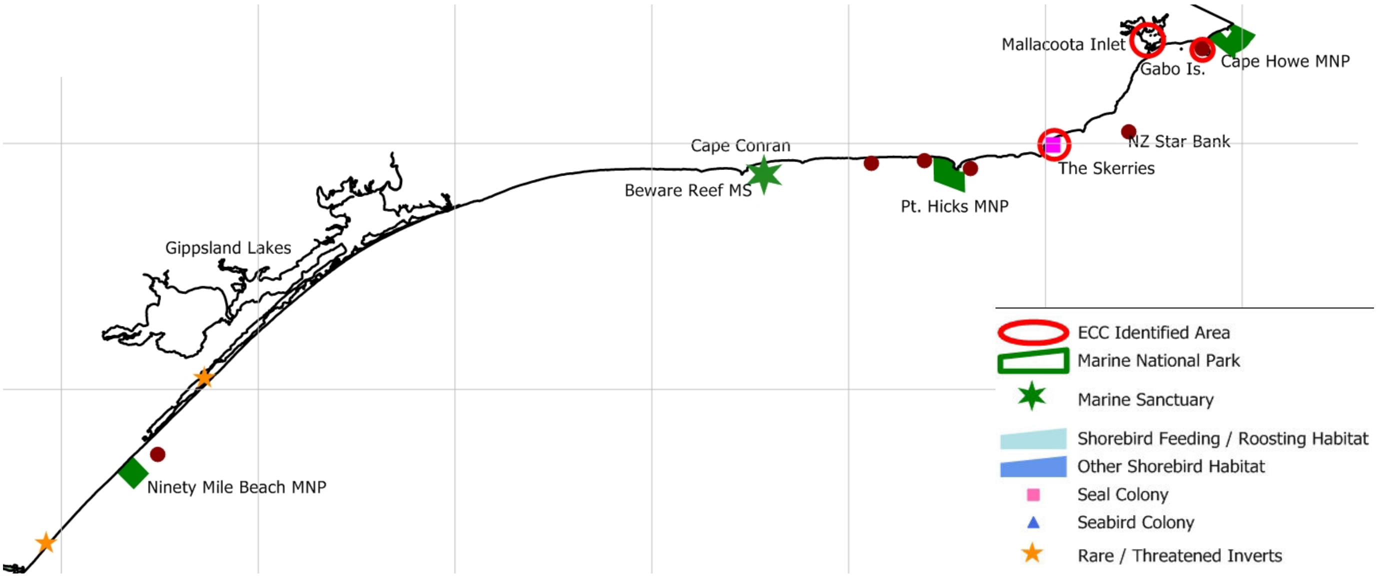
Recommendations

Increase the extent of protected areas in the Flinders bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Sites in the Wilsons Moderate biounit: to protect intertidal and subtidal sediments, *Heterozostera* seagrass, and intertidal, subtidal, intermediate and deep reefs.
  - Sites in the Flinders Offshore biounit: to protect offshore sediment and subtidal, intermediate and deep reefs (review protected area possibilities in conjunction with the Tasmanian strategy).
  - Various islands (eg Norman Island, the Glennie group and the Cliffy Group): to protect representative areas of high value island habitats.
- Expand the following protected area:
  - Wilsons Promontory Marine National Park: to encompass and upgrade protection for Wilsons Promontory Marine Reserve, Marine Park and marine protected zones, and to protect subtidal sediments and *Amphibolis* seagrass beds.

2.4.4 Twofold Shelf bioregion

Figure 2.6 Areas of high conservation value in Twofield Shelf bioregion



This bioregion covers 3.2 million hectares in Victoria, Tasmania and New South Wales, from east of Wilsons Promontory and north to Tathra NSW. It features long sandy beaches broken by rocky headlands, numerous coastal lagoons, and sandy underwater plains.

Sea temperatures and the biota reflect the influence of the East Australian Current that flows from the Coral Sea. Reefs are generally dominated by warm temperate species, including the long-spined sea urchin, which removes kelps from shallow reefs.

Nutrient-rich upwellings along the coast between Lakes Entrance and Gabo Island provide productive feeding areas for seabirds, fish and marine mammals.

The long beaches of Ninety Mile Beach region backed by vegetated dunes shelter a complex of lagoons and wetlands that provide rich habitats for fish, invertebrates and shorebirds. Ninety Mile Beach is an important shorebird breeding area, and the Ramsar-listed Gippsland Lakes support a rich diversity of wetland birds.

Off Ninety Mile Beach, sandy underwater plains harbour an extremely high diversity of invertebrates, among the most biologically diverse sediment beds in the world.

Estuarine lagoons (such as Sydenham Inlet and Tamboon Inlet) along the Croajingolong coast and Mallacoota Inlet are high in nutrients (from freshwater and marine sources), and serve as nurseries for juvenile fish and invertebrates. Mallacoota Inlet is an important feeding and roosting area for birds. The area has important sandflat and saltmarsh habitat as well as estuary grass and lagoon habitats, of high conservation value.

Table 2.22 Twofold Shelf bioregion: biounits, marine protected areas and gaps

Provisional biounits	Location	Protected areas	Gaps in representation
Ninety Mile biounit	McLoughlins Entrance to Marlo	Ninety Mile Beach MNP	intermediate reef [?]
Croajingolong biounit	Marlo to Big Rame Head	Beware Reef MS Point Hicks MNP	
Mallacoota biounit	Big Rame Head to Cape Howe	Cape Howe MNP	
Hogan biounit	Hogan Island Group		offshore sediment, intermediate reef [?], deep reef [?]

Gap analysis

The Twofold Shelf Bioregion can be divided into four biounits and has four marine protected areas (Figure 2.6, Table 2.22).

Australian Marine Ecology identified the following main gaps:

- Ninety Mile Beach Marine National Park has not been surveyed, so its adequacy is unknown. It probably does not encompass any reefs, and may be inadequate to conserve shorebird breeding sites.
- The Cape Howe Marine National Park excludes an area with high richness and diversity of reef fishes that was recommended for protection by the Environment Conservation Council.

Additional areas and habitats warranting protection include:

- the Gabo Island Harbour area
- *Durvillaea* habitat
- areas containing rare seaweeds and with unique community structure such as at Bemm Reef
- probably unique communities in the vicinity of New Zealand Star Banks, which are unsurveyed.

Conservation priorities include the dune and coastal habitat of Ninety Mile Beach and Lakes Entrance region, and Croajingalong subtidal reef (upwelling area).

Recommendations

Increase the extent of protected areas in the Twofold Shelf bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries:
  - Gabo Island and harbour: to the extent necessary to protect representative areas of urchin barren habitat, fish diversity and little penguins.
  - East Hicks (Durvillaea Flats): to protect bull kelp and red algae diversity.
  - Rame Head, Skerries and Wingan Inlet: to protect an Australian fur seal breeding colony, crested tern breeding site, white sharks and an upwelling region.
  - New Zealand Star Bank: to protect offshore deep habitats and upwelling region (if these values are confirmed by a survey)
  - Bemm Reef: to protect areas of upwelling and high productivity, filter feeding assemblages and Seaweed biodiversity, including rare species.
- Expand the following protected area:
  - Ninety Mile Beach Marine National Park: survey the park, including for reef, sediment invertebrate diversity and shorebird breeding habitat, and expand it to include representative areas of these habitats, including intermediate depth low profile reef.
- Improve management in Cape Howe Marine National Park by fostering interstate cooperation.

2.4.5 Victorian Bays and Inlets

This bioregion encompasses more than 120 confined bodies of water that range in size from 195,000 hectares to less than 100 hectares, covering more than 300,000 hectares in total. Some are drowned river valleys, others are drainage areas impounded by dune barrier systems. They are mostly basin-shaped, less than 25 metres deep, sheltered and with muddy or silty bottoms. Western Port has a bed of lamp shells (brachiopods), which arose in the Cambrian Period (490 to 545 million years ago).

The bays are diverse, with habitats including saltmarsh, seagrass, mangroves, swamps and beaches. The largest, Port Phillip Bay, is a marine embayment fringed by seagrass beds, rocky reefs and sandy beaches, with a muddy central region and sandy in the west and east. Western Port and Corner Inlet are large muddy estuaries with extensive mudflats and seagrass beds.

Extensive diverse salt marsh communities can be found at Port Phillip Bay, Corner Inlet, Gippsland Lakes and Western Port – habitat for orange-bellied parrots and many other species, and important for nutrient cycling, trapping of pollutants and sediments and stabilisation of the shoreline. Large seagrass beds occur in the Geelong Arm, southern Port Phillip Bay, Corner Inlet, Western Port, Nooramunga and Gippsland Lakes. They are nursery areas for juvenile fish and invertebrates, and stabilise and trap sediments. Mangroves, important habitats for aquatic life and for nutrient cycling and pollutant trapping, are found in parts of Port Phillip Bay, Corner Inlet, Western Port and Nooramunga. Swamp areas, which trap sediments and provide habitats for waterbirds, fish and crustaceans, are present in Gippsland Lakes and at Yallock Creek in Western Port. Sandy beaches, popular for recreation, occur in southern Port Phillip Bay, Western Port, Corner Inlet and Nooramunga.

Figure 2.7 Areas of high conservation value in Victorian Bays and Inlets bioregion

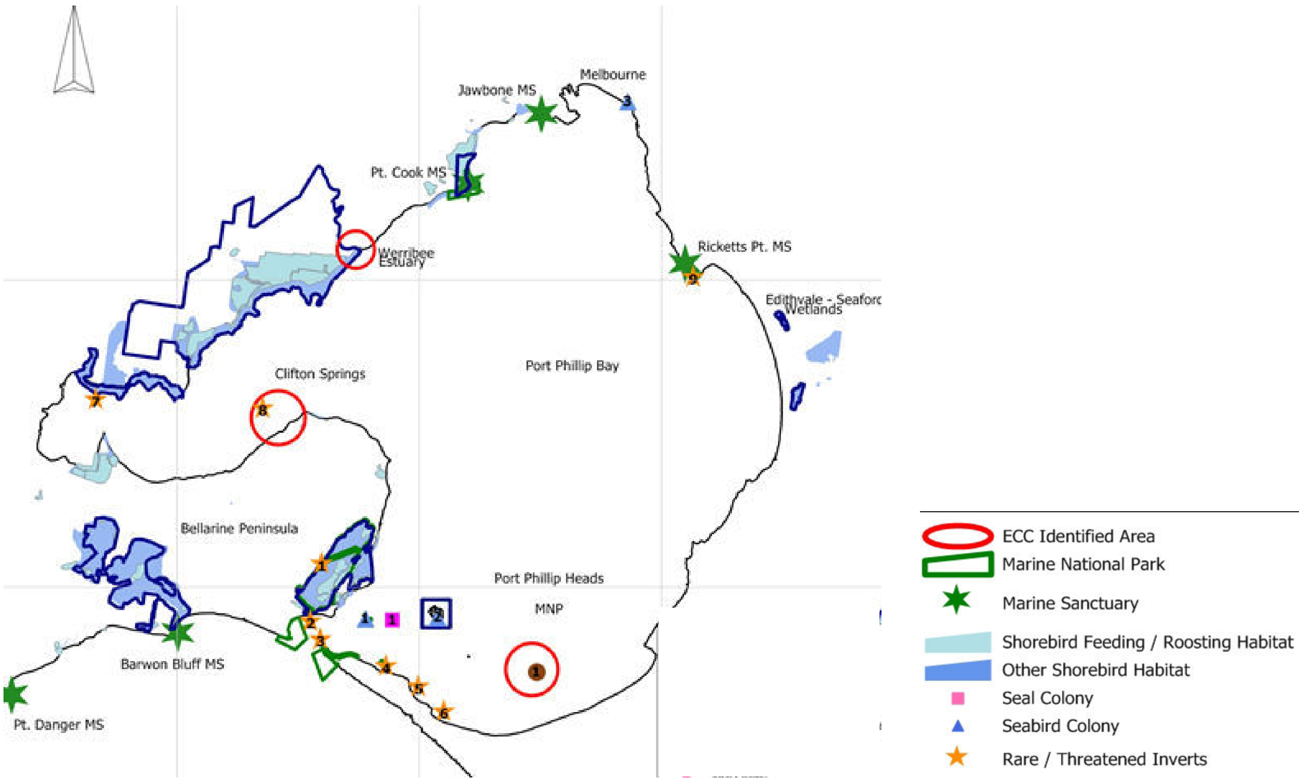


Table 2.23 Victorian Bays and Inlets bioregion: biounits, protected areas and gaps

Provisional biounits	Location	Protected areas	Gaps in representation
Geelong Arm biounit	Geelong Arm and Corio Bay	Point Cooke MS Port Phillip Heads MNP	*Halophila* and *Heterozostera seagrasses*, drift weed mats, *Pyura* clumps
Port Phillip biounit	Port Phillip Bay	Port Phillip Heads MNP Jawbone MS Ricketts Point MS	subtidal sediments (channels), *Pyura* clumps, sponge clumps
Western Port biounit	Western Port	Yaringa MNP French Island MNP Churchill Is MNP	subtidal sediments (channels)
Nooramunga biounit	Corner Inlet and Nooramunga	Corner Inlet MNP	mangroves, intertidal seagrass, *Halophila* and *Heterozostera* seagrasses, *Pyura* clumps [?], sponge clumps [?]
King	Lake Victoria, Lake King		*Ruppia*, intertidal seagrass, subtidal channels, subtidal inshore sand, subtidal silts, *Heterozostera* seagrass
Minor Inlets	Anderson Inlet, Shallow Inlet, Lake Tyers, Sydenham Inlet, Tamboon Inlet, Mallacoota Inlet		*Ruppia*, intertidal seagrass, subtidal channels, subtidal inshore sands, *Heterozostera* seagrass

Gap analysis

The Victorian Bays and Inlets Bioregion can be divided into six biounits and has eight marine protected areas (Figure 2.7, Table 2.23).

The protected areas are generally representative but have several gaps, particularly for drift weed mats and *Pyura* clumps (which are not encompassed in any protected area), channel habitats and seagrass meadows. Other areas warranting protection include:

- some of the nine areas recommended by the Environment Conservation Council for special management zones, including Clifton Springs, Crawfish Rock, San Remo listed community and Mallacoota Inlet areas
- North Arm of Western Port, which supports rare and listed ghost shrimp species
- sediment channel communities of seapens *Virgularia mirabilis* and the 'fossil' shells species of *Neotrigonia margaritacea*, *Anadara tripezia* and *Magellania flavescens*, which are presently unmapped
- sections of Gippsland lakes, consistent with managing the Ramsar wetland values of the area.

Recommendations

Increase the extent of protected areas in the Victorian Bays and Inlets bioregion to better meet reservation targets and protect sites with particularly high values.

- Protect the following sites as marine national parks or marine sanctuaries (to the extent necessary to protect representative areas or particular values):
  - San Remo: to protect a threatened marine community and high invertebrate diversity.
  - Mallacoota Inlet: to protect *Ruppia* and enclosed lagoon habitats and bird feeding and roosting sites.
  - Clifton Springs: to protect intertidal and subtidal seagrass beds and areas of high productivity.
  - Capel Sound: to protect *Virgularia seapens*, hard corals, fish aggregations and a sheltered brown seaweed community.
  - Rhyll Mud Banks and Observation Point: to protect bird foraging and roosting sites.
  - Werribee River Estuary: to protect the estuary, wetland and bird feeding and roosting sites.
  - Bass River Delta: to protect bird foraging and roosting sites, intertidal flats and algal beds.
  - Gippsland Lakes (parts): to better protect Ramsar wetland values.
  - West Channels, Symmonds Channel or Pinnace Channel: to protect sponge clump communities
  - Shallow Inlet Marine Conservation Park: to more adequately protect its values.
- Expand the following protected areas:
  - French Island Marine National Park: to include Crawfish Rock, Barrellier Island and channel habitat to protect a threatened ecological community, high diversity of sessile invertebrates, listed hydroid species, channel habitat, Barrellier Island bird roost and mangrove and saltmarsh habitats. (Otherwise, a new marine sanctuary could be created to protect these sites.) Channel biota needs to be surveyed.
  - Corner Inlet Marine National Park: expand northern boundary to Middle Channel to encompass all *Posidonia* seagrass, expand western boundary of the northern section to encompass *Heterozostera* seagrass and channel habitat and protect a threatened holothurian. Include Corner Inlet Marine Conservation Park to more adequately protect its values.
  - Yaringa Marine National Park: to protect channel habitat, subject to a survey of channel biota and a review of adequacy in conjunction with other protected areas in Western Port.
  - Churchill Island Marine National Park: move the southern boundary to encompass saltmarsh habitats and potentially expand the park to include channel habitat subject to a survey and review of the adequacy of protection within all Western Port marine protected areas.

2.4.6 Twenty bioregional priorities

Table 2.24 lists the 20 highest priorities identified by Australian Marine Ecology to improve Victoria's marine protected area network.

Table 2.24 The top 20 priority areas for protection in Victoria (not in priority order)

Bioregion	Region	Identified area	Habitat class	Habitat	Values
Otway	Bridgewater Bay	Bridgewater Bay	Subtidal to state limit	Sediment beds	Seal haulout Sparse seagrass Listed crustacean
	Deen Maar Island	Deen Maar Island	Coastal Vegetation Exposed Littoral, Subtidal to state limit	Fauna feeding, breeding and resting area Intertidal reef Subtidal reef	Seal breeding colony White shark area Seabird rookery Macrocystis kelp habitat High productivity
Central Victorian	Port Phillip Heads	Port Phillip Heads MNP Point Nepean	Subtidal to state limit	Seagrass	*Amphibolis* seagrass Dolphin refuge
	Port Phillip Heads	Port Phillip Heads MNP Point Nepean	Subtidal to state limit	Deep Reef Canyon	Listed habitat High diversity sessile invertebrate community
	Western Channel, Flinders	Flinders/ Honeysuckle/ Merricks	Exposed Littoral, Subtidal to state limit	Intertidal reef Subtidal reef	Listed species *Amphibolis* seagrass Sea dragon colonies
	Western Channel, Phillip Island	Summerland Peninsula and Seal Rocks	Coastal Vegetation Exposed Littoral, Subtidal to state limit	Fauna feeding, breeding and resting area Intertidal reef Subtidal reef	Seal breeding colony White shark area Penguin colony Muttonbird rookery Macrocystis kelp habitat High productivity
	Southern Phillip Island	Cape Schanck or Phillip Island Pinnacles	Subtidal to state limit	Pinnacle/Canyon Deep Reef	Deep reef and offshore sediment habitat Sessile invertebrate diversity
	Bunurong, Inverloch	Bunurong MCP Conservation Zones	Subtidal to state limit	Seagrass	Listed species *Amphibolis* seagrass habitat Crevice fauna
Twofold	Ninety Mile Beach	Ninety Mile Beach MNP	Subtidal to state limit	Intermediate depth reef Sediment beds	Intermediate depth low profile reef High diversity infaunal community White shark area
	Croajingolong, Marlo to Bemm	Bemm Reef	Subtidal to state limit	Subtidal reef	Upwelling High productivity. Filter feeding assemblages. Seaweed biodiversity – rare species
	Gabo Island	Gabo Island	Coastal Vegetation Exposed Littoral, Subtidal to state limit	Fauna feeding, breeding and resting area Subtidal reef	Penguin colony Seabird rookery High diversity invertebrate community High fish diversity Listed species
Victorian Bays and Inlets	Lillias to Wilson	Clifton Springs	Sheltered subtidal (bays and estuaries)	Seagrass	Intertidal and subtidal seagrass beds High productivity
	Lillias to Wilson	Point Lillias to Point Wilson	Sheltered subtidal (bays, estuaries and wetlands)	Seagrass Saltmarsh	Ruppia/estuarine grass *Halophila* seagrass Saltmarsh
	Northern Geelong Arm	Point Wilson to Kirk Point	Sheltered littoral (bays, estuaries and wetlands)	Saltmarsh	Saltmarsh
	Northern Geelong Arm	Wedge Point, offshore	Sheltered subtidal (bays, estuaries and wetlands)	Drift algae	Unique community

Bioregion	Region	Identified area	Habitat class	Habitat	Values
	North Arm, Western Port	French Island MNP Yaringa MNP Churchill Island MNP	Sheltered subtidal (bays, estuaries and wetlands)	Channels, Seagrass Mangrove and saltmarsh habitats	Channel habitat Barrellier Is bird roost Mangrove and saltmarsh habitats
	North Arm, Western Port	Crawfish Rock	Sheltered subtidal (bays, estuaries and wetlands)	Pinnacle/Canyon Deep Reef Channels	Unique community High invertebrate diversity Listed species
	Lakes Entrance	Gippsland Lakes	Sheltered littoral (bays, estuaries and wetlands), Coastal/Dune, Exposed littoral	Seagrass Fauna feeding, breeding and resting area Ruppia/estuarine grass Grasses Heaths Dune	Biodiversity – Ramsar wetland values
	Anderson Inlet	Anderson Inlet	Sheltered littoral (estuaries and wetlands)	Sandflats, Fauna feeding, breeding and resting area, Saltmarsh	*Ruppia* and enclosed lagoon habitats Bird feeding and roosting.
	Mallacoota Inlet	Mallacoota Inlet	Sheltered littoral (estuaries and wetlands)	Sandflats, Fauna feeding, breeding and resting area, Saltmarsh	*Ruppia* and enclosed lagoon habitats Bird feeding and roosting.

2.5 Coastal bioregional values and priorities

Like the marine environment, Australia's terrestrial environment has been classified into bioregions based on physical and biological features. The *Interim Biogeographic Regionalisation of Australia* identified 89 bioregions and 419 subregions, of which six bioregions and 10 subregions intersect with the 2000 kilometre Victorian coastline: [128]

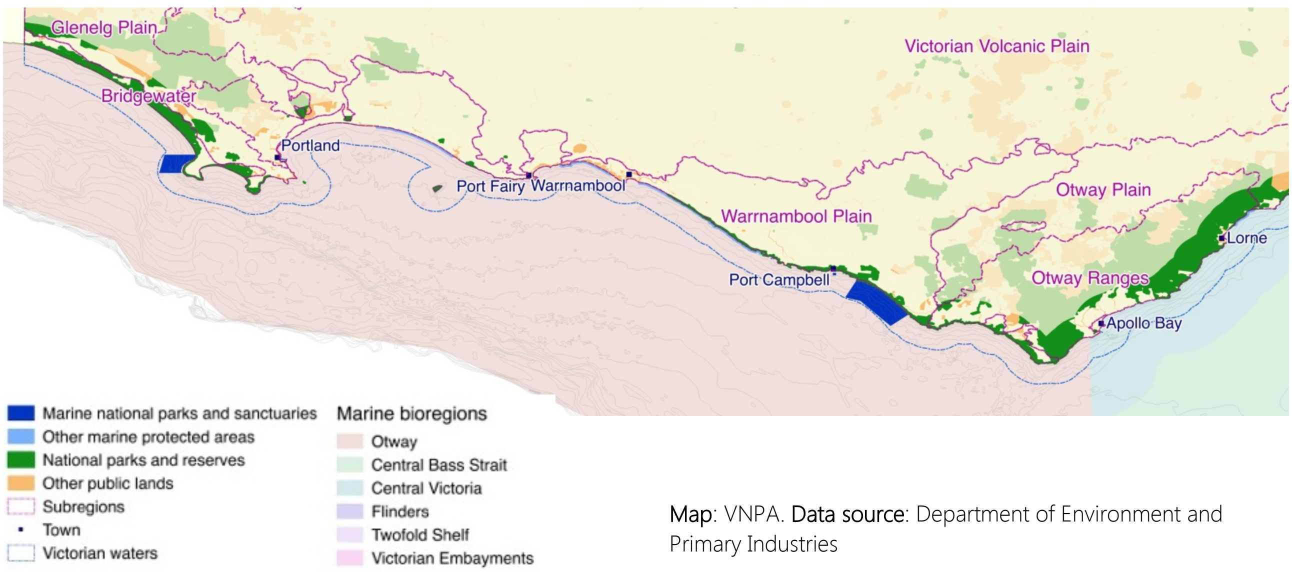
- *Narracorte Coastal Plain*: Bridgewater and the Glenelg Plain
- *South-east Coastal Plain*: Warrnambool Plain, Otway Plain, Gippsland Plain
- *Southern Volcanic Plain:* Victorian Volcanic Plain
- *South-eastern Highlands*: Otway Ranges, Strzelecki Ranges
- *Furneaux*: Wilsons Promontory
- *South-east Corner*: East Gippsland Lowlands.

This section summarises an evaluation by Chris Smyth of values, threats and recommended conservation measures in the 10 coastal subregions.[129] The recommendations focus on four main strategies:

- A coastal private land conservation program to secure the permanent protection of remnants of coastal vegetation on private land by (a) purchase through the Trust for Nature revolving fund and a government coastal land acquisition fund and (b) covenanting projects involving local councils, the state government and interested landholders.
- Establishment of new coastal reserves or expansion or merging of existing reserves, with improved management.
- Restoration of cleared, fragmented or degraded coastal vegetation with priority for threatened ecological vegetation classes or habitat of threatened species.
- Improved regulation and planning to prohibit or reverse inappropriate development on the coast.

For a few subregions, recommendations are made to merge community committees of management. These committees help manage much of the coastal land reserved under the Crown Land (Reserves) Act and have worked with the environment department, local municipalities and environmental consultants to develop coastal management plans that have improved reserve management. Reducing and reorganising some of these committees will 'reduce duplication, enable the pooling of resources, minimise the preparation and implementation costs currently spent on separate strategies and management plans, and improve the opportunities for consistent and integrated day-to-day management along the coast.'[130]

Figure 2.8 Victoria's coastal subregions from Bridgewater to Otway Ranges



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.1 Bridgewater subregion

This small 18,000 hectare region between the South Australian Border and Cape Nelson (Figure 2.8) is a volcanic plain overlaid by Victoria's largest active dune system. Much of it consists of bare sand and freshwater lagoons. With the highest coastal cliffs in Victoria, Cape Bridgewater is one of the state's most scenic coastlines. Most of the public land is in the Discovery Bay Coastal Park. On private land, which has 20% of remnant native vegetation, plantation forestry and livestock grazing are the main land uses. Drainage of saltmarsh for cattle grazing is a major threat on private land behind the coastal park. The coastline from Discovery Bay to Piccaninnie Ponds is a designated important bird area, and the area encompassing Discovery Bay Coastal Park, Lower Glenelg National Park and the Crawford River Regional Park was assessed nationally as a 'critical aquatic system'.[131]

The conservation and scenic values of Cape Bridgewater have been undermined by the installation of 29 wind turbines on its western side (as part of the Portland Wind Project). The turbines were built within remnants of coastal alkaline scrub and are associated with a network of new access roads. Their placement in this sensitive location has been detrimental both for coastal values and for the important cause of renewable energy, with resistance from coastal communities to industrialisation providing impetus to those opposed to climate change action to push for draconian statewide planning regulations for new wind turbine projects. Development in the coastal alkaline scrub was previously opposed by the environment department because of its 'significant ecological values'.

Current threats for coastal biodiversity in this subregion include the following.[132]

Habitat loss and degradation:

- edge effects in narrow strips of coastal vegetation, especially around Cape Bridgewater, and the presence of inliers of private land within the Discovery Bay section of the coastal park
- off-road driving and riding causing erosion, damage to vegetation and archaeological sites, and disturbing ground-nesting birds and other fauna
- pedestrian access to sensitive areas along cliff tops and through dunes, and unregulated and informal paths.

Dysfunction of biological interactions:

- weeds, horses, cattle and rabbits degrading vegetation
- illegal and licensed grazing in conservation reserves
- encroachment of pine plantations and spread of pine wildings into Discovery Bay Coastal Park
- predation of native wildlife by cats and foxes.

Recommendations

Expansion of protected areas

- Expand Discovery Bay Coastal Park through the proposed coastal private land conservation program by securing and restoring the following areas:
  - the inlying private land north of Long Swamp and east of Lake Minibeong
  - the small parcels of private land along the western shores of the Bridgewater Lakes with coastal alkaline scrub, coastal dune scrub and swamp scrub ecological vegetation classes
  - the large triangle of privately owned coastal alkaline scrub ecological vegetation class behind the Bridgewater Bay settlement
  - any other adjacent private land, as it becomes available.

Management and regulatory measures

- Cancel grazing licences for Discovery Bay Coastal Park and fence the boundaries with private land.
- Provide sufficient resources to park managers and adjoining landholders to fence and restore degraded sites, control illegal stock entry, manage invasive species, horse riding and disturbance of ground nesting animals, and establish wildlife corridors (especially on the largely cleared dunes of Cape Bridgewater) within and adjacent to the Discovery Bay Coastal Park.
- Through the proposed coastal private land conservation program develop a collaborative coastal nature stewardship project between the Victorian government, the Shire of Glenelg, private landholders, the local community and Trust for Nature to create a fenced vegetation buffer of 100

metres on private land abutting the narrow Cape Bridgewater section of the Discovery Bay Coastal Park, with the state government covering the cost to landholders of establishment and maintenance.

- Amend the Rural Conservation Zone 1, which applies to Cape Bridgewater, to prohibit any more wind turbines in that area. Ensure that the existing wind turbines are removed at the end of their commercial life and the site is restored.

2.5.2 Glenelg Plain subregion

This 399,000 hectare region consists of a series of low parallel dune limestone ridges that intersect the coast between Cape Nelson and Portland (Figure 2.8). About one-quarter of remnant vegetation is on private land, where the main uses are pine and blue gum plantations and sheep grazing. Flora of state significance occurs in Cape Nelson State Park and at Point Danger. Current threats for coastal nature in this subregion include the following.

Habitat loss and degradation:

- edge effects in narrow strips of coastal vegetation, and the inlier of private land in Cape Nelson State Park
- future expansion of industry in the Point Danger-Cape Sir William Grant area
- future industrial development in the Coastal Headland Scrub at Cape Sir William Grant, including the approved construction of wind turbines.

Dysfunction of biological interactions:

- Weeds, horses, cattle and rabbits degrading vegetation.
- Predation by cats, foxes and dogs.

Recommendations

Expansion of protected areas

- Expand Cape Nelson State Park:
  - secure the freehold inlier (through the proposed coastal private land conservation program) to protect the endangered coastal mallee scrub ecological vegetation class.
- Expand Discovery Bay Coastal Park by adding the following:
  - crown land from the east of She-oak Road (in Nelson Bay Coastal Reserve), to protect the rare coastal sand heathland and endangered coastal headland scrub ecological vegetation classes
  - coastal heathland/heathy woodland/damp heathy woodland/damp heathland mosaic ecological vegetation classes from Bald Hill Recreation Reserve
  - crown land from the Point Danger-Cape Sir William Grant area with coastal heathland/heathy woodland/damp heathy woodland/hamp heathland mosaic and damp heathland/sand heathland mosaic ecological vegetation classes, to protect Mellblom's spider-orchid and the nation's only mainland Australasian gannet colony.

Management and regulatory measures

- Prohibit any further expansion of industry into the Point Danger-Cape Sir William Grant area.

- Enter into an arrangement with Pacific Hydro and landholders involved in the Portland Wind Energy Project IV to ensure that the wind turbines are removed at the end of their commercial life and the land restored. At that time the coastal headland scrub ecological vegetation class in the north-western corner of Cape Sir William Grant, currently zoned Industrial Zone 2, should be purchased and added to the Discovery Bay Coastal Park.

2.5.3 Warrnambool Plain subregion

Stretching from Portland to Moonlight Head near Princetown, this 264,000 hectare region has been more than 80% cleared for livestock grazing and dairy farming, and once-vast wetlands have been drained. Almost half of the remnant vegetation is on private land and a high proportion of the coast has private land abutting high water mark.

Yambuk Lake and Princetown Wetlands are recognised as nationally important, and the estuary and dunes at the mouth of Yambuk Lake and the Port Fairy-Warrnambool coastline are designated important bird areas. Of state significance for fauna are Griffiths Island, the site of a former whaling station, with colonies of little penguins and short-tailed shearwaters, and the Belfast Coastal Reserve, which has breeding sites for crested terns, silver gulls and hooded plovers. Port Campbell National Park, internationally famous for its spectacular coastline of sheer limestone cliffs, rocks stacks and gorges, has flora and fauna of state significance. The area is at increasing risk from tourism development.

The region includes Australia's first indigenous protected area, declared in 1997 over 453 hectares of rolling sand dunes, limestone ridges and farmland to the west of Yambuk Lake. The Framlingham Aboriginal Trust has revegetated the land, and 12 wind turbines have been installed to generate income. The *Kooyang Sea Country Plan* (2004), prepared by members of the Framlingham Aboriginal Trust and Winda Mara Aboriginal Corporation, was the first of its kind in Australia. It covers land within the Glenelg Hopkins and Corangamite catchments and out to the edge of the continental shelf.

Current threats for nature in this subregion include the following.

Habitat loss and degradation:

- loss, severe fragmentation or degradation of coastal vegetation in many places
- the potential for land subdivision and intensification of land use on private land that abuts high water mark on a high proportion of this coastline
- habitat impacts from tourism developments within or adjacent to conservation reserves
- degradation of coastal habitats due to indiscriminate access tracks, grazing, clearing and burning
- the proposed coastal road between Warrnambool and Bay of Islands Coastal Park
- drainage of wetlands and livestock access to riparian habitats
- traffic hazards for native fauna along coastal roads
- vegetation removal and degradation due to road realignments, access roads, car parks, gravel stockpiles, and on disused road alignments.

Climate change:

- sea level rise, erosion and inundation associated with climate change leading to dune and beach erosion.

Changes to disturbance regimes:

- coastal defence works leading to changed coastal processes and the loss of beach and sand dune habitats
- unauthorised openings of estuaries
- compromised estuarine water quality, including algal blooms and increased salinity, due to high sediment and nutrient loads and declining freshwater flows.

Dysfunction of biological interactions:

- weed invasion
- predation of small animals by cats and foxes
- degradation and damage to revegetation projects by rabbits
- disturbance of nesting birds by horses, dogs and beach users.

Over-exploitation:

- illegal removal of orchids (Port Campbell)
- shooting and disturbance of birds by duck shooters.

Recommendations

Expansion of protected areas

- Create Yambuk Lake Coastal Park, to be co-managed by the Framlingham Aboriginal Trust and Parks Victoria:

- include Yambuk Lake Flora and Fauna Reserve, Yambuk Lake, and Yambuk Wetlands Nature Conservation Reserve
- secure (through the proposed coastal private land conservation program) coastal dune scrub remnants and cleared land between the remnants.

▪ Create Belfast Coastal Park, to be managed by Parks Victoria:
- include crown land and Belfast Lough in the existing Belfast Coastal Reserve (excluding the coastal strip between Port Fairy and the Port Fairy Golf Course)
- include crown land at Griffiths Island, Shelly Cove, Levy Point and Thunder Point
- investigate relocation of the Port Fairy Golf Course and Port Fairy Airstrip, which would be followed by restoration of the land and its inclusion in the coastal park.

▪ Expand the Bay of Islands Coastal Park:
- add Lake Gillear to the coastal park, to protect endangered remnants of aquatic herbland, swamp scrub and damp sands herb-rich woodland
- secure (through the proposed coastal private land conservation program) private land between Lake Gillear and the Bay of Islands Coastal Park, and establish a planted and fenced wildlife corridor to the threatened coastal headland scrub/coastal tussock grassland mosaic found on the coast
- secure (through the proposed coastal private land conservation program) the land above the Starlight Cave (a maternity bat cave), and fence and revegetate it
- secure (through the proposed coastal private land conservation program) private land abutting the cliff edge between the Starlight Cave and the western end of the park, to a width of 100 m from the cliff, and revegetate the coastal headland scrub/coastal tussock grassland mosaic and damp sands herb-rich woodland.

▪ Expand the Port Campbell National Park:
- add crown land reserves adjoining or near the national park, including the public purposes reserve and public park reserve on Port Campbell Point, the water reserve (and crown land) east of Port Campbell north of the Great Ocean Road alignment, the small, undeveloped areas of public land between the Great Ocean Road and the park within the township of Port Campbell, west of the Port Campbell Creek, including allotments 2 and 3, and the Loch Ard Public Cemetery
- add the Commonwealth-owned rifle range near Two Mile Bay and restore the land
- secure (through the proposed coastal private land conservation program) private undeveloped land on the Port Campbell headland to protect the southern brown bandicoot
- purchase (through the proposed coastal private land conservation program) private land to the north of the park for the purpose of realigning the Great Ocean Road, and add the land between the new road and the current park boundary to the national park, with restoration of the threatened coastal headland scrub and coastal tussock grassland ecological vegetation classes.

Management and regulatory measures

▪ Merge the committees of management from Narrawong to Port Fairy into a single committee.

▪ Create a new West Coast Shire by amalgamating the coastal section of the Corangamite Shire, Moyne Shire and the City of Warrnambool, combine South Gippsland and Bass Coast shires and Wellington and East Gippsland shires, and merge the Borough of Queenscliffe with the City of Greater Geelong.

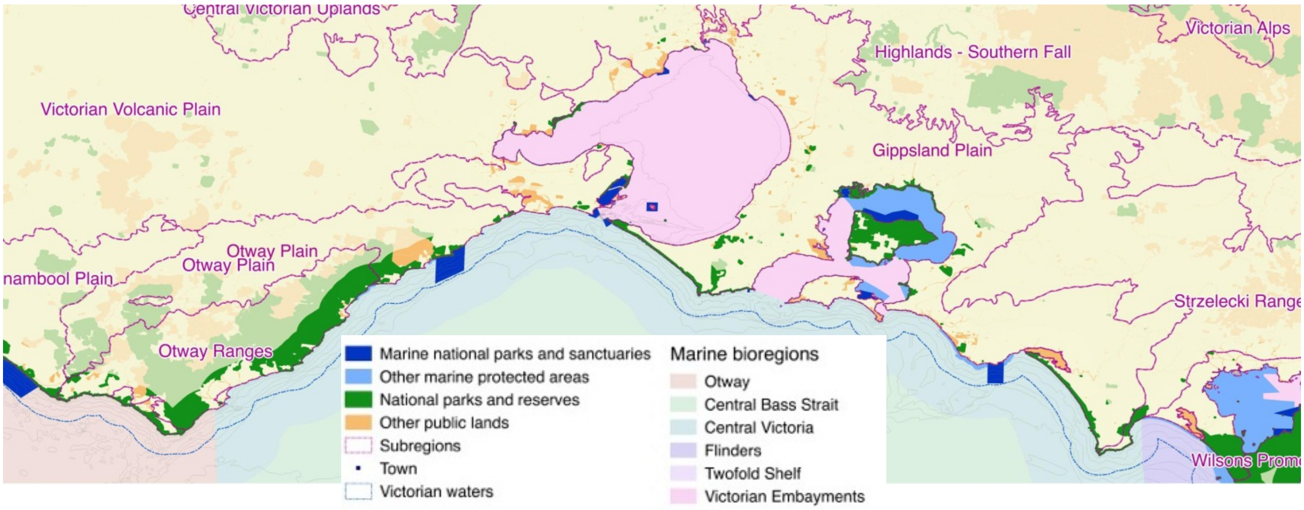
▪ Ensure there are no further housing subdivisions along the Old Coach Road at Narrawong, so as to reduce pressure on the very narrow coastal crown land reserve with threatened coastal dune scrub.

▪ Close the Old Coach Road reserve, add it to the existing coastal crown land reserve, and fence and revegetate it. Provide a walking track only for anglers to access the beach. Apply a vegetation restoration overlay in the planning scheme of the Shire of Glenelg to create a 50 metre buffer from the road to the adjoining freehold land to prevent development, and restore the area.

▪ Amend land-use zones in the planning schemes of the Shire of Glenelg, Shire of Moyne, the City of Warrnambool and the Shire of Corangamite to prohibit wind turbines on private land abutting coastal crown land or the high water mark.

- Reject any proposals to build a coast road between the Bay of Islands Coastal Park and Warrnambool.
- Establish a collaborative coastal nature stewardship project between the Victorian government, the Shire of Moyne, Warrnambool City Council, private landholders, Landcare groups, the community and the Trust for Nature to reconnect coastal and hinterland nature on the Warrnambool Plain. Provide sufficient resources to establish wildlife corridors, rationalise access tracks, erect and maintain boundary fences, and eradicate and manage invasive plants and animals. Focus on re-establishing connections along the coast and the banks of coastal rivers and their estuaries.

Figure 2.9 Victoria's coastal subregions from Otway Ranges to Gippsland Plain



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.4 Otway Ranges subregion

This 150,000 hectare subregion (Figure 2.9) was shaped 30 million years ago by the uplift of freshwater sandstones and siltstones. Native vegetation remains on just over three-quarters of the bioregion, most of it in Great Otway National Park and the Otway Forest Park. About one-quarter of remnant vegetation is on private land, where the main uses are sheep and dairy cattle grazing and softwood plantations.

The Great Ocean Road is a dramatic drawcard for tourists. The most famous section, between Eastern View and Kennett River, was carved from the steep slopes of the Otway Ranges by unemployed workers during the great depression. It is beset with maintenance and safety problems and regular landslides.

Of state significance are excellent examples of western Victoria's coastal scrub and heathland communities at The Gables, intact woodland, forest and scrub from Point Franklin to Shelly Beach, and forest and coastal scrub communities from Cape Patton to Lorne, where fauna is also of state significance, including swamp antechinus, rufous bristlebirds, and a southern bent-wing bat roosting cave. The Otway Ranges bioregion has been designated an important bird area.

The threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- poor condition of vegetation close to the Great Ocean Road and townships due to visitor pressure, pests and altered fire regimes
- fragmentation of vegetation and accentuation of edge effects
- increased infrastructure and developments in response to growing visitor numbers

- changing land use within or adjacent to the Great Otway National Park and along the Great Ocean Road
- unauthorised roads and tracks and informal walking tracks
- Great Ocean Road upgrades, realignments and landslips.

Dysfunction of biological interactions:

- fox and cat predation of wildlife
- disturbance of habitats and wildlife by feral goats and pigs
- rabbits preventing regeneration, causing erosion and facilitating weed spread
- plant dieback at several coastal heathland and woodland sites due to the pathogen *Phytopthora cinnamomi*
- weeds such as blackberry, boneseed, bridal creeper, sweet pittosporum, ragwort and sea spurge
- horse-riding on beaches disturbing nesting birds such as the hooded plover.

Recommendations

Management and regulatory measures

- Merge the committees of management from Breamlea to Clifton Springs to create a single committee, the Bellarine Peninsula Committee.
- Conduct an independent, transparent and rigorous environmental assessment of the proposed upgrade of the Great Ocean Road, including a comprehensive analysis of the impacts on coastal nature, and robust public consultation processes.
- Maintain existing planning scheme provisions that limit the growth of coastal townships along the Great Ocean Road between Eastern View and Marengo. Do not allow any new coastal subdivisions between Eastern View and Kennett River, and between Princetown and Marengo.
- Provide park managers and adjoining rural landholders with sufficient ongoing resources to manage invasive species in the Great Otway National Park and Otway Forest Park, including in coastal areas.
- Ensure that the easing of restrictions on land development and land-use change in the Rural Conservation Zone does not allow resort and hotel developments or the installation of wind turbines on private land between existing townships on the Great Ocean Road.
- Do not permit commercial developments such as hotels and resorts within the Great Otway National Park. Confine tourist developments to the existing main settlements along the Great Ocean Road at heights and spatial extents appropriate for the landscape.

2.5.5 Otway Plain subregion

A small proportion of the Otway Plain's 237,000 hectares is on the coast (Figure 2.9), and very little is conserved within coastal protected areas. Less than a third of the subregion still has native vegetation, almost two-thirds of it on private land, where major land uses are grazing, cropping and dairying.

Dinosaur Cove, part of the Great Otway National Park, is an internationally significant fossil site. Bells Beach is an internationally famous surfing mecca and was the world's first declared surfing reserve but is suffering from the pressure of 1 million visitors a year.

The Aire River is a listed heritage river, and it and the Lower Aire River Wetlands are in the national directory of important wetlands. Rich in small mammals, Urquhart Bluff is of national significance for both flora and fauna. The large and relatively undisturbed estuary and coastal lagoon at Lake Connewarre and the Barwon River have one of the most diverse saltmarsh areas in Australia and a flora of national significance. The Reedy Lake–Lake Connewarre complex and Swan Bay, both part of the Port Phillip and Bellarine Peninsula Ramsar site are internationally significant for shorebirds, waterbirds and other fauna. The fauna of the disturbed saltmarsh at the Geelong Saltworks is nationally significant. Flora of state significance is found between Rotten Point and Point Franklin, at the mouth of Painkalac Creek, on cliffs between Anglesea and Bells Beach and at Swan Bay. The fauna of the dry saltmarsh and moonah dune scrub at Lonsdale Lakes is of state significance. The islands of Swan Bay and Port Philip Bay and Bellarine wetlands are designated important bird areas. However, the Bellarine Peninsula is now seen as an area to accommodate much of the population growth of Geelong.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- coastal development and urban expansion including at Apollo Bay, Torquay and towns of the Bellarine Peninsula, Geelong and western shoreline of Port Phillip Bay
- roads and tracks leading to habitat fragmentation and decline
- edge effects due to extreme fragmentation of most coastal and hinterland vegetation, and narrow strips of vegetation between coastal roads and the shore
- urban encroachment on wetlands such as Lake Connewarre, Murtnaghurt Lagoon, Lonsdale Lakes and Geelong Saltworks, and on sand dunes such as at Buckley Park
- drainage and reconfiguration of wetlands, and landfill on the margins of wetlands
- car parks and other infrastructure in fragile areas such as Bells Beach due to visitor pressure
- coastal engineering works.

Changes to disturbance regimes:

- artificial opening of estuaries
- alteration of wetland hydrology
- water extraction from estuarine catchments
- landfill and altered coastal process by ports and marinas, eg Bay West project and Wyndham Cove.

Dysfunction of biological interactions:

- spread of serious weeds, such as blackberry and sweet pittosporum, and of the pathogen *Phytophthora cinnamomi*
- invasive marine organisms such as Japanese kelp at Apollo Bay
- rabbits and carp degrading habitats
- foxes and cats preying on small animals
- livestock access to riparian zones
- disturbance of shorebirds and waterbirds by shooters, boat users, anglers, off-road vehicles.

Recommendations

Expansion of protected areas

▪ Create a new Geelong and Bellarine Wetlands State Park managed by Parks Victoria, to protect wetland remnants of the Bellarine Peninsula:

- include Lake Connewarre (the game reserve would be degazetted), Reedy Lake, Hospital Swamp and Murtnaghurt Lagoon
- include Salt Lake, Edwards Point, the Barwon River estuary, Sand Island, Buckley Park Foreshore Reserve, Lonsdale Lakes Nature Reserve, Lakers Cutting, south-western shores of Swan Bay, Freshwater Lagoon, Thompson Creek and Karaaf Wetlands at Breamlea, the coastal reserves at Black Rocks, Thirteenth Beach, Barwon Heads and Ocean Grove
- secure (through the proposed coastal private land conservation program) the Geelong Saltworks at Moolap (preventing its development), to protect endangered coastal saltmarsh/mangrove shrubland mosaic
- secure (through the proposed coastal private land conservation program) land zoned Rural Conservation Zone and Farming Zone abutting Murtnaghurt, some of the land between the lagoon and Thirteenth Beach Road currently zoned Comprehensive Development Zone, and part of the Thirteenth Beach Golf Resort (construct a trail and boardwalk to allow golfers to pass between fairways)
- secure (through the proposed coastal private land conservation program) Rural Conservation Zone II land between the western end of the Lonsdale Golf Course and the Collendina Caravan Park, and south of Lake Victoria, and close and rehabilitate the quarry
- secure (through the proposed coastal private land conservation program) unsold allotments on The Point development in the Lonsdale Lakes
- secure land (through the proposed coastal private land conservation program) in the Farming Zone around the Lake Connewarre reserve with remnants of endangered ecological vegetation classes and restore them.

- Expand the Great Otway National Park:
  - degazette the Aire River State Game Reserve and add it to the national park
  - add heathland at Anglesea currently leased by Alcoa (but outside the mine pit) to the national park (Box 2.12).

Management and regulatory measures

- Transfer the management of the Bells Beach Recreational Surfing Reserve to a new committee of management comprising Parks Victoria, the Traditional Owners and the recreational surfing community, with Parks Victoria responsible for day-to-day management. Prepare and implement a new management plan for the reserve to protect the natural, Indigenous and recreational surfing heritage of Bells Beach, and which is consistent with the vision developed by local surfing recreational groups, in collaboration with Traditional Owners, to create the Bells Beach Surf Sanctuary.

- Secure (through the proposed coastal private land conservation program) land along the Aire River between the bridge and the river mouth, to begin the rehabilitation of natural flows within the wetlands.

- Amend the Rural Conservation Zone applying to private and cleared land in the Johanna and Horden Vale areas, and between Marengo and Skenes Creek, to prohibit wind turbines and other development projects within view of the coast.

- Ensure the continuation of existing planning scheme provisions that limit the growth of coastal townships in the Otway Plain Bioregion. No new coastal subdivisions should be allowed from Eastern View to Geelong, and from Geelong to Altona.

- Do not permit the Spring Creek housing development to proceed.

- Ensure the long-term protection of the Ramsar-listed wetlands in the Western Treatment Plant by placing a covenant on the land that allows the operation of the plant but not its conversion to more intensive industrial or urban uses, and requires the land to become a nature conservation reserve or be added to the proposed Corio Bay Coastal Park if the plant closes.

- Prohibit any replication of the artificial beaches of the Wyndham Cove harbour development elsewhere along Port Phillip Bay's Ramsar-listed western shoreline.

Box 2.12 Mining in the Anglesea heathlands

'Anglesea Heath is the richest and most diverse vegetation community in Victoria. Amazingly, about a quarter of Victoria's plant species can be found here including over 80 different types of orchids.'

Parks Victoria[133]

The 7000 hectare Anglesea heathlands are a botanical treasure trove with more than 700 plants species, including more than 80 orchids, four plants endemic to the site – Anglesea grevillea, Anglesea leek orchid, large bearded greenhood (Anglesea) and the Anglesea grey-gum – and dozens of threatened species.[134] The heathlands are important also for native animals, including the critically endangered New Holland mouse.

Since 1968, Alcoa has operated an open-cut coal mine and power station in a 300 hectare portion of the heathland, having been granted a 50-year lease over more than 7000 hectares in 1961 to build a power station for the Point Henry aluminium smelter in Geelong. Recently, Alcoa was granted a new 50-year lease and permission to extend the mine.

In view of the extremely high values of the site, local and state environment groups have proposed that all heathland outside the current mine site be added to the adjacent Great Otway National Park.[135] Alcoa announced in 2014 that it is closing its operations, which should open up opportunities for a new arrangement.

2.5.6 Victorian Volcanic Plain subregion

This vast 2,356,000 hectare bioregion meets the coast only for a short stretch (Figure 2.9) and has few coastal protected areas. The bioregion formed from volcano eruptions, which began about 5 million years ago and continued intermittently until a few thousand years ago. Its flat grasslands and fertile soils attracted sheep graziers and just 16% of the original vegetation remains, almost two-thirds on private land. Its eastern edge, where it reaches Port Phillip Bay, is subject to increasing urban encroachment.

Limeburners Bay supports large numbers of shorebirds and is nationally significant for fauna. This stretch of coast is also part of the designated Werribee to Avalon important bird area. Between the Avalon Saltworks and the Western Treatment Plant is one of Australia's richest saltmarshes, with flora of national significance and fauna of international significance. It is part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site. The wet and dry saltmarsh and dune vegetation at Point Cook and the Cheetham Wetlands is of state significance, while the fauna at this Ramsar site is internationally significant. The Cheetham Wetlands were part of a complex of evaporation ponds and channels created in saltmarshes by Cheetham Salt Pty Ltd in the 1920s. Seawater from Port Phillip Bay was fed into the ponds, where it evaporated. The saltworks closed in the 1990s, but Parks Victoria maintains the channels and ponds for birdlife. From Altona to Williamstown the flora is of state significance and the fauna is nationally significant. Part of the Ramsar site, the area is an important feeding and roosting site for large numbers of shorebirds.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- large losses of coastal and hinterland vegetation leaving fragmented patches suffering from edge effects
- urban encroachment of wetlands
- continuing loss of saltmarsh
- proposals for port and marina expansions
- stormwater and urban runoff, drainage and rubbish impacting on water quality.

Dysfunction of biological interactions:

- degradation by rabbits
- predation of small animals by foxes and cats
- numerous serious weeds
- disturbance of shorebirds and waterbirds by boat users, anglers, off-road vehicles.

Recommendations

Expansion of protected areas

- Create a new Corio Bay Coastal Park to give stronger protection to Ramsar sites between Limeburners Bay and Lake Borrie:
  - include Limeburners Lagoon (Hovells Creek) Flora and Fauna Reserve, The Spit Wildlife Reserve, Point Lillias, Point Wilson and the Avalon Saltworks
  - include Avalon Coastal Reserve and other coastal crown land reserves along that coastal strip
  - negotiate with the federal government to transfer Point Wilson for inclusion.

- Create the Fawthrop Lagoon Nature Conservation Reserve:
  - through the proposed coastal private land conservation program, establish a collaborative coastal nature stewardship project between the Shire of Glenelg, the Glenelg Hopkins Catchment Management Authority and the local community to manage invasive species and reinstate more natural water flows to conserve the estuarine wetland and threatened swamp scrub and herb-rich foothill forest ecological vegetation classes along and north of Wattle Hill Creek.

Management and regulatory measures

- Provide sufficient ongoing resources to rehabilitate and maintain the threatened coastal tussock grassland ecological vegetation class along the coastal reserve at Black Rocks near Breamlea (for land not included in the proposed Geelong and Bellarine Wetlands State Park).

- Reject the Bay West port project. Any expansion of port infrastructure should focus on consolidating port operations in Port Phillip Bay, including Geelong, and Portland, not the Ramsar-listed western shorelines of Port Phillip Bay or Western Port.

- Provide sufficient personnel and other resources to continue the environmental enhancement programs focusing on water quality, invasive species and conservation of threatened ecological vegetation classes at Point Cooke Coastal Park and Cheetham Wetlands.
- Establish a collaborative coastal nature stewardship project between The City of Hobsons Bay, the Port Phillip and Western Port Catchment Authority, Parks Victoria and nearby landholders and local friends groups to further improve the water and habitat quality of Kororoit Creek, and restore and protect coastal saltmarsh, coastal alkaline scrub, mangrove shrubland and plains grassland in the Altona Coastal Park and the Jawbone Flora and Fauna Reserve.

2.5.7 Gippsland Plain subregion

The Gippsland Plain is a vast 1.2 million hectare coastal and alluvial plain (Figure 2.9, Figure 2.11) dominated by barrier dunes, swamps and floodplains. It encompasses 27 river systems, 30 municipalities and a rapidly growing Melbourne expanding into its western edge. Only a quarter of the bioregion has native vegetation, almost half on private land.

This subregion features four Ramsar wetlands – Edithvale-Seaford Wetlands, Western Port, Corner Inlet and Gippsland Lakes – which also include designated important bird areas. The large expanse of saltmarsh, mangroves and relatively undisturbed vegetation at Corner Inlet are Victoria's most extensive intertidal mudflats, the world's most southern mangrove, and Victoria's largest stand of *Posidonia* seagrass. Corner Inlet is ideal habitat for shorebirds and up to 50% of Victoria's migratory shorebirds can be found there. Western Port is the third-most important overwintering site for shorebirds in Victoria.

Other areas designated as important bird areas are Anderson Inlet, Shallow Inlet and Phillip Island. The little penguins on Phillip Island attract nearly 2 million visitors a year. Seal Rocks has national significance, with the world's largest breeding colony of Australian fur seals. French Island National Park is of national significance for its flora, with more than 400 plant species, and Gippsland Lakes are nationally significant for their fauna. Point Nepean and Mornington Peninsula national parks are strongholds for threatened coastal moonah woodland, an ecological community with more than 90% of its former extent cleared from the Mornington Peninsula. For thousands of years, Point Nepean was used by Boonwerrung women as a mothering place.

There are many sites with flora or fauna of state significance. Of state significance for fauna are the artificial freshwater wetlands of Coolart, Point Nepean and Sorrento Coastline, the western and northern shores of Western Port, Phillip Island's south and west coasts and Conservation Hill Wildlife Reserve, French Island National Park, the Bunurong coastline, Anderson Inlet, Shallow Inlet, Jack Smith Lake, and Gippsland Lakes. Of state significance for flora are Sandy Point at Cerberus, from Crib Point to Hastings, Point Nepean and Sorrento Coastline, the western and northern shores of Western Port, Corner Inlet, Quail and Chinaman islands, Phillip Island's south and west coasts, French Island National Park, and Gippsland Lakes.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- increasing pressure and edge effects on the narrow strip of coastal vegetation
- urbanisation, industrialisation and roads leading to fragmentation and loss of vegetation
- recreational pressures within and adjacent to conservation and coastal crown land reserves
- removal of vegetation, both authorised and illegal, to 'improve' views
- loss of vegetation on private land and increased land use intensity due to rezonings
- land-based pollution
- boat traffic disturbing shoreline vegetation and causing erosion
- illegal off-road vehicle use eroding soil and damaging vegetation.

Dysfunction of biological interactions:

- numerous serious weeds

- cats, foxes and dogs preying on small animals
- feral pigs and goats degrading habitats
- rabbits causing erosion and hampering revegetation
- horses, dogs and walkers disturbing nesting sites for hooded plovers
- livestock trampling vegetation and spreading weeds
- dieback of vegetation in seabird roosting sites.

Changes to disturbance regimes:

- damaging fire regimes
- dune destabilisation due to inappropriate access, ad-hoc tracks and off-track access and horse riding
- increasing salinity of the Gippsland Lakes leading to loss of bank vegetation and erosion.

Recommendations

Expansion of protected areas

- Create a new San Remo-Cape Paterson Coastal Park comprising:
  - Punchbowl Coastal Reserve
  - Kilcunda-Harmers Haven Coastal Reserve
  - Kilcunda Nature Conservation Reserve
  - Bunurong Coastal Reserve
  - Wonthaggi Heathlands Nature Conservation Reserve
  - Cape Paterson Nature Conservation Reserve.

- Create a Safety Beach-Portsea Coastal Reserve:
  - merge the existing foreshore reserves between Safety Beach and Portsea
  - place the reserve under the management of one community committee of management.

Management and regulatory measures

- Merge the committees of management along the following stretches of coast into single management committees:
  - Mt Eliza to Mt Martha
  - Safety Beach to Portsea
  - Flinders to Hastings
  - Cannons Creek to Tooradin
  - Lang Lang to Coronet Bay
  - Seaspray to Loch Sport Gippsland Plain
  - San Remo to Inverloch GP
  - Walkerville to Sandy Point GP
  - Port Franklin to Woodside Beach
  - Gippsland Lakes

- Reconfigure the boundaries of the catchment management authorities and municipalities in the Gippsland Lakes area, by establishing the Gippsland Lakes Catchment Management Authority and the Shire of Gippsland Lakes, both with their boundaries encompassing the catchment of the Gippsland Lakes. The current East Gippsland Shire Council should return to the boundaries of the Shire of Orbost, and the East Gippsland Catchment Management Authority should have the same boundary. The Shire of Wellington would be smaller and abut the western boundary of the Gippsland Lakes shire.

- Transfer the Phillip Island Nature Parks from the Crown Land (Reserves) Act to a new schedule (similar to that recommended by the Victorian Environment Assessment Council in its Yellingbo Investigation) in the National Parks Act, and support continued management by the Phillip Island Nature Parks.

- Abandon the construction of the proposed Rosebud Aquatic Centre on the coastal reserve at Rosebud.

- Reject plans to expand the Port of Hastings.

- Reject any further expansion of Port Anthony.

- Encourage and enable the Shire of Bass Coast to apply an environmental significance overlay on the private land abutting the high water mark between Tooradin and San Remo. The overlay would establish a 100-200 m buffer zone where no development is allowed and where landholders are provided with the necessary resources to rehabilitate the land with indigenous vegetation.

- Fund the Shire of Bass Coast to conduct an environmental audit of the sea walls along the north-eastern shoreline of Western Port to determine the environmental, social and economic costs and benefits of their removal or retention.

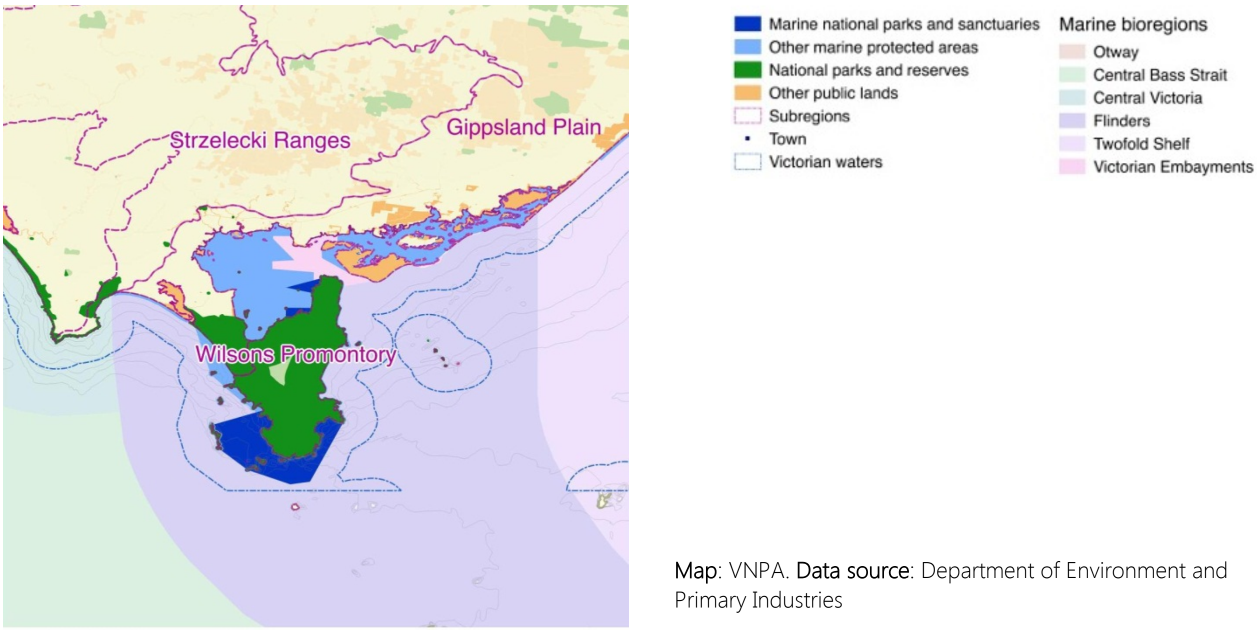
- Fund the Shire of Wellington to conduct an environmental audit of the sea walls along the shorelines of Corner Inlet to determine the environmental, social and economic costs and benefits of their removal or retention.

- Establish an intertidal protected area under the Fisheries Act to protect pipis along sections of the Victorian coast where they are under pressure. Amend the Cape Liptrap Coastal Park management plan to ban pipi harvesting from Venus Bay.

- Use the proposed coastal private land conservation program to support collaborative projects between Parks Victoria, the Shire of Mornington Peninsula and the Mornington Peninsula and Western Port Biosphere Reserve Committee, private landholders and the local community to improve the quality and extent of coast banksia woodland and coastal alkaline scrub (coastal moonah woodland community) across the Mornington Peninsula.

- Establish a collaborative coastal nature stewardship project between the Victorian government, Parks Victoria, the Shire of Wellington, the West Gippsland Catchment Management Authority, the community and private landholders to enhance the natural values of the catchment of Shallow Inlet, and develop wildlife corridors between Shallow Inlet and Walkerville, and from Shallow Inlet to Corner Inlet.

Figure 2.10 Victoria's coastal subregions from Strzelecki Ranges to Wilsons Promontory



Map: VNPA. **Data source**: Department of Environment and Primary Industries

2.5.8 Strzelecki Ranges subregion

This 342,000 hectare region formed at the same time as the Otway Ranges, and has similar geology, topography and vegetation. It meets the coast for a short stretch in South Gippsland (Figure 2.10). Less than a third of native vegetation in the subregion has been retained, with more than half on private land. The Cape Liptrap Coastal Park protects much of the remnant vegetation on public land. Plantation forestry, beef and dairy farming are the main land uses in the hinterland. From Cape Liptrap to Walkerville, the flora and fauna are both of state significance.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- residential development in small rural holdings along the park boundary and at Waratah Bay
- land clearing
- inappropriately sited infrastructure on the primary dune system
- uncontrolled recreation, especially in exposed coastal sites, causing degradation
- unauthorised vehicle and pedestrian access tracks into the coastal park from neighbouring properties

- edge effects in narrow vegetation strips around Cape Liptrap
- degradation from livestock grazing.

Changes to disturbance regimes:

- harmful fire regimes.

Dysfunction of biological interactions

- invasive species.

Recommendations

Expansion of protected areas

- Expand Cape Liptrap Coastal Park:
  - secure adjacent land through the proposed coastal private land conservation program, with priority given to land with remnants of the endangered damp forest ecological vegetation class, and restore this land.
- Create Walkerville-Waratah Bay-Sandy Point Foreshore Reserve:
  - merge the foreshore reserves at Walkerville, Waratah Bay and Sandy Point and place under the management of one community committee of management.

Management measures

- Fund Parks Victoria and adjoining landholders to fence Cape Liptrap Coastal Park to minimise encroachment and impacts of adjoining land use, and to manage invasive plants and animals.

2.5.9 Wilsons Promontory subregion

This 40,000 hectare region is a spectacular area of rocky hills and granite headlands, with 91% retention of native vegetation. It is connected to the mainland by the Yanakie Isthmus (Figure 2.10). The entire bioregion is contained within the Wilsons Promontory National Park, which attracts close to half a million visitors a year. The coastal flora is of national significance, and the fauna is of state significance.

Threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- use of roads and tracks leading to soil compaction and soil erosion
- development proposals for the national park.

Dysfunction of biological interactions:

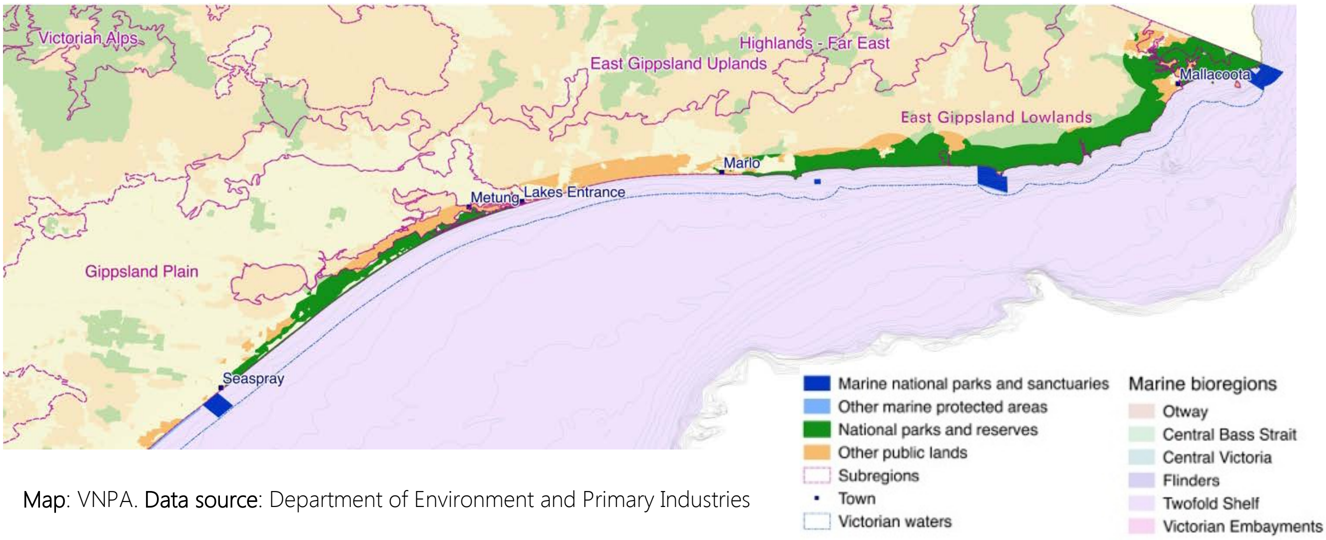
- degradation from native and introduced animals, including rabbits
- weeds, including ragwort, fleabane, sea spurge and thistles
- foxes preying on small animals.

Recommendations

Regulatory measure

- Prohibit any further commercial development within Wilsons Promontory National Park.

Figure 2.11 Victoria's coastal subregions from Gippsland Plain to East Gippsland Lowland



Map: VNPA. Data source: Department of Environment and Primary Industries

2.5.10 East Gippsland Lowlands subregion

This 531,000 hectare subregion of gently undulating terraces, coastal plains, dunefields and inlets extends from Lakes Entrance to the New South Wales border (Figure 2.11). One of the more intact coastal bioregions, it has 62% native vegetation cover, 40% of it on private land. Clearing has mainly occurred on the western edge, due to forestry and farming. Of national significance for both flora and fauna are coastal stretches from Wingan Inlet to Mallacoota, with species-rich and largely undisturbed vegetation, and the dunes from Mallacoota to Cape Howe, which are part of the Nadgee to Mallacoota important bird area.

The threats to coastal nature in this subregion include the following.

Habitat loss and degradation:

- harbour development at Bastion Point, Mallacoota
- increasing intensity of land-uses on coastal land and within catchments
- increasing traffic on coastal walking trails, use of wood for camp fires, and recreational uses in general putting further pressure on sensitive coastal environments
- boating activity degrading shorelines and disturbing breeding seabirds.

Changes to disturbance regimes:

- harmful fire regimes.

Dysfunction of biological interactions:

- serious weeds, including bridal creeper, cape ivy and dolichos pea, and the pathogen *Phytophthora cinnamomi*, especially between Mallacoota and Shipwreck Creek
- dog and fox predation on little terns and hooded plovers
- pigs and goats degrading habitats.

Recommendations

Management and regulatory measures

- Establish a collaborative coastal nature stewardship project between the East Gippsland Catchment Management Authority, Parks Victoria, the Lake Tyers Aboriginal Trust, the community and private landholders in the catchment of Lake Tyers to improve the water and habitat quality of the lake by fencing off lake shorelines and vegetation on private land, managing invasive species, and rehabilitating shoreline and catchment habitats.
- Amend the environmental significance overlay applying to private land abutting the coastal crown land reserve and the shoreline of Lake Tyers in the Shire of East Gippsland to establish a 100 metre buffer zone where development is prohibited and restoration is required. The Victorian government should ensure that private landholders have access to sufficient resources to achieve that rehabilitation.

- Abandon the option 3b Bastion Point harbour development at Mallacoota and initiate a process that establishes a lower cost and sustainable alternative that will have community support. Repair any damage caused by the initial construction works.

2.5.11 Summary – subregional recommendations

Table 2.25 summarises the subregional recommendations for protected areas.

Table 2.25 Summary of proposed new, expanded or upgraded coastal protected areas

New, expanded or upgraded protected area	Areas for inclusion in proposed protected area
Discovery Bay – Three Capes State Park	Discovery Bay Coastal Park
	Cape Nelson State Park
	Cape Nelson Lighthouse Reserve
	Nelson Bay Coastal Reserve
	Point Danger Coastal Reserve
Yambuk Coastal Park	Yambuk Lake
	Yambuk Flora and Fauna Reserve
	Yambuk Wetlands Nature Conservation Reserve
	The Crags Coastal Reserve
	Yambuk Coastal Reserve
Belfast Coastal Park	Belfast Coastal Reserve
	Griffith Island
	Shelly Cove
	Thunder Point Coastal Reserve
Part Campbell – Bay of Islands National Park	Bay of Islands Coastal Park
	Port Campbell National Park
	Port Campbell Rifle Range
	Public Purposes Reserve & Public Park Reserve on Point Campbell Point
	Undeveloped areas of public land between the great Ocean Road & the park within Port Campbell, including allotments 2 & 3, and Loch Ard Public Cemetery
Geelong & Bellarine Wetlands State Park	Lake Connewarre Wildlife Reserve
	Salt Lagoon-St Leonards Wildlife Reserve
	Swan Bay-Edwards Point Wildlife Reserve
	Barwon River estuary
	Sand Island
	Swan Island
	Lonsdale Lakes Wildlife Reserve
	Lakers Cutting
	Southwestern shores of Swan Bay
	Freshwater Lake
	Thompson Creek and Karaaf Wetlands at Breamlea
Port Phillip Wetlands State Park	Limeburners Lagoon (Hovells Creek) Flora and Fauna Reserve
	Avalon Coastal Reserve
	Avalon Saltworks
	Point Lillias
	Point Wilson
	The Spit Wildlife Reserve
	Point Cook Coastal Park & Cheetham Wetlands
	Altona Coastal Park
	Jawbone Flora and Fauna Reserve
North Western Port Coastal Park	North Western Port Nature Conservation Reserve
Reef Island-Bass River Mouth Coastal Park	Reef Island-Bass River Mouth Nature Conservation Reserve
San Remo – Cape Paterson Coastal Park	Punchbowl Coastal Reserve

New, expanded or upgraded protected area	Areas for inclusion in proposed protected area
	Kilcunda-Harmers Haven Coastal Reserve
	Kilcunda Coastal Reserve
	Kilcunda Nature Conservation Reserve
	Bunurong Coastal Reserve
	Wonthaggi Heathlands Nature Conservation Reserve
	Cape Paterson Nature Conservation Reserve
	Bunurong Marine Park
Shallow Inlet Coastal Park	Shallow Inlet Marine and Coastal Park
Corner Inlet – Nooramunga Coastal Park	Corner Inlet Marine and Coastal Park
	Nooramunga Marine and Coastal Park
	Wilsons Promontory Marine Park
	Wilsons Promontory Marine Reserve
	Coastal crown land with conservation value along the margins of Corner Inlet
Gippsland Lakes Coastal Park	Gippsland Lakes Coastal Park
	Lake Coleman Wildlife/Game Reserve
	Lake Coleman West Wildlife/Game Reserve
	Victoria Lagoon Wildlife Reserve
	Clydebank Morass Wildlife/Game Reserve
	Heart Morass Wildlife/Game Reserve
	Dowd Morass Wildlife/Game Reserve
	Blond Bay Wildlife/Game Reserve
	McLeods Wildlife/Game Reserve
	Jones Bay Wildlife/Game Reserve
	Avon River Wildlife/Game Reserve
	Tucker Swamp Gippsland Lakes Reserve
	Poddy Bay Gippsland Lakes Reserve
	The Dardanelles Gippsland Lakes Reserve
	Sale Camping Gippsland Lakes Reserve
	Andrew Bay – Grebe Bay Gippsland Lakes Reserve
	Lake Kakydra Gippsland Lakes Reserve
	Lake Melyandra Gippsland Lakes Reserve
	Clydebank Frontage Gippsland Lakes Reserve
	Avon-Perry River Delta Gippsland Lakes Reserve
	Swell Point – Roseneath Point Gippsland Lakes Reserve
	Salt Lake – Backwater Morass Gippsland Lakes Reserve
	Roseneath Point (1) Gippsland Lakes Reserve
	Roseneath Point (2) Gippsland Lakes Reserve
	Morley Swamp Gippsland Lakes Reserve
	Victoria Lagoon Gippsland Lakes Reserve
	Backwater Morass Gippsland Lakes Reserve
	Steel Bay – Newland Backwater Gippsland Lakes Reserve
	Blond Bay Gippsland Lakes Reserve
	Red Morass Gippsland Lakes Reserve
	Wattle Point Gippsland Lakes Reserve
	Raymond Island Gippsland Lakes Reserve
	Hollands Landing Gippsland Lakes Reserve
	Point Fullarton Gippsland Lakes Reserve
	Eagle Point Gippsland Lakes Reserve
	Mitchell River Silt Jetties Gippsland Lakes Reserve
	Eagle Point Gippsland Lakes Reserve
	Mitchell River Silt Jetties Gippsland Lakes Reserve
	Jones Bay Gippsland Lakes Reserve
	Nicholson Floodplain Gippsland Lakes Reserve
	Slaughterhouse Creek Gippsland Lakes Reserve

New, expanded or upgraded protected area	Areas for inclusion in proposed protected area
	Swan Reach Bay Gippsland Lakes Reserve
	Tambo Delta – Metung Gippsland Lakes Reserve
	Nyerimilang Park Gippsland Lakes Reserve
	Bancroft Bay – Kaimna Gippsland Lakes Reserve
	Flanagan Island Gippsland Lakes Reserve
	Fraser Island Gippsland Lakes Reserve
	Baxter Island Gippsland Lakes Reserve
	Rigby Island Gippsland Lakes Reserve
	All other coastal public land of conservation value along the shores of Lake Wellington, Lake King & Lake Victoria that are not the responsibility of the proposed Gippsland Lakes Coast Committee
	Land bought by Shire of Wellington for the restructure of subdivisions along the Ninety Mile Beach
	Lakes Entrance – Lake Tyers Coastal Reserve
Ewing Morass – Cape Conran Coastal Park	Ewing Morass Wildlife Reserve
	Cape Conran Coastal Park
	Lake Corrigale Wildlife Reserve
	First & Second Island Flora Reserve
	Marlo Coastal Reserve

2.6 Conservation gaps and priorities

2.6.1 Knowledge gaps[136]

A major impediment to marine and coastal conservation in Victoria is a lack of basic information about species and habitats, ecological processes and impacts of human activities (see Box 2.13 for the different types of information required). There is only patchy data about the taxonomy, distribution and conservation status of species and ecological communities, and very little of Victoria's marine environment has been mapped.

Box 2.13 Systematic information required for conservation[137]

- Taxonomy, to understand what species exist and how to identify them.
- Inventory – baseline information about species, communities and habitats, including abundance, distribution and areas of high diversity and endemism.
- Basic biology, including habitat requirements, photosynthesis/feeding, reproduction and behaviour, to understand requirements of life and potential threatening processes.
- Ecology, including processes such as community-environment relationships, production and trophic pathways, as well as habitat formers and shapers, to understand processes of conservation importance and consequences of threats, changes or impacts.
- Environment – physico-chemical environment and impacts of natural and human-induced processes, including levels of natural resource extraction, habitat modification, pollution and pests, to understand existing and potential threats, placed in context with natural variations.
- Monitoring time series, to detect changes for management responses, including for prevention, improvement and rehabilitation.

Major knowledge gaps include the following:[138]

- marine habitat mapping, essential for identifying areas of ecological significance
- taxonomic and distributional information for species below the low tide mark
- information about ecologically important species, including old-age populations, recruitment source communities and keystone species
- ecosystem processes, particularly for subtidal environments, and linkages between catchments, estuaries and coastal waters
- identification of threatened species and ecological communities and an understanding of threatening processes, including the cumulative consequences of coastal developments
- impacts of increased climate variability.

Victoria's 2008 state of the environment report also highlighted the 'lack of suitable data to adequately measure the condition and trends of Victoria's coastal and marine environments', including:[139]

- no recent trend data to track changes in coastal ecological vegetation classes
- uncoordinated and disparate water quality monitoring outside the main estuaries
- limited information about environmental impacts of activities such as tourism
- little information about the condition of marine plants and animals apart from that gathered for maritime industries or in response to activities such as dredging.

Biodiversity mapping: Apart from within marine protected areas, there has been little systematic mapping of habitats. Some sediment infauna and intertidal and subtidal reef habitats have been surveyed but intermediate and deep reefs in particular remain largely unexplored.[140] Systematic mapping of all marine and intertidal habitats is essential for conservation. As a basis for habitat mapping, there needs to be a marine equivalent of the classification system used for terrestrial habitats, which is based on ecological vegetation classes. The Victorian government has been doing statewide mapping of near-shore bathymetry (marine topography), which will facilitate inventory surveys.

Taxonomy: With much of Victoria's marine biodiversity yet to be described (and some yet to be discovered) marine taxonomy requires a considerable boost. At the current level of taxonomic investment, it will take many decades to acquire a comprehensive inventory of Victorian marine species. Victorian waters host an astounding diversity of sponges but fewer than a third of the estimated total have been described, and only a small proportion of sponge collections have been sorted and identified.[141] Recent surveys in Victoria have revealed new seaweeds and echinoderms, and future surveys will undoubtedly find more.[142] There are far too few taxonomists, particularly relative to the high number of endemic species, and a lack of identification guides to assist with ecological surveys and monitoring.[143] Species could be in decline or lost before they are even identified.

Biology and ecology: Victorian marine conservation requires investment in long-term research and monitoring programs. Apart from species exploited for fishing and aquaculture, little is known about the basic biology and ecology of most Victorian marine life, including which populations are unique or rare, which habitats and areas are critical for particular life phases (such as nursery habitats), and their ecophysiological requirements (such as light levels needed for healthy seagrass, kelp and seaweed beds).

Identifying and managing threats requires a much better understanding of ecological processes such as energy and matter (trophic) flows between species, rates of primary and secondary production, nutrient cycling, competitive and predator/prey interactions. Long-term monitoring is essential to detect changes over time and understand threatening processes. Monitoring programs have been limited to a few community types and sentinel stations. The only state-wide monitoring programs are for fished species, seagrass habitats and marine protected area management. Apart from a few beach water quality monitoring programs for human health purposes, Victoria has just three stations to monitor water quality, all in Port Phillip.[144]

The state of knowledge is too rudimentary to be able to predict with certainty the ecological implications of many changes occurring in the marine environment, including recent abalone population declines from viral disease, fisheries management changes, and species shifts with climate change.

Conservation status: Protecting rare or threatened biodiversity is fundamental to conservation but there is too little information about Victoria's marine environment to know which species and ecological communities need extra protection. Apart from mammals, birds, reptiles and syngnathids (seahorses, pipefishes and seadragons), few threatened marine species or communities have been listed. Just 14 marine invertebrates, three fully marine fishes and two marine ecological communities have been formally listed, reflecting the lack of survey effort rather than a realistic conservation status. The process for nominating and assessing threatened marine biodiversity is mostly ad hoc, with just one systematic assessment completed – for molluscs, echinoderms and decapod crustaceans.[145] A program of systematic data collection, with field sampling and taxonomic support, to identify rare and threatened biodiversity, is needed.

Listing is no guarantee of conservation action. Most action statements for marine species do not explicate how recovery will be achieved – only those for the humpback whale and blue whale provide targets and performance assessment of management success – and there are no action statements at all for marine invertebrates, although they were drafted and presented for public comment. Action statements should be prepared or revised for all listed species and communities, to outline measures required for recovery, and fully implemented.

Because comprehensive listings and recovery actions are unlikely to occur in the near-term, the conservation of rare and threatened biodiversity relies in the interim on achieving a sufficiently comprehensive, adequate and representative marine national park estate.

Table 2.25 outlines actions required to address knowledge gaps about Victoria's marine environment, as recommended by Australian Marine Ecology.

A systematic approach through the development of a Marine and Coastal Research Strategy and Action Plan is needed to address knowledge gaps and improve the linkages between research and management priorities. Long-term researching and monitoring programs, including in the national park estate, are needed to establish the extent and state of marine biodiversity. More effective dissemination of information is essential to improve marine and coastal protection, planning and management.

Table 2.26 Actions to address knowledge gaps[146]

Knowledge Gaps	Recommendations
Lack of taxonomic and distributional information for marine species below the low tide mark, including levels of local and regional endemism and rarity.	More and better biodiversity surveys, sampling a wider array of habitats. Standardise methods across projects to provide complimentary data.
Lack of strategic information on marine-dependent species, including the ecological values old-age populations, recruitment source communities and keystone species.	Workshops, review and collation of knowledge about ecosystem processes. Identification of critical knowledge gaps and streamlining of research efforts into an integrated plan for Victoria.
Lack of information on ecosystem linkages and processes, particularly subtidal.	
Most marine habitats not mapped. Lack of consistent approach to community description and mapping.	Hierarchical system of community characterisation based on physical and biological parameters. Initial coarse resolution surveys, then adapted and augmented to finer resolution over time. Complete coverage of fine-resolution bathymetry mapping. Develop predictive models to fill gaps until all areas have been surveyed.
Inadequate listing process for marine threatened species and communities.	More systematic and rapid listing of marine species and, in particular, communities.
Lack of long-term monitoring and time-series information – limited to a few community types and sentinel stations.	Review, standardise and integrate existing programs where possible, with data sharing between organisations. Develop and implement long-term sentinel monitoring across the state.

2.6.2 Marine national park estate

Gaps in the marine national park estate

At the time of their declaration, Victoria's marine reserves were a world-first representative marine network, and were largely based on the best available science outlined in *Marine, Coastal and Estuarine Investigation* by the Environment Conservation Council in 2000.[147] However, accumulating evidence about the biodiversity values of Victorian waters and about the benefits of highly protected marine areas provide strong reason to substantially expand Victoria's marine national park estate.

Many biodiversity values in Victorian waters are poorly or not protected in the existing national park estate. The 2000 assessment by the Environment Conservation Council suffered from a lack of information about many habitats, a situation that has only been partially rectified (section 2.6.1). The gap analysis by Australian Marine Ecology (summarised in section 2.4) found that Victoria's marine national park estate does not meet current government goals based on the accepted CAR (comprehensive, adequate and representative) principles.[148] Limited documentation of objectives, purposes and levels of protection makes it difficult to assess the extent to which Victoria's marine protected areas meet their objectives. There are considerable discrepancies between boundary locations and the stated or presumed conservation objectives of many of the marine national parks. For example, the Ninety Mile Beach Marine National Park does not include low profile reef habitat despite it being of high acknowledged value in that bioregion. The boundaries of most marine sanctuaries are poorly placed or their area is too small to provide adequate protection. Simply adjusting the boundaries of existing reserves will go some way to improving the protected area network, although surveys are needed to fill substantial knowledge gaps about many marine habitats that are poorly protected. Table 2.24 lists the top 20 priorities for additions to the national park estate as assessed by Australian Marine Ecology.

Other marine areas designated by the Victorian government as protected – various marine and coastal parks that existed prior to the 2002 declarations – lack management plans and conservation objectives altogether, and are not protected from exploitation by recreational and commercial fishers. In addition, areas designated as special management zones have not resulted in any increased protection, and there is little security for them, for the designation can be overturned without a parliamentary process.

Targets for marine protection

More than a decade on from the declaration of Victoria's marine national park estate, there is considerably more scientific evidence about the extent of protection needed to sustain marine biodiversity and ecological processes. Many marine ecologists now consider that 30% strict protection (no fishing) of marine habitats is needed (Box 2.14). This is consistent with the level of 'no take' protection in the Great Barrier Reef Marine Park – a systematic rezoning program initiated in 1999 increased strictly protected areas from less than 5% of the park to more than 33% in 2004.

Expanding the national park estate would have two broad conservation benefits – improving the conservation of biodiversity and strengthening resilience so that marine ecosystems are better able to withstand threats. Climate change is increasing the imperative for this insurance role of marine protected areas, which is based on the idea that reducing current pressures will help ecosystems adapt to climate change and be more resilient to threats that cannot be avoided.[149] There are various lines of evidence to support this – experiments showing that intact habitats are more resistant to invasions and observations that organisms in protected areas suffer less from disease, invasive species and trophic cascades (the ecological consequences of predators being added to or removed from communities).[150] The benefits of strictly protected marine protected areas are outlined in Box 2.15.

Expanding the national park and conservation system is also a high priority to protect the coast from developmental pressures and increase its resilience in the face of climate change. This review strongly recommends an investigation by the Victorian Environmental Assessment Council (or similar independent body) to recommend the best ways to achieve a comprehensive, adequate and representative national park and conservation system for marine and coastal ecosystems that will optimise resilience to current and looming threats. Given the extent of threats to these sensitive environments, and consistent with current ecological thinking, the aim should be to protect at least 30% of each habitat type in marine bioregions. Higher levels of protection are needed for the habitat of threatened species and special features, such as Ramsar wetlands. Many such features and options for protection are identified in section 2.4.

Box 2.14 Marine protected area targets, current and recommended

The current international target (endorsed by the Australian government) for marine protected areas is Target 11 of the Aichi Biodiversity Targets adopted at the 2010 Convention on Biological Diversity:

> By 2020, at least ... 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Victoria has not yet achieved this target in the marine environment, either in terms of the percentage area or the requirement for 'ecologically representative and well connected systems'. However, there is a growing realisation by marine ecologists that substantially larger protected area systems are needed for ecologically healthy oceans. The 2003 World Parks Congress recommended that strictly protected areas cover at least 20-30% of each marine habitat by 2012. The following recommendations, which specify protection of a minimum of 30% of each bioregion, were compiled by The Ecology Centre (University of Queensland) as representing the 'broad consensus of the contributed opinions of more than 40 scientists who have an active involvement in the planning and management of marine protected areas in Australia':[151]

- The protected area network should consist of a minimum of 30% of the area of each bioregion.
- Individual conservation features should all be represented in high protection zones at a minimum of 30% as a proportion of their distribution within each bioregion.
- Conservation features reserved in high protection zones should be preferentially of high quality (the most undisturbed state that is available within the bioregion).
- Conservation features known to be significant, threatened or in a degraded state normally require greater proportional representation and specific design consideration, up to 100% reservation, depending on their conservation status in the bioregion.
- Additional representation of conservation features beyond that within high-protection zones can be achieved across other management zones of MPAs within a bioregion.

- Where a physical structure/feature is incorporated into the MPA, the whole feature should be included.

These recommendations have largely been achieved for the Great Barrier Reef Marine Park, with 33% of the park in highly protected no take zones.

The Australian Marine Sciences Association, a professional association of marine scientists with over 1000 members nationally, also recommends higher levels of strict protection.[152]

- No-take protection of 10% 'would slow but not prevent loss of biodiversity', whereas the 33% no-take level in the Great Barrier Marine Park is 'more likely to achieve substantial and sustained biodiversity conservation benefits'.
- 'Rare and vulnerable ecosystems, communities or populations should be provided with greater than 10% protection', and 100% of critically endangered species, ecosystems, or habitat types should be protected in no-take areas.
- Breeding aggregations, migration choke points, and threatened or unique critical habitats should all be carefully considered for inclusion in no-take protected areas.

Box 2.15 The benefits of marine protected areas

Over the last few years, there have been hundreds of peer-reviewed scientific articles confirming the beneficial effects of marine protected areas.

154 marine scientists, 2010[153]

The Australian Marine Sciences Association has identified six main functions for marine protected areas:[154]

- to protect biodiversity and ecosystem functions, including ecological processes
- to assist in maintaining ecosystem services
- to provide scientific benchmarks against which anthropogenic modifications to ecosystems and environments can be monitored and evaluated
- to protect cultural, recreational, spiritual, educational and scientific values
- to protect from disturbance into the future, representative habitats and species for both their intrinsic value and intergenerational equity
- to enhance fisheries production outside reserve boundaries.

Evidence for three main conservation and commercial benefits of highly protected (no-take) marine parks is extensive and growing:[155]

- Well-planned, managed and enforced no take protected areas 'generally harbour denser populations, larger individuals, and higher biomass of previously exploited species'.
- Recovery of exploited predatory and/or herbivorous species often results, over time, in striking differences in the community ecology of protected areas compared to surrounding areas.
- Fisheries benefits can include enhanced larval transport out of reserves, spill-over of adults from reserves, and increased catches adjacent to reserves.

A 2009 meta-analysis of 149 peer-reviewed studies in 124 no-take marine protected areas in 20 countries found they resulted in significant average increases in density, biomass, organism size, and species richness of the communities within reserve boundaries.[156] This applied both to tropical and temperate regions. Organism biomass increased by an average 446% and density by an average of 166% across these studies. The 2012 scientific audit of marine parks in NSW concluded there is 'a very significant body of research' in support of the finding that most marine species (particularly exploited species) increase in size and abundance when fishing ceases.[157] For exploited species this is the case even for 'well-managed' fisheries.

It can take many years for the benefits of protection to peak. Monitoring of marine protected areas in Tasmania found that changes in protected reef communities had steadily manifested over 16 years and were still underway.[158] The reef communities were changed markedly as the effects of fishing – decline of large predators, increased grazing invertebrates, changes in algal communities and other ripples through the food web – were reversed. 'Once fishing ceases, each of these trophic steps adds time lags of many years before the ecosystem can be considered fully recovered.' After 16 years, the biomass of large fishes and rock lobsters had increased by an order of magnitude.

Marine national park management

Parks Victoria could not demonstrate that it is effectively managing [marine protected areas] or that it is being effective or efficient in protecting marine biodiversity within [marine protected areas].

Victorian Auditor General, 2011[159]

In a 2011 audit of the management of marine protected areas, the Victorian auditor general was highly critical of many aspects of management (it wasn't a review of whether the marine protected areas are ecologically effective and achieving their conservation benefits). The audit criticisms included:[160]

- the lack of policy to guide ecosystem-based management of the marine environment
- the lack of, or poor implementation of, management plans for marine protected areas
- the lack of dedicated staff and expertise to protect the marine environment (only six park rangers with marine-specific skills, four of whom had other duties as well)
- an inability to demonstrate effective management of marine protected areas and to account for funds intended for their management
- the lack of integrated planning across agencies with responsibilities for different aspects of management.

Victoria had a management strategy for marine protected areas but it expired in 2010 without having been fully implemented.[161] Noting the interconnectedness of the marine environment, the auditor general also criticised the lack of any detailed planning policy or management strategy for habitats outside marine protected areas.

The Victorian Environmental Assessment Council found that while there had been some improvements in response to the auditor-general's report, the allocation of resources was not consistently aligned with priorities for threat management and that there was more focus on planning than on implementation. The council considered that draft conservation action plans for the marine national parks and sanctuaries could be improved by more scientifically rigorous identification of ecological values and threats, systematic reconciliation against progress with actions in existing management plans and more priority to managing recreational activities in the protected areas. The 2011 recommendations by the Victorian auditor-general should be implemented in full, informed by recommendations by the Victorian Environmental Assessment Council in 2013 (Box 2.16).

Currently, there is a loophole in the National Parks Act that could allow for mining exploration in marine national parks and sanctuaries. The Victorian Environmental Assessment Council has recommended the government consider limiting this 'by providing for the advice of the National Parks Advisory Council to be obtained prior to giving consent to petroleum exploration; and for tabling and disallowance provisions for consents to be similar to those for terrestrial national parks'.[162] Consistent with the cardinal principle of national park management that nature conservation has primacy, the national park estate should be permanently protected from all forms of mining exploration.

Box 2.16 The Victorian auditor general's recommendations in *Environmental Management of Marine Protected Areas* (2011)[163]

1. Parks Victoria should:

- document its marine environmental management programs, including program logic, implementation plans, reporting frameworks and evaluation plans
- implement a system to track time spent by staff on specific activities, particularly on activities related to protecting marine protected areas
- allocate funding dedicated to the management of marine protected areas, to that activity, as intended
- develop a capable and sufficient workforce to discharge its obligations to environmentally manage marine protected areas.

2. The biosecurity standing committee should assign expertise to develop a marine pest biosecurity plan.

3. Parks Victoria should:

- develop park management plans for all marine protected areas with supporting plans that specify actions, targets, performance indicators, accountabilities and time frames for delivery
- develop management reporting that enables the assessment of performance against park management plans
- regularly and routinely review its risk assessments, including prioritisation, for marine protected areas
- as park manager, develop and lead collaboration with other agencies to better inform its planning
- review, for effectiveness, *Victoria's System of Marine National Parks and Marine Sanctuaries: Management Strategy 2003–2010*, to inform the development of a new strategy.

4. The Department of Sustainability and Environment should implement a new services agreement with Parks Victoria that clearly specifies the responsibilities of both agencies, performance standards and indicators, funding levels and reporting requirements.

2.6.3 Coastal national park and conservation system

Expanding the national park and conservation system should be a high priority to better protect Victoria's coast from developmental pressures and foster resilience and adaptation to climate change. As noted above, this review strongly recommends an investigation by the Victorian Environmental Assessment Council (or similar independent body) to recommend the best ways to achieve comprehensive, adequate and representative protection of coastal and marine ecosystems.

The aim should be to securely protect 100% of remnant coastal vegetation. This is important because it has unique and exceptionally high environmental, social and economic values (the latter due to tourism and ecosystem services) that are under extreme pressures. The coastal zone is the land's first line of defence, forming a critical buffer against winds, storms and seawater, forces that will increase with climate change. About two-thirds of the coast (within 500 metres of the shoreline) has remnant vegetation, and about 57% of it is in the national park and conservation system (Table 2.6). An additional 27% is in some form of other reserve (eg a coastal reserve), which may not be secure or well managed (Table 2.9). This leaves about 16% (less than 12,000 hectares) not in some form of conservation tenure, most of which is public land.

Secure protection can be achieved for much of the remaining remnant coastal vegetation by upgrading the level of protection for crown land reserves, by acquiring or leasing private land for the national park and conservation system, and by protecting private land through perpetual covenants. Section 2.5 has identified coastal areas of high conservation value that warrant protection within the national park and conservation system.

About 42,000 hectares (37%) of coastal land are privately owned. This review recommends the establishment of a coastal private land conservation program to secure the future of high priority remnant vegetation. It would fund acquisitions or leases of private land with a focus on properties near reserves or abutting the high water mark. Initial priorities should be private land inliers and land next to coastal conservation reserves. A public acquisition overlay should be applied to protect high priority private land from development and give the government first option to buy when properties are offered for sale.

In addition to the specific additions to the national park and conservation system recommended in section 2.5, coastal public lands should be more securely protected for conservation and other public purposes by applying more appropriate tenure and zoning arrangements for reserves currently managed under the Crown Land (Reserves) Act. To better recognise the values of coastal nature conservation reserves and integrate their management within the national park and conservation system, they should be transferred from the Crown Land (Reserves) Act into a new schedule of the National Parks Act (see section 3.5.1). For other coastal crown land reserves, changes to the state planning policy framework are needed to strengthen protection for conservation and public purposes. Currently, the most common planning zones applied to coastal crown land are Public Conservation and Resource Zone (PCRZ) and Public Park and Recreation Zone (PPRZ). The PCRZ is usually applied to national parks, coastal parks, conservation reserves and less developed coastal sections, and the PPRZ is generally applied to recreation and settlement nodes. The zones prohibit some activities but allow others under permit (eg renewable energy facilities and emergency service facilities) and others without a permit (eg boat launching facilities, camping and caravan parks, car parks). The two elements of the PCRZ, conservation and resource use, are in conflict. This should be addressed by splitting them into separate zones. Conservation reserves should be excluded from the application of statutory planning zones but the new zones should be applied to coastal reserves (consistent with the 1978 recommendations of the Land Conservation Council), with the Victorian Coastal Council determining the location of the zones. When coastal reserves were recommended by the Land Conservation Council and the Environment Conservation Council, the intention was to provide permanent protection for coastal crown land located between coastal conservation reserves for the purposes of public recreation, education and inspiration. Another recommended tenure change is to incorporate lighthouse reserves within adjoining national or state parks.

Improved tenure arrangements for coastal lands need to be supplemented by more effective management. Because coastal conservation reserves are mostly small and narrow, they are highly vulnerable to edge effects of weed and feral animal invasion, bushfire, livestock intrusion and impacts of adjacent land uses. Effective management planning and implementation are essential for specifying management actions and informing the community about the values at stake.

All protected areas should have management plans and, as noted, coastal protected areas have particularly challenging management issues arising from edge effects and high visitation pressures. Each national, state and coastal park has a management plan but most are more than a decade old and need reviewing.[164] Most coastal reserves and nature conservation reserves lack management plans (the exception being where they are included in plans for other protected areas). This is despite the Crown Land (Reserves) Act requiring a management plan for each nature conservation reserve.

The agencies jointly responsible for park planning – Parks Victoria and the Department of Environment and Primary Industries – are taking a new approach to planning by developing a series of landscape-wide management plans to encompass multiple protected areas. While this approach is sensible in theory, it has mostly been poorly implemented (see section 3.5.1), and there is a risk that the prime objective of protected areas to protect natural and cultural heritage will be compromised by the elevation of tourism and economic goals as major drivers of day-to-day management.

The Victorian government has passed legislation to allow developers to hold leases for up to 99 years in national parks, and has invited applications for developments in two-thirds of Victoria's national park estate. Several iconic national parks on the coast are likely to be impacted: Port Campbell, Great Otway, Point Nepean and Wilsons Promontory national parks. Problems with the state government's push for commercial tourism developments, discussed in chapter 3, include that they are likely to undermine the primary aim of park management of protecting natural values, diverting focus and resources from conservation. History shows that they tend to expand over time, and that developers, rather than most visitors and protected areas, are the beneficiaries

2.6.4 Bays, inlets and estuaries

Although greatly appreciated by the community for their natural, aesthetic and recreational values, many of Victoria's bays, inlets and estuaries also host industries and settlements that threaten those values, and they are sensitive to polluting and degrading activities in their catchments both near and far upstream. Sea level rise and other aspects of climate change will bring many more pressures. A special conservation focus on bays and inlets is warranted because both values and threats are high. Currently, divided agency responsibilities and a lack of strategic direction and formal protection are undermining Victoria's capacity to effectively manage these areas.

An independent authority is needed to oversee the health of Victoria's two largest bays – Port Phillip Bay and Western Port – and their catchments (amalgamating the catchment management functions of Melbourne Water, Central Coastal Board and the Port Phillip Westernport Catchment Management Authority).

Other measures to foster more effective management of bays and inlets are five-yearly reports on their environmental condition, and clear improvement targets for water quality, ecosystem health and social values (recreation and open space). To assess progress, monitoring programs are needed to establish both baseline condition and chart changes over time. A 2008 analysis of Victoria's estuaries concluded there was a lack of data on water quality and biota, estuarine condition, the number and size of estuaries, how they function and the threats they face.[165] The 2013 state of the environment report also noted there 'remains little data available on the ecological condition of estuaries'.[166]

New planning measures are needed to ensure that future developments and land use changes are compatible with achieving improvement targets for bays and inlets. One vital instrument is a state environment protection policy for estuaries to provide clear statutory objectives and controls to protect estuaries.

Protecting shorebirds

Few birds inspire birdwatchers more than the shorebirds: a diverse group of elegant, active, predominantly wetland dwelling species which carry out some of the most amazing migrations in the natural world.

Julie Oldland & others, 2009[167]

As reflected in the listed values of five coastal Ramsar wetlands and the many sites designated as 'important bird areas', coastal Victoria has immensely important habitats for shorebirds (also known as waders). At least half of the 20 important bird areas support more than 1% of the world populations of certain migratory shorebirds (eg red-necked stints and sharp-tailed sandpipers) which travel up to 25,000 kilometres a year between Victorian shores and breeding grounds in the high Arctic.[168] Many are also important for resident shorebirds like hooded plovers.

All over the world shorebirds are declining, mainly due to loss of habitat. In coastal Victoria, they are under pressure from this, and also from human recreation, and predation by cats, foxes and black rats. Disturbance from human recreation (walking, dogs, horse-riding) can reduce the birds' feeding and resting time, and undermine their ability to put on enough weight to migrate. Proposed developments such as port expansions are likely to cost shorebirds even more habitat.[169]

A substantial proportion of the eastern subspecies of hooded plovers, endemic to southeastern Australia and assessed as threatened in the recent action plan for Australian birds, occur on Victorian beaches.[170] Victorian populations declined by about one-third between 1980 and 2008 (from 600 to 400 individuals) due to threats such as coastal development, disturbance and egg and chick trampling by humans, dogs and illegal vehicles, predation, and weeds.[171] There has been considerable work in Victoria by BirdLife Australia to monitor populations and raise public awareness about safe recreation.

This review recommends the development of a shorebird protection strategy to promote measures to address the major threats to shorebirds.

2.6.5 Marine and coastal management

It is necessary to build the full consideration of ecological processes into legislative and institutional frameworks, policy and planning processes, and on-ground management of Victoria's marine and coastal environment. This requires a network approach rather than exclusive management of the marine environment as a series of isolated protected areas.

Australian Marine Ecology, 2010[172]

Marine management is plagued by shortcomings arising from a predominant focus on single sectors and single species. The complex interconnectedness of marine environments requires a holistic focus on ecosystems and ecological processes (see Table 2.25 for the differences), including for sustainable exploitation of commercial species: 'A single commercially valuable fish species, for example, may depend on a range of widely separated habitats over its life, depending on whether it is young or adult, feeding, spawning, or migrating. It needs access to each habitat at the right time, as well as ample food, clean water, and shelter.'[173]

Australia's Oceans Policy outlines the aims of ecosystem-based management as being to maintain:

- ecological processes in all ocean areas, including, for example, water and nutrient flows, community structures and food webs, and ecosystem links
- marine biological diversity, including the capacity for evolutionary change
- viable populations of all native marine species in functioning biological communities.

In essence, it requires maintaining (or restoring) environmental 'structure, function and composition' in a holistic network approach rather than a piecemeal focus on protected areas.[174]

Table 2.27 Contrasting single-issue focused management with ecosystem-based management[175]

Single issue focus	Ecosystem-based management
Manage individual species	Manage entire ecosystems
Manage single sectors (eg fisheries)	Integrate management of all sectors affecting the ecosystem
Focus management at a local scale	Coordinate management at all levels relevant to the ecosystem
Take a short-term perspective: what do we need from the ecosystem this year?	Take a long term perspective: what will the ecosystem be like in 20 years?

Although governments have accepted that an ecosystem approach is essential, there are few examples of implementation. Ecosystem-based management is challenging due to incompatible goals of different stakeholders and 'perceptions that it is too complicated and has prohibitive information requirements'.[176]

Australian Marine Ecology emphasised the importance of placing 'absolute limits' (setting thresholds) on changes to important ecosystem components or processes.[177] One example is protection of marine benthic vegetation in Western Australia, where limits are placed on the cumulative loss of marine plant habitats.[178] Thresholds range from none in highly impacted areas to 1% in highly protected areas and 10% in development areas. Examples of ecosystem components or processes that could be protected with this approach include primary carbon production rates (linked to light availability), denitrification (removal of nitrogen) efficiencies in sediments, and abundance of functional species (such a predators).

One of the main goals of ecosystem-based management is to build ecological resilience – to sustain or restore the capacity of ecosystems to 'resist, buffer or recover from changes caused by increased environmental pressures, at lower disturbance levels'.[179] This is vital in the face of climate change.

Building resilience can require multiple approaches:

- restore ecosystem components or processes, such as large predators (most Victorian reefs are missing large predators)
- provide a buffer above minimum sustainable limits of exploitation
- reduce controllable perturbations to increase capacity for response to uncontrollable or unforeseen disturbances
- maintain redundancy of functional components or species and areas (such that multiple species are present to fulfil ecological roles and there are multiple sources of recruitment)
- have a representative and comprehensive system of highly protected marine areas, including areas with minimal human disturbance to maximise the potential for rebuilding fully functional systems and areas that act as biogeographical buffers.

Coastal protection and restoration

Where land, sea and air merge is naturally a place of high energy and natural dynamism. Victoria's coast is also the interface between multiple, often conflicting human agendas – for recreation, industry, habitation and conservation – which greatly accelerate the scale and rapidity of change.

With climate change already impacting coastal nature and much more change seemingly inevitable, 'resilience' and climate 'adaptation' need to become much more than buzzwords. Easing existing pressures on coastal habitats (due to development, invasive species, bushfires among others) and restoring natural habitats are the most effective ways of fostering the capacity of coastal nature to absorb or adapt to climatically induced changes. As a starting point, objectives to foster resilience and adaptation should be included in Victorian planning provisions and the state planning framework, complemented by changes to coastal statutory zoning and overlays to provide for in situ protection of coastal nature for as long as possible and assist inland retreat as sea levels rise. Planning is needed to identify how coastal settlements and biodiversity will be accommodated as sea level rises and the priority areas that should be protected to permit species movement

With developmental and other threats to coastal habitats mounting, stewardship programs (such as BushBroker and CoastalTender) to support landholders to protect and restore remnant vegetation on private land should be expanded. Protection and restoration of native vegetation is fundamental to coastal health. A new vegetation restoration overlay in the Victorian planning provisions is recommended to protect a 100-200 metre buffer around vegetated coastal public lands, including estuaries and wetlands, within which development is prohibited and management of invasive species and other threats is required. Any changes in land use zones for the coast should be referred by the planning minister to the environment minister (the Planning and Environment Act will need to be amended to require this).

Because they are so attractive to people, coastal habitats are being burdened by an accumulation of infrastructure – roads, tracks, car parks, buildings and utilities – that compromise natural, scenic and recreational values. Much of this infrastructure is unnecessary or could be sited elsewhere. An independent review of infrastructure adjacent to the coastal national park and conservation system should be commissioned with the aim of relocating, removing or better managing it to minimise impacts on natural values. Commercial tourism developments in national, state and coastal parks should be prohibited, and any construction or upgrade of boat ramps, and the impacts of fishing enabled by such development, should be rigorously assessed.

In addition to compromising coastal values, much infrastructure on the coast is at risk from eventual inundation under climate change. An initial assessment by the Australian government (in 2009) predicted that by 2100, under a scenario of a 1.1 metre rise in sea level with a 1-in-100 storm tide, from 27,600 to 44,600 residential buildings in Victoria would be at risk of inundation.[180] Much other infrastructure (commercial buildings, roads, sea walls, bridges, groynes, power lines water and sewer mains, septic tanks, gas pipelines, stormwater drains, jetties) would also be at risk. It makes economic, social and environmental sense to ensure that coastal infrastructure is assessed, designed, constructed and maintained taking future climate change into account, as is consistent with the principles of ecologically sustainable development. Priority areas for defence (eg by sea walls) and retreat will have to be identified, and the issue of coastal dependency (which infrastructure is reliant on a coastal location) will have to be addressed. It would be wasteful of public resources and unnecessarily environmentally damaging to build defensive structures for infrastructure that need not be located on the coast.[181] A coastal infrastructure unit (modelled on the Victorian Ports and Harbours Division of some years ago) should be established to assess and manage boating infrastructure, coastal defensive works, artificial reefs and the planned retreat of coastal infrastructure for all coastal locations except for the major ports (Portland, Geelong, Melbourne and Hastings).

Boating infrastructure

Victoria has extensive boating infrastructure but there is pressure to build even more access points and upgrade existing facilities. In boating coastal action plans, the environmental impacts of such infrastructure have been considered in terms of site impacts and the effect on coastal currents and sand movement but no consideration has been given to environmental impacts of the activities (boating and fishing) facilitated by new infrastructure. Limits on boating infrastructure should be set based on an assessment of the boat 'carrying capacity' of Victoria's estuaries.

Managing oil spills

Oil spills can have catastrophic impacts on wildlife and marine and coastal habitats. Planning and management systems are needed to minimise the risk of spills – prevention should be the first goal – and to maintain response preparedness. Planning should be shaped by risk assessment of current and projected shipping traffic from each Victorian port and high priority given to protecting the national park estate (Parks Victoria has emergency response plans for parks and reserves that include oil spills).[182] Decisions about port expansions such as at the Port of Hastings should take into account the heightened risk of oil spills.

Managing invasive species

Current approaches to invasive species tend to be the opposite of ecosystem-based management – more reactive than proactive, mostly focused on just a few harmful species, and prioritising short-term commercial benefit from use of invasive species over long-term ecological health. The well-accepted prevention-first hierarchy has not been comprehensively implemented – exotic plants, in particular, are generally permitted into Victoria without the most basic precaution of assessing their invasion risks. For some widespread invasive species, control to protect particular habitats or species may be all that is feasible. But ecosystem-based management requires a broader focus, including management or restoration to bolster resilience to invasive species impacts (eg. by restoring predators or reducing nutrient enrichment) and integration with management of interacting threats – such as harmful fire and water flow regimes, over-fishing, and disturbance. There also needs to be a strong focus on preventing new invasions by requiring risk assessment of all introductions and responding quickly to new incursions.

In a 2011 audit of marine protected area management, the auditor general found that the then Department of Sustainability and Environment was ill-prepared to respond to new incursions of invasive marine species. Deficiencies included a lack of detailed planning to assign roles and responsibilities to prepare for, detect and respond to incursions, poor integration between departments, and a lack of resources. There was no marine pest monitoring system (no systematic or routine monitoring occurs in any Victorian port). The auditor general recommended that the cross-agency biosecurity standing committee develop a marine pest biosecurity plan. This is essential, and it should have a strong prevention focus.

2.6.6 Governance structures and processes

Ecosystem-based management – in contrast to species-based, industry-based or site-based management –has not been incorporated into state laws and institutions. Victoria's governance structures and processes are too disparate and unfocused to achieve the state's goals for marine and coastal management. Recommendations specific to the coast and seas include new legislation to implement ecosystem-based management and ecologically sustainable development (a Marine and Coastal Planning and Management Act) and a marine and coastal strategy to provide an over-arching framework. The specific measures and targets for each region would be set out in regional marine and coastal plans, encompassing the current multiple action plans for coasts, estuaries and boating, and including strategies to prepare for climate change.

To provide the necessary oversight and integration, an independent authority – a proposed Victorian Marine and Coastal Authority – should be established to absorb and expand on the functions of the existing Victorian Coastal Council, with regional marine and coastal boards to replace the existing coastal boards. Integration with catchment management would be facilitated by aligning the boundaries of coastal regions with those for catchment management authorities (splitting the three coastal regions into five regions) and by establishing close links between the relevant policies and plans.

2.6.7 Commercial and recreational fishing

Ecosystem-based management

Victoria's Fisheries Act includes the following objective relevant to ecosystem-based management: 'to protect and conserve fisheries resources, habitats and ecosystems including the maintenance of aquatic ecological processes and genetic diversity'. Although a requirement for ecosystem-based management is recognised in some Victorian fisheries (such as for southern rock lobster, giant crab and abalone) there has been no rigorous evaluation of their ecosystem effects and knowledge of ecosystem processes on which to base evaluations is largely lacking.[183] Criteria to assess the ecological sustainability of all fisheries, whether commercial or recreational, and site-specific ecological risk assessments are needed. The introduction of ecosystem-based limits – such as the abundance of particular functional species in fished ecosystems – is 'a partial solution' to the difficulties of insufficient ecosystem knowledge,[184] and a precautionary approach where information is lacking is essential.

One of the goals of ecosystem-based management is to maintain or build resilience (discussed above). This will require reducing fishing pressure on some targeted populations, which are maintained at very low proportions of virgin biomass, to buffer communities against other disturbances. For example, maintaining healthy populations of large adult rock lobsters can help prevent the destruction of giant kelp marine forests by long-spined sea urchins, as demonstrated in Tasmanian marine protected areas.[185] Rock lobsters are efficient sea urchin predators but are currently fished down to low densities.

Ecosystem-based management also requires better protection of habitats critical to targeted species (such as fish nurseries and important feeding grounds) and whole-of-catchment programs to improve water quality and protect coastal habitats.

Recreational fishing

While commercial fishing pressure in Victoria has declined or stayed stable, recreational fishing has surged in popularity. For several species the recreational catch is similar to or exceeds the commercial catch and pressures on some species and ecosystems are substantial (Table 2.17). Participation rates, where fishing occurs and total catches of target and non-target species are basic information required to manage recreational fishing but there is no program to collect such data. The most recent survey was about eight years ago and focused only on the catch of snapper in Port Phillip Bay and Western Port.[186] It should be a high priority to assess recreational fishing catch and impacts by a range of methods, including regular large-scale surveys of participation and catch, licencing all recreational fishers with endorsements for particular coastal regions, expanding the angler diary program, monitoring the main targeted species and conducting annual trawl surveys of Port Phillip Bay. Recreational fishers typically catch a wide range of species and discard most, retaining a few favoured species. The impacts of this on discarded species could be substantial, particularly for rare or declining species (such as grey nurse sharks), and need to be investigated.

Enforcement

With about 570,000 participants in recreational fishing, enforcement is difficult – 'governments experienced in managing commercial fisheries are finding unique challenges in the recreational sector and experiencing the failure of traditional monitoring, evaluation and enforcement methods'.[187] Enforcement is also hamstrung by the typical problems of too few resources and low priority (for there is little 'political reward' in rigorous enforcement of this sector).[188] Parks Victoria is accountable for compliance in the national park estate but mostly relies on Fisheries Victoria for implementation. This has resulted in a blurring of accountability, and there is widespread concern that the values of marine protected areas are being compromised by poaching.[189] Education, surveillance and rigorous enforcement are needed to better protect marine national parks and sanctuaries from illegal take. The Victorian Environmental Assessment Council has recommended a review of cross-agency coordination to clarify roles and accountabilities, sufficient funding and education and interpretation programs.[190]

Indirect fishing impacts

There is need for 'a better-defined and more collaborative system of identifying and addressing' fishing-related impacts that are of high or moderate risk such as bird and mammal entanglements with lost fishing gear, death or injury of marine animals due to boat strikes, the spread of invasive species and fish 'stock enhancement'. Risks can be reduced by measures that include phasing in the use of biodegradable hooks and fishing lines, requiring all stock enhancement proposals to be subject to risk assessment and public environmental impact assessment and prohibiting the transport of live invasive species (such as European green shore crabs) as bait.

Licence sales

Several million dollars ($5.9 million in 2010-11) are collected annually from sales of recreational fishing licences. A small proportion is spent on habitat management, about one-quarter is spent on compliance, and most of it goes to promote recreational fishing opportunities, including stocking invasive fish species. A much more substantial proportion should go to habitat management.

2.7 Future directions

Australia's southern seas are a natural treasure trove, with dazzling diversity and uniqueness unmatched globally for seaweeds, sea mosses and several other groups. The level of endemicity in many groups is close to 90%. But Victoria's marine habitats are under-studied, under-appreciated and under-protected, for the land lubber bias applies in Victoria as elsewhere. Little more than 5% of state waters are protected in the national park estate.

As the interface between land and sea, where many different landforms and oceanic influences meet, Victoria's coast is naturally a dynamic and diverse environment. As the most popular zone for living and recreating, Victoria's coast is certainly appreciated but is under much pressure from development, harmful catchment changes and invasive species.

Marine and coastal habitats are among the most vulnerable to climate change. Strengthening protection is essential not only to protect biodiversity from multiple existing current threats but to foster their resilience and adaptation to future changes.

Knowledge of biodiversity and ecology is essential for management of any environment but is particularly lacking for Victoria's marine habitats. Even for the national park estate, one of the serious threats highlighted in government assessments is 'limited ecological knowledge of important processes'.[191] Knowledge gaps need to be addressed systematically with long-term research and monitoring and detailed mapping of ecological communities.

It is more than a decade since a network of highly protected areas was established in 5.3% of Victorian waters. A gap analysis (summarised in section 2.4) shows they are inadequate to protect the values they were established for and to achieve a comprehensive, adequate and representative network. The past decade has also brought compelling evidence that a substantially larger network is needed to protect biodiversity and ecological processes and to foster ecosystem resilience.

Although more than a third of the coast (to 500 metres inland) is in the national park and conservation system, many endangered coastal vegetation communities are scantly protected and coastal habitats are at great risk from development and poor management. Bioregional priorities for increased protection have been identified in section 2.5, which can be achieved by upgrading protection for public lands and buying, leasing or covenanting private land.

As a high priority, Victoria needs a comprehensive independent inquiry into marine and coastal biodiversity to recommend new areas for protection based on targets that will foster resilience to climate change and multiple other threats.

With very high values and threats, Victoria's bays, inlets and estuaries warrant a special conservation focus – an independent authority to manage the two largest, the internationally significant Port Phillip Bay and Western Port, and a program with clear measurable improvement targets, monitoring and public reporting.

The complex interconnectedness of marine and coastal environments requires a holistic management focus on ecosystems. But current governance arrangements, laws and policies lack integration and perpetuate sector-, site- or species-focused management. An essential basis for ecosystem-based management is a new overarching legal and policy framework and a marine and coastal authority with the mandate to achieve this outcome.

To restore ecological health to many marine and coastal habitats will also require better management of fisheries, invasive species, coastal vegetation and water quality.

Following is a summary of reforms recommended as high priorities over the next decade to make substantial progress on the protection and restoration of Victoria's marine and coastal ecosystems.

Research and information sharing

M1 Prepare and implement a marine and coastal research strategy and action plan, and establish a website to provide public access to all information relevant to marine and coastal protection, planning and management.

M2 Establish a long-term scientific research and monitoring program for marine national parks and sanctuaries and other coastal and marine environments, which includes:

- completion of a systematic biodiversity assessment program across Victorian waters to map all marine and intertidal habitats at a fine scale
- a state-wide 1:10,000 scale map showing predominant community types for reef and sediment areas and locations for seagrass beds, produced within two years.

M3 Establish a marine and coastal research and information service to address high priority knowledge gaps, promote the value of research, and function as a clearing house for information and advice.

National park and conservation system

M4 Commission the Victorian Environmental Assessment Council (or other independent credible body) to conduct an inquiry into biodiversity across all Victorian marine and coastal ecosystems with the purpose of recommending new targets and new protected areas to achieve a comprehensive, adequate and representative national park and conservation system and to foster resilience to climate change. The latest science and expert opinions, taking into account the threats to Victorian ecosystems, suggest the following targets are warranted:

- protection for at least 30% of each habitat type in each marine bioregion
- protection of 100% of remnant coastal vegetation
- protection of additional areas that will assist in protecting biodiversity from the future impacts of climate change
- greater levels of protection for the habitat of threatened species and special features, including Ramsar wetlands and sites identified in the nature conservation review gap analyses (in sections 2.4 and 2.5)
- configuration to provide connectivity and secure movement pathways.

M5 Implement all outstanding recommendations from the 2011 inquiry by the Victorian auditor general into the environmental management of marine protected areas.

M6 Prohibit mining exploration in the marine national park estate.

M7 Establish a coastal private land conservation program with a fund to buy, lease or covenant private land abutting coastal conservation reserves, coastal crown land reserves or the high water mark for restoration and inclusion in reserves or, in the case of leases and covenants, to be managed consistently with such reserves.

M8 Strengthen protection of coastal crown land reserves for conservation and public purposes by:

- developing regulations and coastal management plans specific to their purpose
- applying a zoning scheme to coastal reserves consistent with the recommendations of the Land Conservation Council (1978), with the location of the zones to be identified by the Victorian Coastal Council through a project similar to the Coastal Spaces Initiative
- progressively removing from coastal reserves infrastructure that is not dependent on a coastal location, and restoring the land with indigenous vegetation.

M9 Improve protection for lighthouse reserves by incorporating them within adjoining national or state parks.

Iconic bays and inlets

M10 Establish a Two Bays Board for strategic oversight of the health of Port Phillip and Western Port and their catchments. The board should be an independent authority and amalgamate the catchment management functions of Melbourne Water, Central Coastal Board and the Port Phillip Westernport Catchment Management Authority.

M11 Produce standalone 5-yearly *State of the Bays* reports covering the four main bays and inlets (Port Phillip, Western Port, Corner Inlet and Gippsland Lakes) and the smaller bays. The first report should include a detailed condition study, comprehensively review all pressures and describe existing and planned responses.

M12 Develop improvement targets for bays and inlets with water quality, ecosystem health and open space and recreation criteria that are easy to measure and include some highly visible outcomes (for example the return of whales and other flagship species to the bays and the recovery of threatened terrestrial fauna). Link the improvement targets to statutory planning instruments and controls on future development through local environmental improvement plans or similar instruments.

M13 Set up a scientific monitoring program to assess and publicly report every two years on progress made towards meeting the bays and inlets improvement targets.

M14 Establish an ongoing educational program to build awareness of and support for conservation measures proposed for the iconic bays and inlets.

M15 Prepare and implement a state environment protection policy for estuaries.

M16 Determine the boat carrying capacity of Port Phillip Bay, Western Port and other bays and estuaries in Victoria, and set limits on boat numbers consistent with carrying capacity.

M17 Develop a shorebird protection strategy.

Marine and coastal management

Legislation and institutions

M18 Develop a Victorian Marine and Coastal Planning and Management Act with objectives and strategies to implement ecosystem-based and ecologically sustainable management of all marine and coastal waters.

M19 Establish a Victorian Marine and Coastal Authority (absorbing and expanding the functions of the existing Victorian Coastal Council) and regional marine and coastal boards (replacing the existing coastal boards).

M20 Mandate processes that guarantee transparency and community participation in marine and coastal planning and decision-making.

M21 Require that all coastal catchment management authorities have at least one-third of their board members with coastal or marine expertise.

M22 Merge the many small committees of management along the following sections of coast into combined community committees of management:

- Narrawong to Port Fairy
- Breamlea to Clifton Springs (Barwon Coast and Bellarine Bayside committees)
- Mt Eliza to Mt Martha
- Safety Beach to Portsea
- Flinders to Hastings
- Cannons Creek to Tooradin
- Lang Lang to Coronet Bay
- Seaspray to Loch Sport
- San Remo to Inverloch
- Walkerville to Sandy Point
- Port Franklin to Woodside Beach
- Gippsland Lakes.

Strategies and plans

M23 Develop a Victorian marine and coastal strategy, coordinated by the proposed Victorian Marine and Coastal Authority, to provide an over-arching framework for ecologically sustainable, ecosystem-based management of all human uses and impacts affecting Victoria's oceans and coast. This strategy should take precedence over and inform regional catchment strategies and local planning policies for coastal areas.

M24 In the longer-term, seek inter-governmental agreement for an over-arching national framework consisting of an Australian Oceans Act and National Oceans Commission established through a joint agreement between the federal government and state and territory governments. The commission would develop and coordinate a strong regional plan for Victorian oceans that incorporates the Victorian marine and coastal strategy.

M25 Prepare and implement regional marine and coastal plans (which encompass the current multiple coastal action, estuary and boating action plans). Include strategies to prepare for the impacts of climate change on coastal and marine ecosystems by identifying areas at risk and measures to limit damage and promote adaptation.

M26 Better integrate marine, coastal and catchment management by aligning the boundaries of coastal regions with those for catchment management authorities (splitting the three coastal regions into five regions) and by establishing close links between policies and plans for marine, coastal and terrestrial environments.

M27 Develop ecosystem-based management plans for marine and coastal invasive species threats, including a strong focus on prevention and rapid responses to new incursions, and integration with management of other processes and threats (fire, nutrient enrichment, fishing, disturbance, hydrology included).

M28 Ensure that protection of the environment and the marine and coastal national park estate are high priorities in oil spill prevention and response plans.

Coastal protection and restoration

Stewardship programs

M29 Expand and strengthen the BushBroker, CoastalTender and saltmarsh protection projects, with an emphasis on protection and restoration of vegetation on private land abutting the high water mark and coastal conservation and crown land reserves.

Coastal infrastructure

M30 Commission an independent review of infrastructure (including access tracks, car parks, roads, buildings and utilities) within and adjacent to the coastal national park estate and crown land reserves with the aim of relocating or removing infrastructure or better managing it to minimise impacts on natural values.

M31 Amend the National Parks Act to rule out 99 year leases that allow commercial tourism development within national, state and coastal parks along the Victorian coast.

M32 Establish a coastal infrastructure unit with an objective of ensuring that coastal infrastructure is assessed, designed, constructed and maintained within the principles of ecologically sustainable development and ecosystem-based management. The unit would carry out works, assess and manage boating infrastructure, coastal defensive/protection works, artificial reefs and the planned retreat of coastal infrastructure for all coastal locations except for the major ports of Portland, Geelong, Melbourne and Hastings.

M33 Require rigorous environmental impact assessments of proposed development or upgrade of boat ramps, including the impacts of any recreational fishing enabled by the infrastructure.

Climate change adaptation

M34 Foster the capacity of coastal nature to adapt to sea level rise and other impacts of climate change by:

- mapping current settlements, priority areas for coastal nature protection and enhancement, and predicted sea level rises
- identifying where coastal settlements and nature can move to as a result of sea level rise
- reviewing the zoning and conservation status of all identified priority areas for coastal nature protection and enhancement to determine whether they will adequately protect coastal nature.

M35 Include in the Victorian planning provisions and the state planning framework an objective to protect coastal nature to help adaptation and retreat in response to sea level rise and other climate change impacts. Amend coastal statutory zoning and overlays to aim for in situ protection of coastal nature for as long as possible and assist inland retreat as sea levels rise.

Vegetation

M36 Introduce a vegetation restoration overlay to the Victorian planning provisions, to protect a 100-200 metre buffer around vegetated coastal public land, including estuaries and wetlands. Within that buffer:

- prohibit development
- require management of harmful invasive species and encourage vegetation maintenance and restoration
- identify and progressively remove infrastructure at risk of erosion and inundation from sea level rises (rather than build defensive structures)
- encourage fencing of buffers and boundaries between private and public land to encourage vegetation restoration.

M37 Amend the Planning and Environment Act to require the planning minister to refer any changes in land use zones for coastal lands to the environment minister.

Fishing

M38 Implement ecosystem-based management of commercial and recreational fisheries by:

- establishing a program to identify and declare ‘key fishery habitat’ to become part of marine and coastal planning and protection
- implementing whole-of-catchment plans to maintain coastal habitat and water quality
- establishing criteria to assess the ecological sustainability of individual commercial and recreational fisheries
- conducting location-specific ecological risk assessments of recreational and commercial fisheries, mitigating identified risks and taking a precautionary approach where information is lacking
- developing a policy framework to follow up and manage important risks uncovered in environmental risk assessments
- monitoring the community ecology of important benthic and pelagic ecosystems.

M39 Assess the recreational fishing catch and impacts by:

- conducting large-scale surveys of participation and catch every 3 to 5 years
- requiring all recreational fishers to be licenced, with no licence fees for current exempt groups, and with licences endorsed for particular coastal regions (to enable measurement of participation and catch levels)
- conducting onsite surveys at all major boat ramps
- expanding the angler diary program to focus on key species and major recreational estuaries
- implementing fisheries-independent monitoring for key recreational species
- re-establishing annual trawl surveys of Port Phillip Bay
- investigating the impacts of fishing discards on declining target species (eg sand flathead, dusky flathead) and non-target species of low abundance (eg rare rays and sharks).

M40 Improve enforcement of fishing laws, with a strong focus on protecting marine national parks and sanctuaries from illegal fishing.

M41 Reduce risks associated with stocking, movement of invasive species and fishing gear by:

- requiring all stock enhancement proposals to be subject to a public environmental impact assessment supported by a comprehensive, independent risk assessment
- prohibiting the transport of live invasive species (eg European green shore crabs) as bait
- phasing in over five years the use of biodegradable hooks and fishing lines.

M42 Allocate a substantial proportion of fishing licensing fees to support long-term fish habitat recovery projects.

2.8 Sources

Endnotes

[1] Environment Conservation Council (2000)

[2] Geoscience Australia (2010)

[3] Environment Conservation Council (2000)

[4] Veevers (1991)

[5] Edmunds et al (2000). The three provinces are the western warm-temperate Flindersian Province; the eastern warm-temperate Peronian Province; and the southern cool-temperate Maugean Province.

[6] Environment Australia (1998)

[7] Environment Australia (1998). There is a more recent version, which differs in some respects.

[8] Edmunds et al (2010)

[9] Australian Government (2012)

[10] Oldland et al (2009)

[11] Wilson & Allen (1987); Poore (1995)

[12] Edmunds et al (2010) citing the following. For seaweed: Womersley (1990); Phillips (2001). For marine sediment infauna: Poore and Wilson (1993); Coleman *et al* (2007). For hydroids: Watson (1982). For bryozoans: Bock (1982). For sponges: Wiedenmayer (1989).

[13] Phillips (2001)

[14] Phillips (2013)

[15] Hooper (2005)

[16] Edmunds (2007)

[17] Department of Environment and Primary Industries (2014)

[18] Charlton-Robb et al (2011)

[19] WorleyParsons (2013)

[20] Ipsos (2012)

[21] URS (2007)

[22] Worley Parsons (2013)

[23] WorleyParsons (2013)

[24] Descriptions can be found in the following. Corner Inlet: Department of Sustainability Environment Water Populations and Communities (2011). Gippsland Lakes: BMT WBM (2011). Port Phillip Bay (Western Shoreline) and Bellarine Peninsula: Department of Sustainability and Environment (2003b). Edithvale-Seaford Wetlands: Department of Sustainability and Environment (2011). Western Port: Kellogg Brown & Root (2010)

[25] Dutson et al (2009)

[26] Edmunds et al (2010)

[27] Edmunds et al (2010)

[28] Department of Sustainability and Environment (2009b); Department of Sustainability and Environment (2013)

[29] Department of Sustainability and Environment (2005); Department of Sustainability and Environment (2009b); Department of Sustainability and Environment (2013)

[30] Edmunds et al (2010)

[31] Edmunds et al (2010)

[32] Moxham et al (2010)

[33] Department of Sustainability and Environment (2009a)

[34] Department of Sustainability and Environment (2003a)

[35] Smyth (2014)

[36] VicRFASC (1999); Department of Sustainability and Environment (2007)

[37] Victorian Environmental Assessment Council (2010)

[38] Victorian Environmental Assessment Council (2013)

[39] Public Record Office of Victoria (2005)

[40] Analysis of intersection of DEPI public land management spatial data (PLM25) with areas 200m and 500m inland from the intertidal zone as at Jun 2011.

[41] Smyth (2014)

[42] Victorian Environmental Assessment Council (2013)

[43] Barton et al (2008)

[44] Barton et al (2008)

[45] Barton et al (2008)

[46] Barton et al (2008)

[47] Edmunds (2007)

[48] Environment Conservation Council (2000)

[49] Environment Conservation Council (2000)

[50] Hewitt et al (2004)

[51] Melbourne Water (2011)

[52] Lau (2014)

[53] Environment Conservation Council (2000)

[54] Kellogg Brown & Root (2010); Melbourne Water (2011)

[55] Melbourne Water (2011)

[56] Hansen et al (2011)

[57] Melbourne Water (2011)

[58] Asia-Pacific Applied Science Associates (2013)

[59] Kirkman (2014); Lau (2014)

[60] Environment Protection Authority Victoria (2013)

[61] BMT WBM (2011)

[62] BMT WBM (2011)

[63] Auld & Keith (2009)

[64] Ricklefs et al (1984); McGregor et al (2008). The quote is from Ricklefs et al.

[65] McGregor et al (2008); Bennett et al (2009)

[66] McGregor et al (2008); Bennett et al (2009)

[67] Department of Climate Change (2009)

[68] Thompson et al (2009)

[69] Victorian Coastal Council Science Panel (2011)

[70] Edmunds et al (2010)

[71] Hennessy et al (2008)

[72] Edmunds et al (2010)

[73] Edmunds et al (2010); Victorian Coastal Council (2013). Temperatures: CSIRO & Bureau of Meteorology (2007). Sea levels: Bates et al (2008). East Australia Current: Cai et al (2005). Acidity: Hobday et al (2006a). Stratification: Hobday et al (2006a). Solar radiation: Hobday et al (2006a). Sea surface winds: Hobday et al (2006a). Rainfall: CSIRO & Bureau of Meteorology (2007). The changes to the East Australia Current will depend on changes to the El Niño–Southern Oscillation (ENSO). Collins et al (2010) explain that ENSO variability is controlled by a delicate balance of feedbacks, and one or more of the processes responsible for determining the characteristics of ENSO will probably be modified by climate change. It is not yet possible to say whether ENSO activity will be enhanced or damped, or if the frequency of events will change.

[74] Edmunds et al (2010); Victorian Coastal Council (2013)

[75] Hönisch et al (2012)

[76] Shi et al (2010); Beman et al (2011)

[77] Riebesell et al (2000); Hinga (2002); Engel et al (2005); Orr et al (2005);

[78] Edmunds et al (2010)

[79] Vermeer & Rahmstorf (2009)

[80] Department of Climate Change (2009)
[81] Bruun (1962); Gippsland Coastal Board (2008)
[82] Department of Climate Change (2009)
[83] Hewitt et al (2004)
[84] Hewitt et al (2004)
[85] Dommisse & Hough (2004); Ford & Gilmour (2013)
[86] Ford & Gilmour (2013)
[87] Boon et al (2011)
[88] Booth et al (2009)
[89] Boon et al (2011)
[90] Ford & Gilmour (2013)
[91] Fisheries Victoria (2012)
[92] Fisheries Victoria (2012)
[93] Smyth (2014)
[94] Auld & Keith (2009)
[95] Commissioner for Environmental Sustainability (2008)
[96] Commissioner for Environmental Sustainability (2008)
[97] Victorian Coastal Council (2013), citing Australian Bureau of Statistics
[98] WorleyParsons (2013)
[99] Ipsos (2012)
[100] Smyth (2014)
[101] Save Bastion Point Campaign (2010)
[102] Smyth (2014)
[103] McComish (2013)
[104] Asia-Pacific Applied Science Associates (2013); Kirkman (2014); Lau (2014)
[105] Edmunds et al (2010)
[106] McCauley et al (2000)
[107] Edmunds et al (2010); Smyth (2014)
[108] Department of Sustainability and Enviroment (2005)
[109] Department of Environment and Primary Industries (2013)
[110] Department of Sustainability and Enviroment (2005)
[111] State of the Environment 2011 Committee (2011)
[112] Edmunds et al (2010)
[113] Edmunds et al (2010)
[114] Department of Primary Industries (2010)
[115] State of the Environment 2011 Committee (2011); Ford & Gilmour (2013)
[116] Ford & Gilmour (2013), adapted from Department of Primary Industries (2010)
[117] Sustainable Australian Seafood Assessment Program (2012)
[118] This section is based on Ford & Gilmour (2013)
[119] Ford & Gilmour (2013)
[120] Braccini et al (2008)
[121] Ford & Gilmour (2013)
[122] Otway et al (2003)
[123] The major source of information is Edmunds et al (2010). Some information for the bioregional descriptions comes from Environment Australia (1998) and VNPA (nd).
[124] Edmunds et al (2010). There are a few modifications to the analysis due to the exclusion of marine conservation parks, marine reserves and other tenures that VNPA regards as insufficiently protected to count as genuine protected areas.
[125] Environment Australia (1998). Based largely on physical features such as bathymetry, coastal geomorphology, sediments, currents, water chemistry and water temperature, which are used as surrogates of biological variability.
[126] Environment Conservation Council (2000)
[127] Edmunds et al (2010)
[128] Australian Government (2012)
[129] Smyth (2014)
[130] Smyth (2014)
[131] 'Critical aquatic systems' have environmental values critical to the Australian lifestyle and economy, and are internationally important sites for flora, fauna and cultural heritage. Unfortunately, the Victorian government no longer recognises the validity of the critical aquatic system assessment process.
[132] The threats are classified according to the taxonomy by Auld & Keith (2009).
[133] Parks Victoria (nd)
[134] Parks Victoria (2002); Geelong Environment Council (2013)
[135] Smyth (2014)
[136] Most of this section is based on Edmunds et al (2010)
[137] Edmunds et al (2010)
[138] Edmunds et al (2010); Victorian Coastal Council Science Panel (2011)
[139] Commissioner for Environmental Sustainability (2008)
[140] Edmunds et al (2010). Surveys have included the following: intertidal reef biodiversity (O'Hara, Museum Victoria unpublished data); sediment infauna biodiversity (Coleman et al. 1997, 2007); and habitat structures (Roob 2000 – and also unpublished observations by Roob and Currie), and subtidal reef biodiversity (eg Wilson et al. 1983; O'Hara 2000, Edmunds et al. 2000a, 2000b).
[141] Hooper (2005)
[142] Kraft (2001); Edmunds et al (2003); O'Loughlin (2007)
[143] Edmunds et al (2010)
[144] Matt Edmunds (pers. comm.) June 2012.
[145] O'Hara & Barmby (2000)
[146] Edmunds et al (2010)
[147] Environment Conservation Council (2000)
[148] Edmunds et al (2010)
[149] Hobday et al (2006b)
[150] Beeton et al (2012), citing Stachowicz et al (1999), Stachowicz et al (2002), Byers 2002, Occhipinti-Ambrogi & Savini (2003), Clark & Johnston (2009), Clark & Johnston (2011), Piola & Johnston (2008) (for experimental evidence on invasions); Behrens & Lafferty (2004), Freeman & MacDiarmid (2009) (for diseases); Edgar et al (2004) (for invasions)' Pederson & Johnson (2006), Sweatman (2008) and McCook et al (2010) (for trophic cascades).
[151] The Ecology Centre (2009)
[152] Australian Marine Sciences Association (2012)
[153] Possingham et al (2009)
[154] Australian Marine Sciences Association (2012)
[155] Australian Marine Sciences Association (2012)
[156] Lester et al (2009)
[157] Beeton et al (2012)
[158] Edgar et al (2009)
[159] Victorian Auditor General (2011)
[160] Victorian Auditor General (2011)
[161] Parks Victoria (2003)
[162] Victorian Environmental Assessment Council (2013), Recommendation R9.
[163] Victorian Auditor General (2011)
[164] Smyth (2014)
[165] Barton et al (2008)

[166] Commissioner for Environmental Sustainability (2013)
[167] Oldland et al (2009)
[168] Oldland et al (2009)
[169] Lau (2014)
[170] Garnett et al (2011)
[171] BirdLife Australia (2013)
[172] Edmunds et al (2010)
[173] United Nations Environment Program (2011)
[174] Edmunds et al (2010)
[175] United Nations Environment Program (2011)
[176] Tallis et al (2010)
[177] Edmunds et al (2010)
[178] Edmunds et al (2010), citing (WAEPA 2004)
[179] Edmunds et al (2010)
[180] Department of Climate Change (2009)
[181] Smyth (2014)
[182] Victorian Environmental Assessment Council (2013)
[183] Edmunds et al (2010)
[184] Edmunds et al (2010)
[185] Ling et al (2009)
[186] Ryan et al (2009)
[187] Ford & Gilmour (2013)
[188] Ford & Gilmour (2013)
[189] Victorian Environmental Assessment Council (2013)
[190] Victorian Environmental Assessment Council (2013)
[191] Barton et al (2012)

References

Asia-Pacific Applied Science Associates (2013) *Quantitative Assessment of Exposure Risks Due to Oil Spills from Shipping in Western Port Bay.* Asia-Pacific Applied Science Associates, East Perth

Auld TD, Keith DA (2009) Dealing with threats: integrating science and management. *Ecological Management & Restoration* 10: S79-S87

Australian Government (2012) *Interim Biogeographic Regionalisation of Australia Version 7.* Department of Sustainability, Environment, Water, Population and Communities,

Australian Marine Sciences Association (2012) *Position Statement on Marine Protected Areas.* Australian Marine Sciences Association

Barton J, Pope A, Howe S (2012) *Marine Natural Values Study Vol 2: Marine Protected Areas of the Victorian Embayments Bioregion, Part 1 Port Phillip Bay.* Victorian Government Parks Victoria

Barton J, Pope A, Quinn G, Sherwood J (2008) *Identifying Threats to the Ecological Condition of Victorian estuaries.* Victorian Government Department of Sustainability and Environment

Bates B, Kundzewicz Z, Wu S, Palutikof J (2008) *Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change.* IPCC Secretariat, Geneva

Beeton R, Buxton C, Cutbush G, Fairweather P, Johnston E, Ryan R (2012) *Report of the Independent Scientific Audit of Marine Parks in New South Wales.* NSW Department of Primary Industries and Office of Environment and Heritage

Beman JM, Chow C-E, King AL, Feng Y, Fuhrman JA, et al (2011) Global declines in oceanic nitrification rates as a consequence of ocean acidification. *Proceedings of the National Academy of Science* 108: 208-13

Bennett AF, Haslem A, Cheal DC, Clarke MF, Jones RN, et al (2009) Ecological processes: a key element in strategies for nature conservation. *Ecological Management & Restoration* 10: 192–99

BirdLife Australia (2013) *Threatened Species Nomination for Hooded Plover (Eastern) (Thinornis rubricollis rubricollis).* BirdLife Australia

BMT WBM (2011) *Ecological Character Description of the Gippsland Lakes Ramsar Site.* Australian Government Department of Sustainability, Environment, Water, Population and Communities

Boon P, Allen T, Brook J, Carr G, Frood D, et al (2011) *Mangroves and Coastal Saltmarsh of Victoria: Distribution, Condition, Threats and Management*

Booth C, Carr G, Low T (2009) *Weedy Pasture Plants for Salinity Control: Sowing the Seeds of Destruction.* Invasive Species Council

Braccini J, Walker T, Conron S (2008) *Evaluation of Effects of Targeting Breeding Elephant Fish by Fecreational Fishers in Western Port.* Victorian Government Department of Primary Industries

Bruun P (1962) Sea level rise as a cause of shore erosion. *Journal Waterways and Harbours Division,* 88: 117-30

Cai W, Shi G, Cowan T, Bi D, Ribbe J (2005) The response of the Southern Annular Mode, the East Australian Current, and the southern mid-latitude ocean circulation to global warming. *Geophysical Research Letters* 32: L23706

Charlton-Robb K, Gershwin L, Thompson R, Austin J, Owen K, McKechnie S (2011) A new dolphin species, the Burrunan Dolphin *Tursiops australis* sp. nov., endemic to southern Australian coastal waters. . *PLoS ONE* 6: e24047

Collins M, An S-I, Cai W, Ganachaud A, Guilyardi E, et al (2010) The impact of global warming on the tropical Pacific Ocean and El Niño. *Nature Geoscience* 3: 391–97

Commissioner for Environmental Sustainability (2008) *State of the Environment Victoria 2008.* Commissioner for Environmental Sustainability, Melbourne, Victoria

Commissioner for Environmental Sustainability (2013) *State of the Environment Victoria 2013.* Commissioner for Environmental Sustainability Victoria

CSIRO, Bureau of Meteorology (2007) *Climate change in Australia. Technical Report.* CSIRO, Bureau of Meteorology

Department of Climate Change (2009) *Risks to Australia's Coast: A First Pass National Assessment.* Australian Government Department of Climate Change

Department of Environment and Primary Industries (2013) *Index of Stream Condition: The Third Benchmark of Victorian River Condition.* Victorian Department of Environment and Primary Industries

Department of Environment and Primary Industries (2014) *Port Philip Bay.* http://www.depi.vic.gov.au/forestry-and-land-use/coasts/marine/bays-inlets-estuaries-and-lakes/port-phillip-bay. Accessed February 2014

Department of Primary Industries (2010) *Fishery Status Report 2010.* Victorian Government Department of Primary Industries

Department of Sustainability and Enviroment (2005) *Index of Stream Condition: The Second Benchmark of Victorian River Condition* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2003a) *Action Statement, Flora and Fauna Guarantee Act. Central Gippsland Plains Grassland; Forest Red Gum Grassy Woodland; Northern Plains Grassland; South Gippsland Plains Grassland; Western (Basalt) Plains Grassland.* Victorian Government Department of Sustainability and Enviroment

Department of Sustainability and Environment (2003b) *Port Phillip Bay (Western Shoreline) & Bellarine Peninsula Ramsar Site Strategic Management Plan.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2005) Advisory List of Rare or Threatened Plants in Victoria - 2005. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2007) *Native Vegetation Information: Overview of native vegetation spatial datasets.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009a) *Action Statement, Flora and Fauna Guarantee Act 1988. Cool Temperate Rainforest Dry Rainforest (Limestone); Warm Temperate Rainforest (Coastal East Gippsland); Warm Temperate Rainforest (Cool Temperate Overlap, Howe Range); Warm Temperate Rainforest (East Gippsland Alluvial Terraces); Warm Temperate Rainforest (Far East Gippsland); Human activity which results in artificially elevated or epidemic levels of Myrtle Wilt within Nothofagus dominated Cool Temperate Rainforest.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009b) Advisory List of Threatened Invertebrate Fauna in Victoria - 2009. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2011) *Description of the Ecological Character of the Edithvale-Seaford Wetlands Ramsar Site.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2013) Advisory List of Threatened Vertebrate Fauna in Victoria 2013. Victorian Department of Sustainability and Environment

Department of Sustainability Environment Water Populations and Communities (2011) *Corner Inlet Ramsar Site: Ecological Character Description.* Australian Government Department of Sustainability, Environment, Water, Populations and Communities

Dommisse M, Hough D (2004) *Controlling the northern Pacific seastar (Asterias amurensis) in Australia.* Victorian Government Department of Sustainability and Environment

Dutson G, Garnett S, Gole C (2009) *Australia's Important Bird Areas: Key Sites for Bird Conservation.* Birds Australia

Edgar G, Barrett N, Stuart-Smith R (2009) Exploited reefs protected from fishing transform over decades into conservation features otherwise absent from seascapes. *Ecological Applications* 19: 1967–74

Edmunds M (2007) *Port Phillip Channel Deepening Project Supplementary Environmental Effects Statement Panel Hearing: Expert Witness Statement of Matt Edmunds. Prepared for Port of Melbourne Corporation, Melbourne.*

Edmunds M, Hart S, Elias J, Power B (2003) *Victorian Subtidal Reef Monitoring Program: The Reef Biota at Bunurong Marine National Park and Surrounding Coast.* Parks Victoria

Edmunds M, Mustoe S, Stewart K, Sheedy E, Ong J (2010) *VNPA Nature Conservation Review: Marine Conservation Priorities and Issues for Victoria.* Australian Marine Ecology

Edmunds M, Roob R, Ferns L (2000) Marine biogeography of Central Victoria and Flinders Bioregions – a preliminary analysis of reef flora and fauna In *Environmental Inventory of Victoria's Marine Ecosystems Stage 3* ed. LW Ferns, D Hough: Victorian Government Department of Natural Resources and Environment

Engel A, Zondervan I, Aerts K, Beaufort L, Benthien A, et al (2005) Testing the direct effect of CO2 concentration on a bloom of the coccolithophorid *Emiliania huxleyi* in mesocosm experiments. *Limnology and Oceanography* 50: 493-507

Environment Australia (1998) *Interim Marine and Coastal Regionalisation of Australia Version 3.3. An Ecosystem-based Classification for Marine and Coastal Environments.* Australian Government Environment Australia

Environment Conservation Council (2000) *Marine, Coastal and Estuarine Investigation: Final Report.* Gill Miller Press Pty Ltd, East Melbourne

Environment Protection Authority Victoria (2013) *Gippsland Lakes Condition Report 1990-2011.* Environment Protection Authority Victoria

Fisheries Victoria (2012) *A Review of Rebuilding Options for the Victorian Abalone Fishery.* Victorian Government Department of Primary Industries

Ford J, Gilmour P (2013) *The State of Recreational Fishing in Victoria. A review of Ecological Sustainability and Management Options.* Victorian National Parks Association

Garnett S, Szabo J, Dutson G (2011) *The Action Plan for Australian Birds 2010* CSIRO Publishing

Geelong Environment Council (2013) *Anglesea Heathlands - A coal mine for 50 years or protected forever?* http://geelongenvironment.org.au/Main.asp?_=Anglesea%20Heathlands&FormID=5. Accessed November 2013

Geoscience Australia (2010) *Coastline Lengths* http://www.ga.gov.au/education/geoscience-basics/dimensions/coastline-lengths.html. Accessed June 2013

Gippsland Coastal Board (2008) *Climate change, sea level rise and coastal subsidence along the Gippsland coast.* Gippsland Coastal Board

Hansen B, Menkhorst P, Loyn R (2011) *Western Port Welcomes Waterbirds: Waterbird Usage of Western Port.* Victorian Government Department of Sustainability and Environment

Hennessy K, Fawcett R, Kironoa D, Mpelasoka F, Jones D, et al (2008) *An Assessment of the Impact of Climate Change on the Nature and*

Frequency of Exceptional Climatic Events. Australian Government Bureau of Meteorology and CSIRO

Hewitt C, Campbell M, Thresher R, Martin R, Boyd S, et al (2004) Introduced and cryptogenic species in Port Phillip Bay, Victoria, Australia. *Marine Biology* 144: 183-202

Hinga K (2002) Effects of pH on coastal marine phytoplankton. *Marine Ecology Progress Series* 238: 281-300

Hobday A, Okey T, Poloczanska E, Kunz T, Richardson A (2006a) *Impacts of Climate Change on Australian Marine Life. Part B. Technical Report.* Australian Government Australian Greenhouse Office

Hobday AJ, Okey TA, Poloczanska ES, Kunz TJ, Richardson AJ (2006b) *Impacts of Climate Change on Australia Marine Life, Part A: Executive Summary, Report to the Australian Greenhouse Office.* CSIRO

Hönisch B, Ridgwell A, Schmidt DN, Thomas E, Gibbs SJ, et al (2012) The geological record of ocean acidification. *Science* 335: 1058-63

Hooper J (2005) *Phylum Porifera Grant, 1836*. Australian Faunal Directory, Australian Biological Resources Study. Australian Government Department for the Environment, Water, Heritage and the Arts

Ipsos (2012) *Executive Summary Coastal and Marine Environment Community Attitudes and Behaviour, (Wave Four) Report, prepared for Victorian Coastal Council.* Ipsos Australia, Richmond

Kellogg Brown & Root (2010) *Western Port Ramsar Wetland Ecological Character Description.* Australian Government Department of Sustainability, Environment, Water, Population and Communities

Kirkman H (2014) *Impact of Proposed Port of Hastings Expansion on Seagrass, Mangroves and Salt Marsh. Report to Victorian National Parks Association.*

Kraft G (2001) *A survey of Subtidal Marine Benthic Algae from the Point Hicks Region of East Gippsland. Report to the Abalone Fishermens Cooperative Limited, Mallacoota.*

Lau J (2014) *Impact of Proposed Port of Hastings Expansion on the Birdlife of Western Port.* BirdLife Australia

Lester SE, Halpern BS, Grorud-Colvert K, Lubchenco J, Ruttenberg BI, et al (2009) Biological effects within no-take marine reserves: a global synthesis. *Marine Ecology Progress Series* 384: 33-46

Ling S, Johnson C, Frusher S, Ridgway K (2009) Overfishing reduces resilience of kelp beds to climate-driven catastrophic phase shift. *Proceedings of the National Academy of Science* 52: 22341-45

McCauley RD, Fewtrell J, Duncan AJ, Jenner C, Jenner M-N, et al (2000) *Marine Seismic Surveys: Analysis and Propagation of Air-gun Signals; and Effect of Air-Gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid. Prepared for Australian Petroleum Exploration Association.* Curtin University of Technology,

McComish S (2013) Guy helps free up Narrawong property for development. *The Standard*, 9 July 2013:

McGregor A, Coffey B, Deutsch C, Westcott G, Robinson J (2008) *Ecological Processes in Victoria: Policy Priorities for Sustaining Biodiversity. Discussion Paper Rep.*

Melbourne Water (2011) *Understanding the Western Port Environment: A Summary of Current Knowledge and Priorities for Future Research.* Melbourne Water

Moxham C, Turner V, Walker G, Douglas I (2010) *A Field Guide to Coastal Moonah Woodland in Victoria*. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment.

O'Hara T, Barmby V (2000) *Victorian Marine Species of Conservation Concern: Molluscs, Echinoderms and Decapod Crustaceans.* Victorian Government Department of Natural Resources and Environment

O'Loughlin P (2007) New cucumariid species from southern Australia (Echinodermata: Holothuroidea: Dentrochirotida: Cucumariidae). *Memoirs of Museum Victoria* 64: 23-34

Oldland J, Rogers D, Clemens R, y LB, Maguire G, Gosbell K (2009) *Shorebird Conservation in Australia.* Birds Australia

Orr J, Fabry V, Aumont O, Bopp L, Doney S, et al (2005) Anthropogenic ocean acidification over the twenty-first century and its impacts on calcifying organisms. *Nature* 437: 681-86

Otway N, Burke A, Morrison N, Parker P (2003) *Monitoring and Identification of NSW Critical Habitat Sites for Conservation of Grey Nurse Sharks.* NSW Fisheries Office

Parks Victoria (2002) *Anglesea Heath Management Plan.* Parks Victoria and Alcoa World Alumina Australia

Parks Victoria (2003) *Victoria's System of Marine National Parks and Sanctuaries: Management Strategy 2003–2010.* Victorian Government Parks Victoria

Parks Victoria (nd) *Anglesea Heath*. http://parkweb.vic.gov.au/explore/parks/anglesea-heath. Accessed March 2014

Phillips J (2001) Marine macroalgal biodiversity hotspots: why is there high species richness and endemism in southern Australian marine benthic flora? *Biodiversity and Conservation* 10: 1555-77

Phillips J (2013) Seaweed celebration. *Wildlife Australia* 50: 9-13

Poore G (1995) Biogeography and diversity of Australia's marine biota In *The State of the Marine Environment Report for Australia Technical Annex: 1 The Marine Environment*, ed. L Zann, P Kailola, pp. 75-84: Australian Government Department of Environment, Sports and Territories

Possingham H, Nevill J, 154 signatories (2009) *Science Supporting Marine Protected Areas: Open Letter to the Prime Minister and Leader of the Opposition.*

Public Record Office of Victoria (2005) *Function VF 236, Coastal Management*. http://www.access.prov.vic.gov.au/public/component/daPublicBaseContainer?component=daViewFunction&breadcrumbPath=Home/Access%20the%20Collection/Browse%20The%20Collection/Function%20Details&entityId=236.

Ricklefs RE, Naveh Z, Turner RE (1984) Conservation of ecological processes. *The Environmentalist* 4: 6-16

Riebesell U, Zondervan I, Rost B, Tortell P, Zeebe R, Morel F (2000) Reduced calcification of marine plankton in response to increased atmospheric CO2. *Nature* 407: 364-67

Ryan K, Morison A, Conron S (2009) *Evaluating Methods of Obtaining Total Catch Estimates for Individual Victorian Bay and Inlet Recreational Fisheries.* Fisheries Research and Development Corporation

Save Bastion Point Campaign (2010) *Save Bastion Point, Mallacoota, Victoria.* savebastionpoint.org

Shi D, Xu Y, Hopkinson BM, Morel FMM (2010) Effect of ocean acidification on iron availability to marine phytoplankton. *Science* 327: 676-80

Smyth C (2014) *The Coast is Unclear: An Uncertain Future for Nature Along the Victorian Coast.* VNPA

State of the Environment 2011 Committee (2011) *Australia State of the Environment 2011.* Australian Government Department of Sustainability, Environment, Water, Population and Communities

Sustainable Australian Seafood Assessment Program (2012) *Overview.* Australian Conservation Foundation; Univerisity of Technology Sydney

Tallis H, Levin PS, Ruckelshaus M, E.Lester S, L.McLeod K, et al (2010) The many faces of ecosystem-based management: Making the process work today in real places. *Marine Policy* 34: 340–48

The Ecology Centre (2009) *Scientific Principles for Design of Marine Protected Areas in Australia: A Guidance Statement.* The Ecology Centre, University of Queensland

Thompson PA, Baird ME, Ingleton T, Doblin MA (2009) Long-term changes in temperate Australian coastal waters: Implications for phytoplankton. *Marine Ecology – Progress Series* 394: 1-19

United Nations Environment Program (2011) *Taking Steps toward Marine and Coastal Ecosystem-Based Management - An Introductory Guide.* United Nations Environment Program

URS (2007) *Assessing the Value of the Coast to Victoria.* URS, Melbourne

Veevers J (1991) Phanerozoic Australia in the changing configuration of Proto-Pangea through Gondwanaland and Pangea to the present. *Australian Systematic Botany* 4: 1-11

Vermeer M, Rahmstorf S (2009) Global sea level linked to global temperature. *Proceedings of the National Academy of Science* 106: 21527–32

VicRFASC (1999) *Gippsland: Comprehensive Regional Assessment Report* Joint Commonwealth and Victorian Regional Forest Agreement Steering Committee

Victorian Auditor General (2011) *Environmental Management of Marine Protected Areas.* Victorian Auditor-General's Office

Victorian Coastal Council (2013) *Draft Victorian Coastal Strategy 2013.* Victorian Government Department of Environment and Primary Industries

Victorian Coastal Council Science Panel (2011) *Emerging Scientific Issues on Victoria's Coast: 2011 Update.* Victorian Coastal Council

Victorian Environmental Assessment Council (2010) *Remnant Native Vegetation Investigation Discussion Paper.* Victorian Environmental Assessment Council

Victorian Environmental Assessment Council (2013) *Marine Investigation Draft Proposals Paper.* Victorian Environmental Assessment Council

VNPA (nd) *Explore Underwater Victoria.* http://www.exploreunderwatervictoria.org.au/. Accessed March 2013

Wilson B, Allen G (1987) Major components and distribution of marine fauna In *Fauna of Australia Vol 1A: General Articles*, ed. G Dyne, D Walton. Canberra: ABRS

WorleyParsons (2013) *Assessing the Value of the Coast to Victoria.* Worley Parsons

3. Terrestrial Ecosystems

A guide to chapter 3

The focus in this chapter is terrestrial biodiversity, particularly native vegetation and the national park and conservation system. There is some overlap with coastal ecosystems and inland waters (chapters 2 and 4).

Section 3.1 highlights the high natural, social and economic values of Victoria's terrestrial ecosystems, and describes the major habitat types. Section 3.2 outlines the current state of biodiversity, native vegetation and public and private protected areas. Section 3.3 is a gap analysis of the national park and conservation system in terms of its protection of subregional ecological vegetation classes, applying criteria defined for this review (the 'NCR reserve targets'). Section 3.4 describes and exemplifies four major categories of threat to terrestrial biodiversity and ecological processes – climate change, habitat loss and degradation, invasive species and altered fire regimes. Finally, sections 3.5 and 3.6 identify major policy gaps and high priority reforms in the following areas: the national park and conservation system (public, private and Indigenous), protection of native vegetation, including forests, and the management of bushfires and invasive species.

Topics covered

3.1 Values

3.2 State of terrestrial ecosystems

- Biodiversity
- Land use
- Native vegetation
- Lands managed for conservation

3.3 Gaps in the national park and conservation system

3.4 Major threats

- Climate change
- Invasive species
- Habitat loss and degradation
- Fire regimes

3.5 Gaps and priorities

- National park and conservation system
- Native vegetation protection
- Bushfire management
- Invasive species management

3.6 Future directions

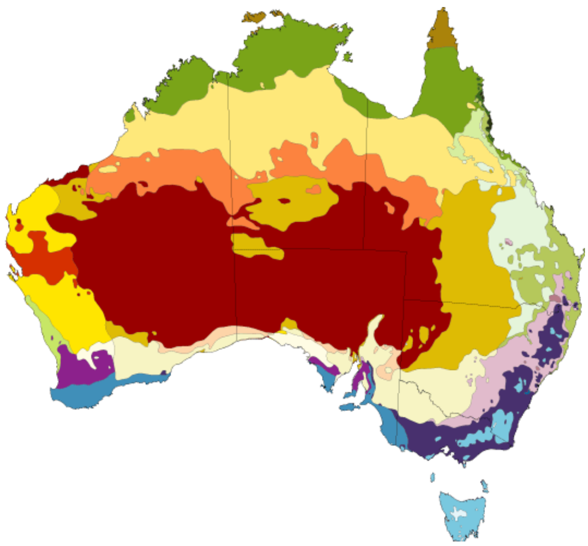
3.7 Sources

3.1 Values

From sprawling salt-sprayed coastal scrubs to high alpine herbfields, from grasslands and heathlands of intricate beauty to rainforests of mossy lushness, from stunted dry mallee woodlands to wet eucalypt forests of towering grandeur, Victoria offers an abundance of natural diversity and beauty. The state's 23 million hectares of climatically, geographically and geologically diverse landscapes are inhabited by a multitude of different life forms. But with less than half the land retaining its original vegetation and only a quarter with largely intact vegetation, major challenges lie ahead to protect the precious remnants, avert major threats and restore health to Victoria's terrestrial ecosystems.

Although Victoria accounts for just 3% of Australia's land mass, it spans two of six national climate zones (Figure 3.1) and 11 of 85 bioregions (Figure 3.2). The northwest is climatically classed as 'grassland' (hot and semi-arid) and the rest as 'temperate'.[1] Victoria's wide climate range is exemplified by median annual rainfalls of more than 1800 mm in some of the north-east to less than 250 mm in the Mallee, and by temperatures that have peaked at a searing 48.8 °C (in 2009) and a chilly −11.7 °C.[2]

Figure 3.1 Climate classification of Australia[3]



Source: Bureau of Meteorology. The classification is based on mean rainfall, maximum temperature and minimum temperature from 1961-1991. Victoria encompasses two climate zones: grassland (cream) and temperate (blues & purple), and four climate classes within the temperate zone.

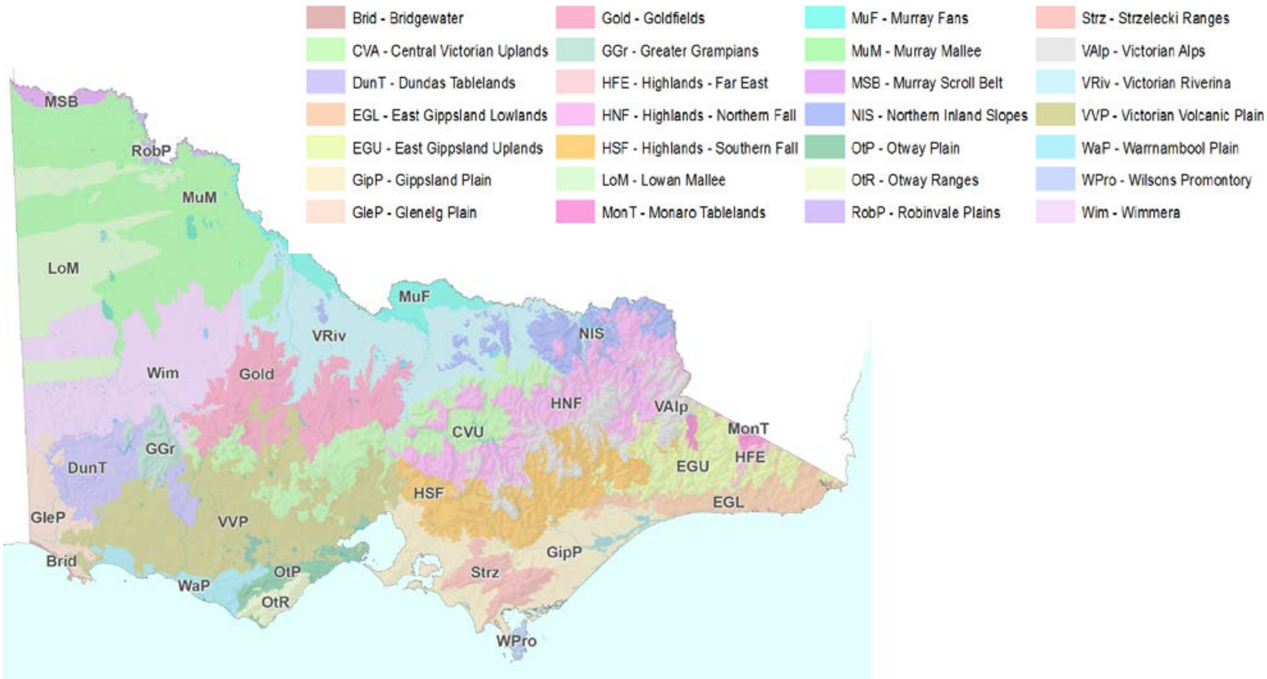
3.1.1 Biodiversity

Victoria's varied climates, landforms, soils and vegetation types provide a diverse suite of habitats for an outstandingly rich biological diversity. Landscape diversity is reflected in the 11 national bioregions represented in Victoria, which encompass 28 subregions.[4] The diversity of native vegetation communities is represented by about 300 vegetation types (known as ecological vegetation classes) and more than 2000 subregional ecological vegetation classes (see chapter 2, Box 2.3, for an explanation). Ecological vegetation classes at the subregional level are the main basis for analysis in this review.

Victoria's terrestrial habitats support some 80,000 to 100,000 species, including about 3600 plants and more than 600 vertebrates (animals with backbones) (Table 3.1). There are many species yet to be identified or described, particularly invertebrates (animals without backbones), fungi and non-vascular plants (mosses for example). The majority of species are small and overlooked – the likes of insects, worms and fungi (Figure 3.3) – but their ecological importance is immense.

Australia is recognised as one of the world's megadiverse countries,[5] and on the 3% of land area constituting Victoria can be found about half of Australia's bird species, more than a quarter of mammals and lichens, and about one-fifth of vascular plants. More than 500 species are unique to the state (endemic), mostly plants and invertebrates (Table 3.1). With only a small land area, it is unsurprising that just three terrestrial vertebrate species – one mammal (Leadbeater's possum), one frog (baw baw frog) and one reptile (alpine bog skink) – are endemic to Victoria but there are several endemic subspecies of birds and mammals, and Victoria provides a substantial proportion of habitat for many species confined to southeast Australia. (For endemic freshwater fish, see chapter 4.)

Figure 3.2 Victoria's 28 subregions



Map: VNPA. Data source: Department of Environment and Primary Industries

Vascular plants: Almost one-fifth of Australia's known plant species are native to Victoria and 344 (about 10% of Victoria's indigenous plants) are endemic to the state. Victoria has one of the world's richest flora of terrestrial orchids with about 420 known species.[6] This is more than one-quarter of Australia's ground orchids, and 40% or so are endemic to Victoria.[7]

Bryophytes (mosses, liverworts and hornworts): Victoria has at least 750 mosses and liverworts, about one-third of Australia's estimated total.[8] Small (and beautiful), bryophytes are largely overlooked vital components of most ecosystems – early colonisers after fire, protectors of soil, shelter for invertebrates and important for nutrient cycling.[9]

*Fungi***:** Estimates for Australia vary from 50,000 to 250,000, and Victoria has an estimated 30,000 species, only about 20% named, several hundred of which are expected to be endemic.[10]

- *Macrofungi*: an estimated 5000 species in Victoria (50% named) with less than 5% endemism.[11]
- *Microfungi*: an estimated 25,000 species (5-10% named), with an uncertain level of endemism, but likely to be less than 10%.
- *Lichens* (a composite of a fungi and a green alga or cyanobacteria): close to a third of Australia's known species and 45 known endemics.[12]

Frogs: Victoria has 38 frogs, 16% of Australia's known species, including the endemic (and critically endangered) baw baw frog.

Reptiles: Victoria has 130 species, about 15% of Australia's total, including the endemic (and endangered) alpine bog skink.

Mammals: Victoria has 100 terrestrial species, about 30% of Australia's total, including the endemic (and endangered) Leadbeater's possum. There are also two endemic subspecies: an eastern barred bandicoot (extinct in the wild) and a Grampians subspecies of dusky antechinus.[13]

Birds: With 370 species, Victoria hosts more than half of Australia's terrestrial birds. No species is endemic, but seven subspecies are: the helmeted honeyeater (critically endangered), rufous bristlebird (Otway Ranges), white-browed scrubwren (Otway Ranges and South Gippsland), large-billed scrubwren (central Gippsland), brown-headed honeyeater (Otway Ranges and South Gippsland), olive whistler (Otway Ranges and South Gippsland) and pied currawong (western Victoria).[14]

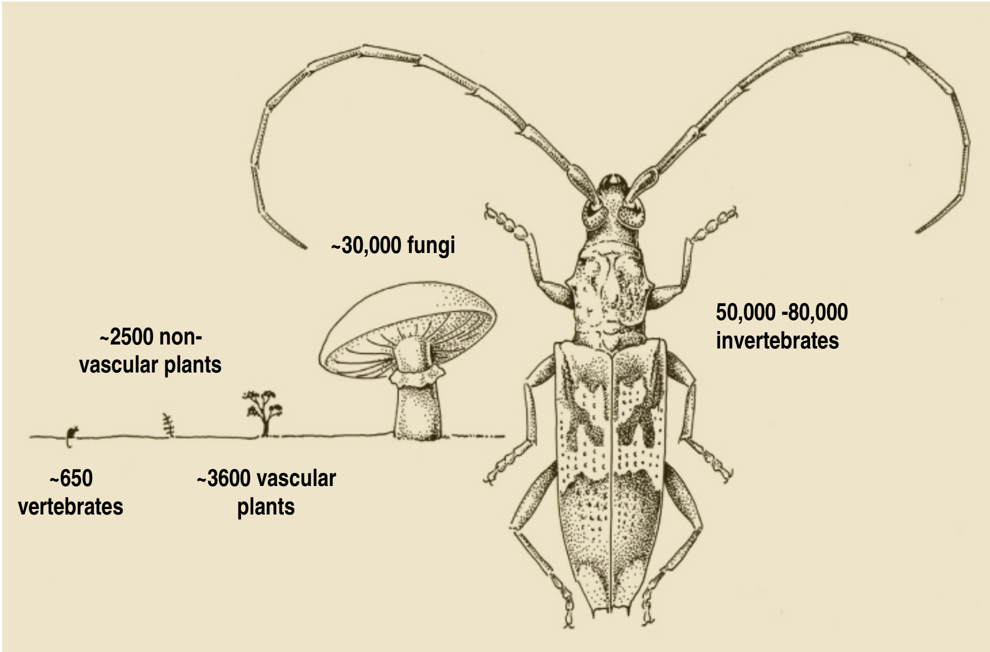
Invertebrates: Victoria probably has at least 50,000 invertebrate species, including 137 known endemic species in terrestrial and freshwater habitats (for freshwater invertebrates, see chapter 4). The giant

Gippsland earthworm and Eltham copper butterfly are two well-known and threatened endemic invertebrates.

About one-fifth of Victoria's terrestrial vertebrates (mammals, birds, reptiles, frogs) and plants are threatened (Table 3.2), and just as many are rare or near threatened or too poorly known to determine their status. More than half of Victoria's ecological vegetation classes are threatened and 11 terrestrial ecological communities are listed nationally as threatened (Figure 3.6).

As well as the intrinsic value of each component of Victoria's biodiversity, many species and ecological communities have great value for their contribution to ecosystem services. Mountain ash forests, for example, have the highest known biomass carbon density in the world, of value for mitigating global warming[15]; insects, birds and mammals provide pollination services, including for economically valuable timber trees; worms and many other soil organisms maintain productive soils; and natural places provide clean water and fresh air as well as great recreational opportunities and aesthetic pleasures. The services provided are numerous and of immense value for humans, but poorly documented and appreciated. Attempts are being made to estimate the economic values of ecosystem services, and to incorporate these values into accounting, decision-making and policy setting but much more work is needed to achieve this.[16]

Figure 3.3 Relative numbers of native species in Victoria represented by size



Graphic: VNPA. The size of the images is proportionate to the relative number of species in Victoria, which total 80,000-100,000. See table 3.1 for relative numbers.

Table 3.1 Status of some terrestrial (non-marine) groups in Victoria[17]

	Indigenous to Victoria(1)	Proportion of Australian species	Endemic to Victoria	Extinct(2)	Threatened(3)
Mammals	100	~30%	1	19	18 (18%)
Birds(4)	370	>50%	0	2	79 (21%)
Reptiles	130	~15%	1	1	32 (24%)
Frogs	38	16%	1	0	15 (39%)
Invertebrates	>50,000	unknown	137	6	121
Vascular plants	3596	~20%	344	49	745 (21%)
Bryophytes	750	40%	unknown	2	28
Lichens	1018	29%	47	0	0

Notes: (1) Includes extinct and extant. (2) Includes extinct from Victoria only, nationally extinct and extinct in the wild. (3) Includes critically endangered, endangered and vulnerable, based on Victoria's advisory lists. (4) This is for land birds and breeding species; it excludes pelagic species and penguins that do not breed in Victoria, vagrants and introduced species. Three pelagic species breed in Victoria: white-faced storm-petrel, common diving-petrel, short-tailed shearwater. The little penguin is the only penguin breeding in Victoria.

3.1.2 Important places

Protected areas

Of immense environmental, social and economic value is the 17% of Victoria's land area in the national park and conservation system. In 2005, there were 4303 native flora and 948 native animal taxa recorded on public lands in the national park and conservation system; 1282 plants and 177 animals are known only from these lands and about 90% of listed threatened species are recorded there.[18]

About two-thirds of the national park and conservation system is in largely intact landscapes, contributing to the maintenance of landscape-scale ecological processes. In fragmented landscapes, the national park and conservation system often protects the last remaining large areas of natural vegetation and forms core areas for restoration and repair. It also provides the following social and economic benefits:[19]

- protection of cultural heritage
- support of human health and wellbeing, including due to recreation
- nature based tourism – in 2012-13, there were 96 million visits to parks and waterways, including 35 million to national and state parks[20]
- economic benefits – an estimated $960 million (a 2002-03 estimate)
- clean water – up to one third of the state's water run-off
- climate control – sequestration and storage of large amounts of carbon.

Private lands permanently managed for conservation – close to 100,000 hectares – that form part of the national park and conservation system, also provide many of these benefits, particularly in areas where protected public land is scarce.

Biodiversity hotspots

Some Victorian sites have been recognised for outstanding biodiversity values. The Australian Alps is one of 11 Australian centres of plant endemism.[21] A large proportion of alpine species are endemic and most have restricted ranges.

The Victorian Volcanic Plain has been recognised as one of 15 national biodiversity hotspots, due to its combination of high values and high levels of threat, with 65 species listed as nationally threatened and more than 170 threatened at a state level.[22] The grasslands and grassy eucalypt woodlands of the bioregion are listed nationally as critically endangered. It is rich in endemic orchids. Nine of its lakes are recognised as internationally significant and 26 are listed as nationally significant.[23]

Important bird areas

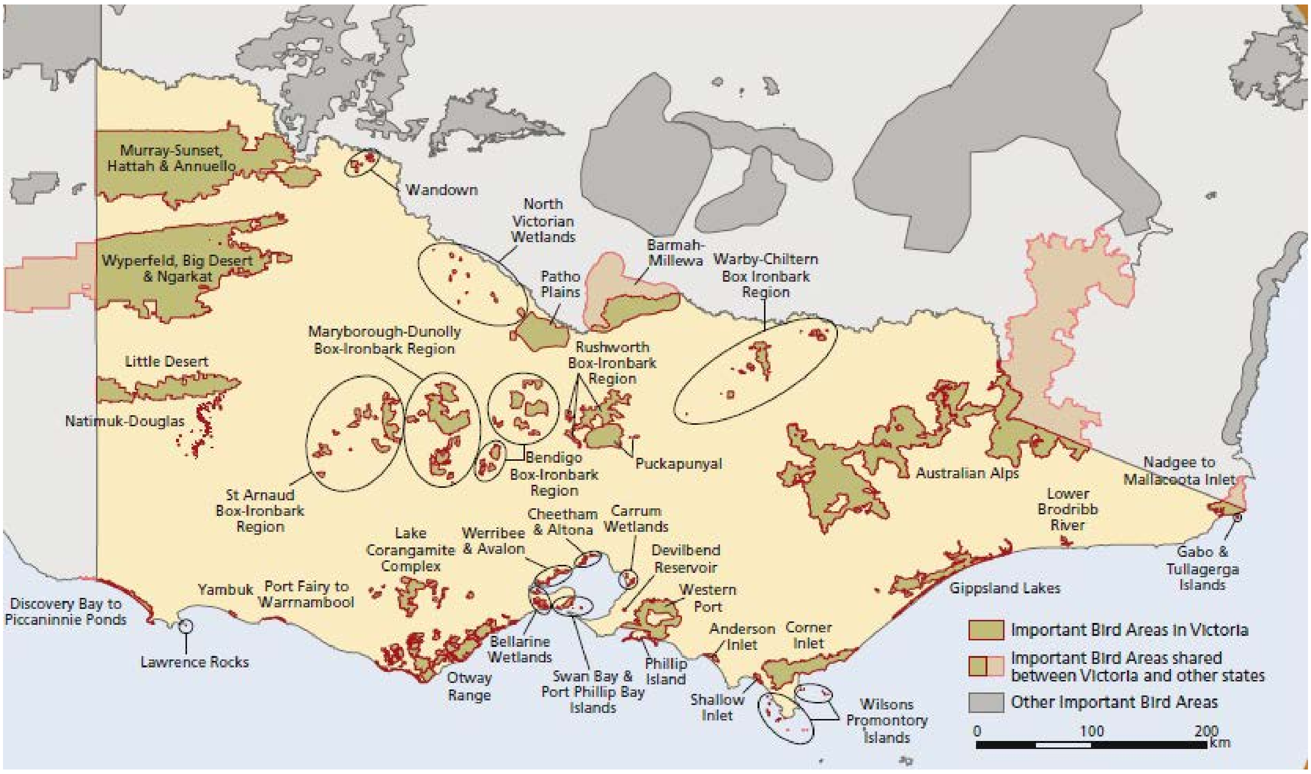
Of Victoria's 37 'important bird areas' (Figure 3.4), the following 17 are important for terrestrial birds (and many other species as well).[24]

- *Mallee birds*: Little Desert, Murray-Sunset, Hattah and Annuello, Wandown, Wyperfeld, Big Desert and Ngarkat.
- *Threatened woodland birds*: Barmah-Millewa, Bendigo Box-Ironbark Region, Maryborough-Dunolly Box-Ironbark Region, Puckapunyal, Rushworth Box-Ironbark Region, St Arnaud Box-Ironbark Region, Warby-Chiltern Box-Ironbark Region.
- *Other birds*: Australian Alps (pilotbird), Nadgee to Mallacoota Inlet (eastern bristlebird), Otway Range (rufous bristlebird), Patho Plains (plains-wanderer).

Tall trees

Victoria specialises in giant trees, with the tallest flowering plant in the world, mountain ash, found only in Victoria and Tasmania. One felled in 1880 at Thorpdale (south-east of Melbourne) was over 114 metres, only a metre or so less than the current tallest tree in the world, a north American coast redwood (a conifer, which is not a flowering plant).[25] Several mountain ashes in Victoria currently exceed 90 metres.[26] Large old trees are immensely important habitats, providing shelter, nesting sites and food (fruits, flowers, leaves and nectar) for many species, creating microenvironments with high levels of soil nutrients and plant species richness and playing a crucial role in local hydrological regimes (Box 3.8).[27] They also store large quantities of carbon.[28] In stands of trees more than 100 years old, mountain ash forests in the Central Highlands have the highest biomass carbon density known. Conserving forests with large stocks of biomass avoids significant carbon emissions to the atmosphere.[29]

Figure 3.4 Important bird areas of Victoria[30]



Source: Birds Australia (now BirdLife Australia). These areas were selected for their significant contributions to habitat for threatened bird species, birds with restricted ranges or shorebirds, waterbirds or seabirds.

3.1.3 Major habitat types

The following descriptions convey something of the rich diversity of Victoria's terrestrial ecosystems. They are mainly a summary of information from the Viridians biological database.[31]

Alpine and sub-alpine ecosystems occur in the eastern highlands mostly above 1300 metres, with rainfall and snowfall usually more than 1400 milimetres a year. Most of the area is on public land, about three-quarters protected. The vegetation consists of snow gum woodlands (small, multi-stemmed eucalypts with an understorey of shrubs, herbs and grasses), grasslands (tussock grasses, small sedges and a wide range of herbs) and heathlands (shrubs on dry shallow soils and heaths, sedges, rushes and sphagnum in peaty wet depressions). The alps have a greater range of tussock grasses, herbaceous daisies, buttercups, eyebrights and small sedges than any other Victorian ecosystem and support a rich invertebrate fauna. Four skink species, three frogs and one mammal (mountain pygmy-possum) are mostly restricted to alpine and sub-alpine areas. Each is threatened, mostly critically endangered. There has been little clearing of native vegetation but alpine and sub-alpine habitats have been damaged by cattle grazing, and are increasingly impacted by feral horses, deer and weed invasion. All cattle licenses in the Alpine National Park were ended in 2006 in recognition of the damage caused by grazing, but there are ongoing attempts to reintroduce them. Alpine ski resorts in Victoria have increased in number and size over the past 50 years. There are six designated resort areas on public land, with four as separate tenured inholdings surrounded by national park.

Wet sclerophyll forests occur on deep soils of sheltered hillsides mostly 600 to 1300 metre above sea level (asl), with more than 1100 millimetres rainfall. A little over one third of their area is protected. They are the tallest of all Victorian forests with eucalypts (mainly mountain ash), regularly reaching 80 metres, some more than 90 metres, over an understorey of climbers, broad-leafed shrubs, tree ferns, ground ferns, small herbs and coarse grass. They have a deep leaf litter (rich in fungi and invertebrates) and diverse fleshy-fruited plants. These are the most productive forests for timber, with growth rates almost double that for other forests, but most of the old-growth forest has been severely depleted by logging and fires. Hollows, which are vital for many animals, take at least 120 years to form.

Damp sclerophyll forests are the most widespread and variable forest type, found on relatively sheltered hillsides, mostly at 200 to 1100 metres asl, with a rainfall of 750 to 1200 millimetres. About a third have been lost to clearing and a little over one fifth are protected. In wetter parts, trees (mostly messmate) may grow to 60 metres or more, over an understorey of climbers, broad-leafed and small leafed shrubs, occasional tree ferns, ground ferns, dense wire-grass and herbs. In drier parts, trees (mostly messmate and narrow-leaf peppermint) are usually less than 40 metres, with an understorey of a few climbers and scramblers, wattles, small-leafed shrubs, tussock-forming and rhizomatous grasses, occasional ferns, and soft-leafed herbs. These are some of the most botanically diverse ecosystems in the state (particularly rich in *Eucalyptus* and *Pomaderris*) and also support a rich fauna (including long-footed potoroo, the spot-tailed quoll, the grey goshawk and large owls). They are heavily used – logged in higher rainfall areas, cleared for farming, harvested for firewood and burned frequently. Most stands are relatively young regrowth.

Dry sclerophyll forests grow on shallow rocky soils on exposed hillsides, mostly 200 to 1000 metres asl, with rainfall of 550 to 1000 millimetres. About 45% have been lost to clearing and a little over one fifth are protected. They feature fairly small and often crooked, spreading trees (a diverse array of eucalypts), usually less than 25 metres tall, over a normally sparse understorey of wattles and small-leafed shrubs, and a dense, diverse ground cover of grasses and small herbs. These forests have been heavily used and degraded – they are the most invaded forest type, with abundant rabbits, foxes, thistles, gorse, blackberries and introduced grasses, and are often burned.

Riparian forests (see chapter 4) grow along the sheltered banks of rivers over a wide altitude range, with rainfall between 800 and 1500 millimetres a year. About 45% of their area has been lost to clearing and less than one sixth is protected. They are characterised by tall, straight trees (such as manna gum) with an understorey of climbers, broad-leafed and narrow-leafed shrubs, ferns (including tree ferns), scrambling grasses and soft-leafed herbs. Riparian forests are the most diverse (because they are in an overlap zone) and most disturbed forest type. They support about 80% of Victoria's possums, gliders and bats and most of the common forest birds and tree skinks, and have a deep leaf litter with a rich invertebrate fauna. Apart from clearing, most have been degraded by runoff from farms, housing and industry and invaded by weeds and exotic animals. Nonetheless, most stands still have more native species than most other ecosystems. They are of immense ecological value.

Box-ironbark forests occur on flat to undulating landscapes on rocky soils, mainly in central Victoria, at 150 to 600 metres asl with rainfall of 500 to 800 millimetres. About 55% have been lost to clearing and less than one fifth of their extent is protected. They feature box, ironbark and gum-barked eucalypts to 25 metres height, over a sparse understorey of wattles and shrubs, herbs and grasses. The trees are amongst the most prolifically flowering eucalypts, a major source of nectar for wildlife. There are more species and greater numbers of honeyeaters and lorikeets in these forests than elsewhere. During the gold rush years in the mid-1800s, these forests were subjected to intensive digging and clearing, and large areas were then cleared for grazing. The vegetation has been heavily fragmented and invaded by weeds.

Rainforests occupy only small areas, in sheltered gullies ranging from about 200 to 1200 metres asl, with rainfall of 800 to 1500 millimetres. A little over one third of their area is in protected areas, and all are protected from clearing and timber harvesting. Rainforests are dominated by a dense canopy of non-eucalypt trees over an understorey of climbers (which often climb into the canopy), broad-leafed shrubs, tree-ferns, epiphytic ferns, ground ferns and small soft-leafed herbs. There are two main types in Victoria: cool temperate rainforest found at higher altitudes with higher rainfall and warm temperate rainforest along steep creeklines at lower altitudes. Both are listed as threatened ecological communities under the Flora and Fauna Guarantee Act. Cool temperate rainforest is affected by myrtle wilt, a native fungus that infects the dominant beech trees, and warm temperate rainforest is often weedy and disturbed where the surrounding forest has been removed or altered.

Red gum ecosystems are found in flat to undulating country at low altitudes, with rainfall of 250-1000 millimetres, near watercourses or on alluvial soils subject to periodic floods. Although river red gum trees remain widespread, over 70% of the native understorey has been cleared or substantially altered. Just over 10% of the area has been protected. The understorey typically consists of grasses, sedges and herbs, and small and prostrate shrubs, many adapted to inundation by floodwaters. With a wide geographic spread and varying distance from watercourses, they are one of the most variable habitat types in the state. Because most have been used for grazing, weeds are abundant – more than half of the 50 most common plants are introduced. River red gums need floods for germination, and excessive regulation of rivers in Victoria (chapter 4) has caused widespread deterioration of the ecosystem and a lack of regeneration. Dependent wildlife – frogs, wetland birds, hollow-dependent birds and mammals – are declining.

Black box woodlands occur on flat to slightly undulating landscapes on alluvial soils in north-west Victoria, generally at 50 to 150 metres asl, with rainfall of 250 to 450 millimetres. About 65% have been lost to clearing, and just over 15% of the area is protected. They are characterised by black box, usually 15-20 metres tall, over a sparse to dense understorey of saltbushes and short-lived herbs and grasses, with occasional patches of lignum. Saltbushes are successful in this salty, changing and uncertain environment, and have become increasingly dominant due to heavy grazing by stock, rabbits and kangaroos, as more nutritious grasses and herbs have declined. Much of the ground cover is highly weedy, with limited value for grazing animals. Regeneration of black box relies on an adequate water supply after seed fall, which has been compromised by extended droughts and diversion of water flows. The seedlings are highly susceptible to trampling and browsing by stock and rabbits.

Mallee occurs on flat to undulating landscapes on sandy, clay or rocky soils in north-western Victoria, generally at 50 to 200 metres asl, with rainfall of 250 to 400 millimetres. About 35% has been lost to clearing and less than one-third is protected. Mallee habitats are characterised by high summer temperatures, relatively infertile soils and low, unreliable rainfall. The mallee trees are small, multi-stemmed trees, with a ligno-tuber that allows them to survive long dry periods. The understorey consists of shrubs, grasses and herbs. Some of the wildlife (malleefowl, mallee emu-wren) are mallee specialists. Reptiles make up close to one-fifth of vertebrate species, the highest proportion of any Victorian ecosystem. Most of the agricultural areas are on the more fertile alluvial soils (less than 20% protected), where extensive clearing has led to dryland salinity, and overgrazing has caused severe erosion.

Pine-buloke woodlands occur on flat to slightly undulating landscapes on sandy-loam soils in north-west Victoria, generally at 50 to 150 metres asl with a rainfall of 250 to 450 millimetres. About half have been lost to clearing and just over 35% of the area has been protected. They are characterised by a generally sparse canopy of slender cypress-pine and/or buloke (and in some places white cypress-pine or belah), over an often dense understorey of shrubs and short-lived herbs and grasses. They are the only inland woodland or forest type not dominated by eucalypts. The four main tree species are wind-pollinated and produce their seeds within small woody cones. The understorey varies considerably, and several species produce nectar-rich flowers and fleshy fruits that feed local bird and insect populations. In good years, nomadic nectar-eating, fruit-eating and insect-eating birds are present in large numbers. When native grasses and herbs are abundant after rain, ground-feeding birds become common. Pine-buloke woodlands are one of the most widespread but fragmented of inland ecosystems. Early settlers sought them out for their comparative fertility and for timber. Much of the area was cleared and the trees don't regenerate well when grazed by sheep or rabbits. Buloke populations (which extend beyond the pine-buloke ecosystem across 30% of Victoria) have been reduced to less than 5% of what they were at the time of European settlement. Weeds are common.

Heathlands (other than alpine heathland) occur on gently undulating, acidic, nutrient-poor sandy soils in southern and western Victoria, generally at 50 to 300 metres asl, with rainfall of 600 to 1100 millimetres. About 55% have been lost to clearing and about a quarter are protected. Heathland ecosystems are characterised by a dense layer of small-leafed shrubs, usually 1-2 metres tall, over a ground layer of sedges, coarse lilies, rope-rushes, prostrate shrubs and herbs. They may occasionally have small spreading eucalypts on deeper soils. The key ecological feature is extremely low nutrient soils, to which plants have adapted by small stature, slow growth, storage lignotubers, associations with soil fungi (mycorrhizae) and parasitism. Relatively frequent fires return nutrients to the soils and open the canopy for regeneration of small, ground-layer species such as orchids, sundews, and lilies. Heathlands support the greatest proportion of orchids in Victoria, many of which respond quickly to fire. But too frequent or poorly timed burning of some areas has led to domination by bracken and prickly tea-tree. Areas with deeper and slightly more fertile soils have been cleared for marginal agriculture, where sheep grazing has been enabled by fertilisers and introduced pasture grasses.

Grassland ecosystems (excluding alpine grasslands) occur in flat to gently undulating country at low altitudes, with rainfall of 400 to 1000 millimetres, on relatively nutrient-rich soils. About 85% have been lost to clearing or modification, and less than 5% of their area is protected. Grassland communities vary considerably over a large climatic and geographic range – from the volcanic plains to the south-west, the calcareous flats of the Wimmera in the west, the alluvial plains of the north and South Gippsland, the high-altitude hillsides of East Gippsland and the low country around Port Phillip Bay and Westernport. The ground layer is dominated by perennial grasses, with some rhizomatous or stoloniferous species and a few annuals, and often with a wide range of perennial and annual herbs, sedges, lilies and small shrubs. Some areas have occasional trees and there may be scattered shrubs. This most widespread of habitat types is also the most damaged and threatened, most of it used for crops or grazing. Grasslands were heavily grazed by sheep in the early days of European settlement, which substantially altered their composition. Exotic pasture grasses and clovers were sown over large areas and fertilisers were applied. Invasive plants and animals are widespread. Some of the last areas of critically endangered grassland are to be cleared for urban expansion around Melbourne. Many once common grassland species are extinct or gravely threatened – eg plains wanderers, Australian bustards, eastern barred bandicoots, bush stone-curlews and striped legless lizards.

Banksia woodlands occur on flat to undulating sandy soils in coastal and near-coastal parts of southern and eastern Victoria, generally at 10 to 100 metres asl with rainfall of 700 to 1000 millimetres. At least a quarter have been lost to clearing and about 40% are protected. There are two main types – one coastal (dominated by coast banksias) and one near-coastal that occurs up to 30 kilometres inland (dominated by saw banksias). The banksias grow with other small trees (wattles, tea-trees, she-oaks, eucalypts) over an understorey of small shrubs, herbs, sedges and grasses. The soils are extremely infertile and have little water-holding capacity.

Coastal scrubs (chapter 2) occur on sand dunes or coastal limestone soils, at 0 to 200 metres asl, with rainfall of 700 to 1200 millimetres. About 60% have been lost to clearing and about one-fifth of their area is protected. They consist of a dense layer of sprawling shrubs, usually 2-5 metres tall, interspersed with grasses, herbs and sedges. They are more of a grassland and herbland closer to the sea and grade into banksia woodland on the landward side.

Saltmarshes (chapter 2) occur on intertidal mud-flats in southern, eastern and far-western Victoria, with rainfall of 650 to 900 millimetres. About 30% have been lost to clearing and close to a quarter of their area is protected. The usually narrow bands of vegetation consist of small succulent shrubs, succulent and semi-succulent herbs, grasses and sedges, often bordered on the seaward edge by a mangrove shrubland.

3.2 State of terrestrial ecosystems

3.2.1 Biodiversity

200 years of human activity has severely affected Victoria's species and ecosystems. … Despite the conservation efforts of governments, non-government organisations, communities and individuals over many decades, the health of our species and ecosystems continues to decline.

Department of Sustainability and Environment, 2010[32]

Victoria's terrestrial ecosystems have suffered grievous losses: more than 80 species known to be extinct since European colonisation, more than 1000 threatened and another 1000 or so rare, near threatened or with their status unknown, and 60% of ecological vegetation classes threatened.

Threatened species

Table 3.2 Threatened and extinct taxa in some terrestrial groups[33]

	CR	E	V	Total threatened	Extinct(1)
Mammals	3	7	9	19 (19%)	19
Birds	12	28	41	81 (22%)	2
Reptiles	13	11	10	35 (27%)	1
Frogs	8	4	3	15 (39%)	0
Molluscs	3	2	5	10	0
Annelids	0	1	0	1	0
Insects	14	10	37	102	5
Vascular plants	NA	270	475	745 (21%)	49

Sources: State government advisory lists. Notes: CR: critically endangered. E: endangered. V: vulnerable. Includes some species that inhabit freshwater habitats (covered in chapter 4). (1) Extinct includes extinct from just Victoria, totally extinct and extinct in the wild. With mammals, nine species are globally extinct, nine are extinct from Victoria (surviving elsewhere in Australia) and one is extinct in the wild.

Mammals have suffered the greatest losses, especially small to medium-sized and ground-dwelling species (quolls, small wallabies, bandicoots, marsupial mice and rats): at least 14% of Victoria's terrestrial mammals are extinct and a fifth threatened. Regional losses have been greater. A Gippsland study of sooty owl pellets (comparing contemporary and sub-fossil pellets) found that mammal prey diversity had declined by two-thirds, from 28 species 150 years ago to just 10 today.[34] The current small mammal community is 'a small fraction of its former state'. However, there is potential for future recovery of some species, for about half the mammal species lost from Victoria survive elsewhere in Australia. This will require much better control of foxes and cats, and habitat restoration.

The losses and severe declines of mammals and other animals have disrupted many ecological processes (section 3.4), with consequences for vegetation structure and composition and soil quality. Many of the lost mammals, for example, dug for food or to create burrows, in the process mixing, aerating and breaking down the soil, creating pits that captured leaf litter, faeces, seeds and water, and spreading the spores of mycorrhizal fungi that benefit trees. Their loss is likely to have compromised the productivity and composition of native plant communities.[35] Some declining birds are important long-range pollinators that help eucalypts adapt to changing conditions (Box 3.6). Both the status of invertebrates and the consequences of declines are very poorly known.

Many species in Victoria have yet to suffer the eventual consequences of what is known as an 'extinction debt' for losses that occurred decades ago, which means that maintaining the status quo will not be sufficient to halt declines and extinctions. For example, even if all old paddock trees are protected, animals that use their hollows face a major shortage in future because the trees are mostly not regenerating. Hollows take more than a century to form.[36] Small populations isolated in habitat patches might hang on for many generations (decades or even centuries) before going extinct due to chance events (such as extreme weather events), inbreeding, or loss of genetic diversity, which reduces their ability to adapt to new environmental conditions.[37]

Only some threatened species in Victoria are formally listed under the Flora and Fauna Guarantee Act (Table 3.3). Because there is no systematic approach, the listings are highly inadequate for tracking the conservation status of species and ecological communities (chapter 5).[38] Assessments of habitat condition and other indicators suggest a downward trend in Victorian biodiversity.[39] Table 3.3 shows that the number of species considered extinct or threatened in state government advisory lists has grown since the 2001 nature conservation review. Some changes are due to an increased (or decreased) potential for extinction, but many are due to changes in knowledge, taxonomy or methods of data collection, processing and categorisation, so it is not possible to track trends with any precision.[40]

Table 3.3 Extinct and threatened taxa, current and 2001, formally listed and advisory[41]

	State-listed (FFG Act)(1)	Current state advisory lists(2)	2001 state advisory lists(3)
Mammals	38	38 (2013)	43 (1999)
Birds	78	83 (2013)	75 (1999)
Reptiles	29	36 (2013)	28 (1999)
Frogs	11	15 (2013)	10 (1999)
Invertebrates	72	127 (2009)	26 (1995)
Vascular plants	352	794 (2005)	646 (2000)

Sources: (1) Taxa listed under the Flora and Fauna Guarantee Act. (2) Current state government advisory lists: 2005 (plants), 2009 (invertebrates) and 2013 (vertebrates). (3) State government advisory lists current in 2001: 2000 (plants), 1995 (invertebrates), 1999 (vertebrates).

According to the 2013 state of the environment report, from 2007 to 2013 the conservation status of eight species improved and the status of 33 worsened; 13 were added to the advisory list due to decreasing populations and three were removed due to increases; but for many species population trends were 'inconclusive, unclear or variable'.[42]

Concern should extend beyond rare and threatened species to some widespread species as well. The greater glider, living along the Great Dividing Range from northern Queensland to southern Victoria, is generally thought to be secure. But monitoring from 1997 to 2010 at 160 sites in the Central Highlands found dramatic declines over 12 years, at an annual rate of 8.8%, thought to be driven by declining rainfall, forest landscape changes, logging and wildfire.[43] Apart from the potential for decline as conditions change, reasons to focus on more common species include the contribution of some to ecological processes such as seed dispersal and pollination, their role in food webs, and contributions to structure and biomass in ecosystems and to variance in species richness.

Threatened ecological communities

The conservation status of the state's 300 ecological vegetation classes was assessed by the Victorian government in 2007 using criteria that take into account their estimated pre-European extent, current extent and level of degradation. At a subregional level, less than one-quarter are classed as 'least concern' and more than 60% as threatened (Table 3.4). Predictably, the most heavily cleared subregions have the highest numbers of endangered ecological vegetation classes: the Victorian Volcanic Plains has 45 (35% of vegetation classes in the subregion) and the Wimmera has 40 (30% of vegetation classes in the subregion) (Figure 3.5).

Thirty-seven terrestrial ecological communities (including coastal and freshwater communities) have been listed under the state Flora and Fauna Guarantee Act and 11 under the federal Environment Protection and Biodiversity Conservation Act (Figure 3.6).

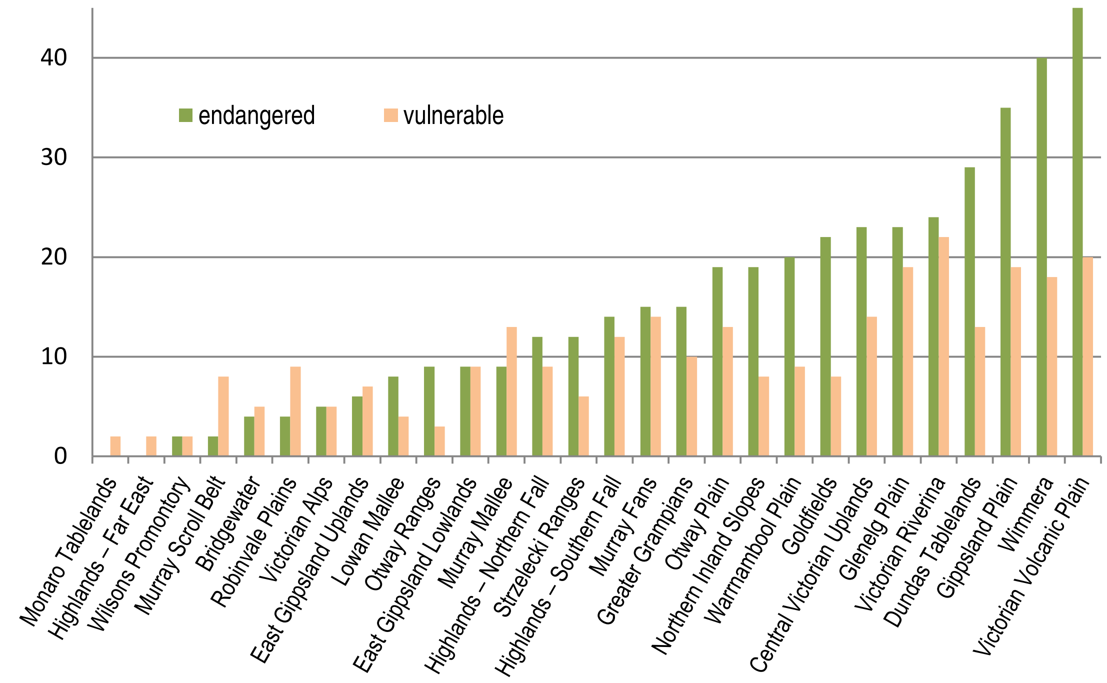
Table 3.4 Conservation status of subregional ecological vegetation classes (EVCs), 2007[44]

Status	EVCs	EVC mosaics complexes & aggregates(1)	Total (#)	Total (%)
Endangered	425	278	703	37
Vulnerable	283	188	471	24
Rare	77	21	98	5
Depleted	138	98	236	12
Least concern	255	162	417	22
Total	1178	747	1925	100

Source : Department of Sustainability and Environment.

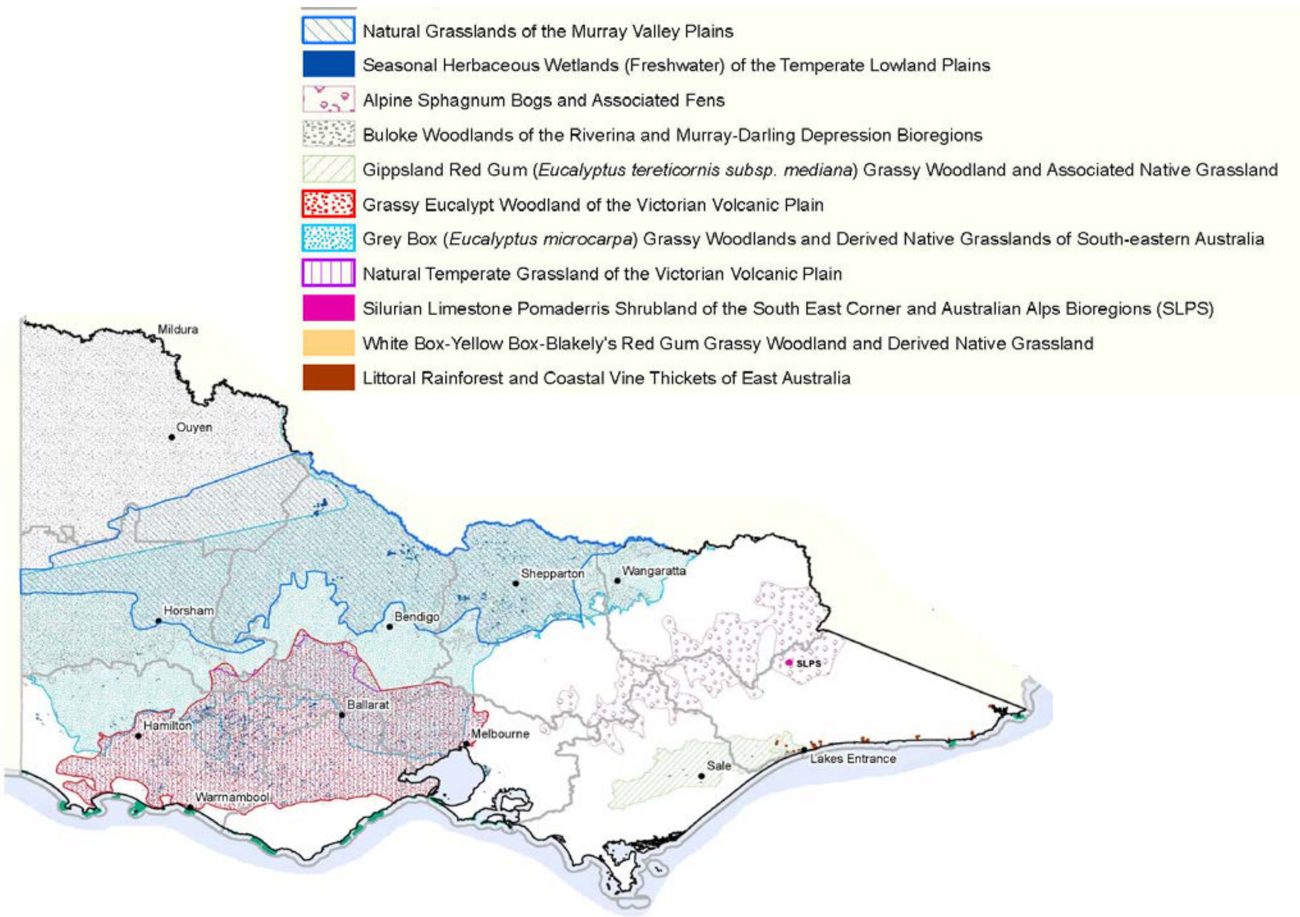
Notes: The EVC dataset was produced by combining modelled pre-1750 EVCs, subregions and current native vegetation extent. The pre-1750 dataset is based on field data, environmental spatial data (soils, rainfall, topography etc) and historical records such as parish plans. Wetland EVCs are included. (1) EVC complexes, mosaics and aggregates apply to sites where specific EVCs cannot be identified at the spatial scale used for vegetation mapping.

Figure 3.5 Numbers of endangered and vulnerable ecological vegetation classes in Victorian subregions



Data source: Department of Environment and Primary Industries

Figure 3.6 Nationally listed ecological communities in Victoria[45]



Source: Australian Government, Department of the Environment

Introduced species

Much of Victoria is now dominated by non-indigenous plants and animals. The majority of land area, including the most fertile and productive areas, is dedicated to sustaining cropped plants, sheep and cattle (some on exotic pastures). Other exotic species, established in the wild, also have a dominant presence, sequestering much of Victoria's natural productivity, compromising ecological processes, degrading habitats and causing extinctions and declines (section 3.4.2).

Table 3.5 Non-native species established in the wild[46]

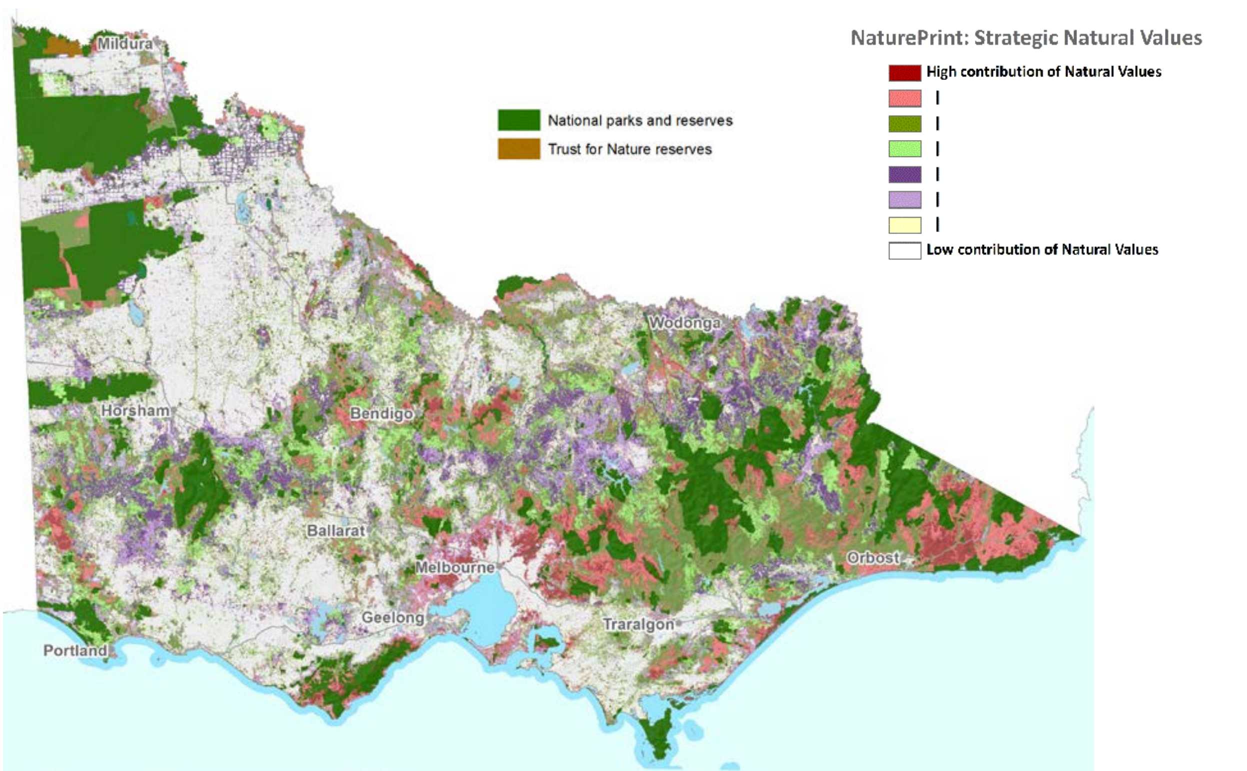
	Naturalised species	Proportion of Victorian species
Vascular plants	1237	26%
Mammals	18	12%
Birds	20	5%
Slugs & snails (SE Australia)	22	~25%

More than 1200 exotic plant species (including some native to elsewhere in Australia) now make up more than a quarter of Victoria's flora and include some of the most abundant and widespread plants in Victoria (Table 3.5). Non-indigenous species make up more than 10% of Victoria's mammals and about 5% of the birds. The numbers of introduced invertebrates are unknown. More than 200 species of fungi that cause plant diseases, including myrtle rust, have been introduced to Victoria, although many have not moved into natural ecosystems from their cultivated plant hosts.[47]

Areas with high biodiversity values

Through a method known as NaturePrint, the state government has mapped areas that contribute most to maintaining Victoria's biodiversity values (Figure 3.7). The modelling combines information on the distribution or co-location of mammals, birds, amphibians, reptiles, fish and plants; rare and threatened species; and the connectivity and recoverability potential of habitats.[48] It doesn't include aquatic ecosystems but does include information on fish and freshwater crayfish distribution. Information from NaturePrint has been used by Trust for Nature as the basis for its prioritisation of areas for private land conservation (Figure 3.16) and by VNPA to assist in identifying priority landscapes for conservation effort (section 5.3).

Figure 3.7 Relative habitat values identified through NaturePrint



Map: VNPA. Data source: Department of Environment and Primary Industries. The red, pink and dark green colours signify high value areas where it is essential to protect existing values. The areas of light green, purple and mauve are more likely to signify areas with potential for re-establishing and improving habitat values including connectivity.

3.2.2 Land use

More than three-quarters of Victoria's land area is used primarily for economic or residential purposes, mostly for agriculture (56% land area) (Table 3.6, Figure 3.8).

Table 3.6 Land uses in Victoria[49]

Major land use	% land area
Public land (7.9 million hectares)	34.6
National park & conservation system	16.8
State forest	13.8
Services & utilities (roads, sewerage etc)	2.6
Parks (metropolitan, regional, forest)	0.5
Private land (14.9 million hectares)	65.4
Agricultural holdings	55.8
Urban & industrial	3.5
Plantation forestry	2.2
Rural residential	0.9
National park & conservation system (included in above categories)	0.4

Sources: Department of Environment and Primary Industries, Australian Bureau of Statistics, Trust for Nature, Victorian Environmental Assessment Council

Victorian farms, consisting (in June 2012) of 32,500 enterprises, occupy about 13 million hectares.[50] In 2011-12, crops were grown on about 35% of farmland (4.4 million hectares) and more than 16 million sheep and 4 million cattle grazed across about 7 million hectares of land on mainly 'improved' pastures (sown with exotic species).[51] About 28% of farms used irrigation across 558,000 hectares, and 58% applied fertiliser.[52]

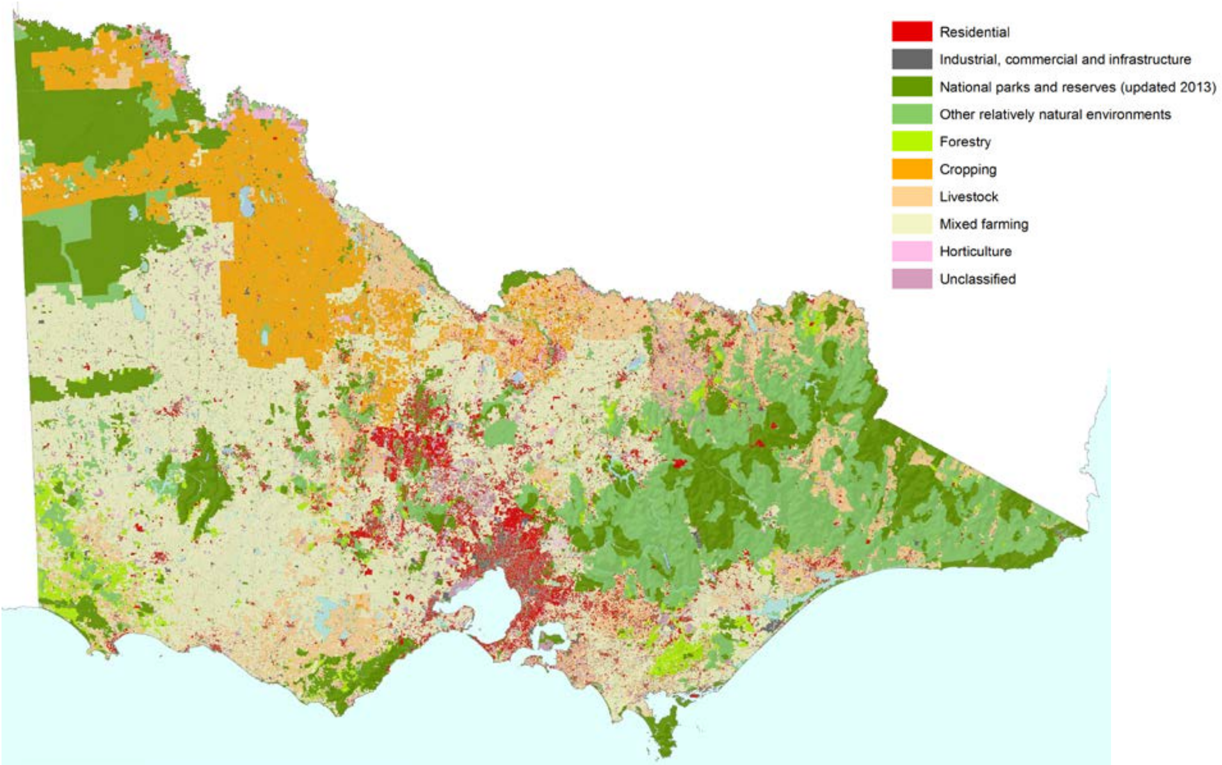
Although agriculture dominates land use, the sector employs just 3% of the Victorian workforce and contributes about 2.5% of the gross state product.[53] In many areas agriculture is increasingly being combined with conservation activities, although the area managed for conservation (2.8% of farmland) is small (Table 3.7). There is much potential to revitalise rural economies by combining low impact agriculture with conservation supported in part by stewardship payments.

Table 3.7 Agricultural land uses, 2011-2012[54]

Activity	Area (million hectares)	% of farmland
Grazing	6.86	54.0
(on improved pastures)	(5.35)	(42.1)
Crops	4.45	35.0
Set aside for conservation	0.35	2.8
Other not used for agriculture	0.36	2.8
Forestry production	0.05	0.4
Total agricultural holdings	12.70	100.0

Source: Australian Bureau of Statistics

Figure 3.8 Land use in Victoria



Map: VNPA. Data source: Department of Environment and Primary Industries

3.2.3 Native vegetation

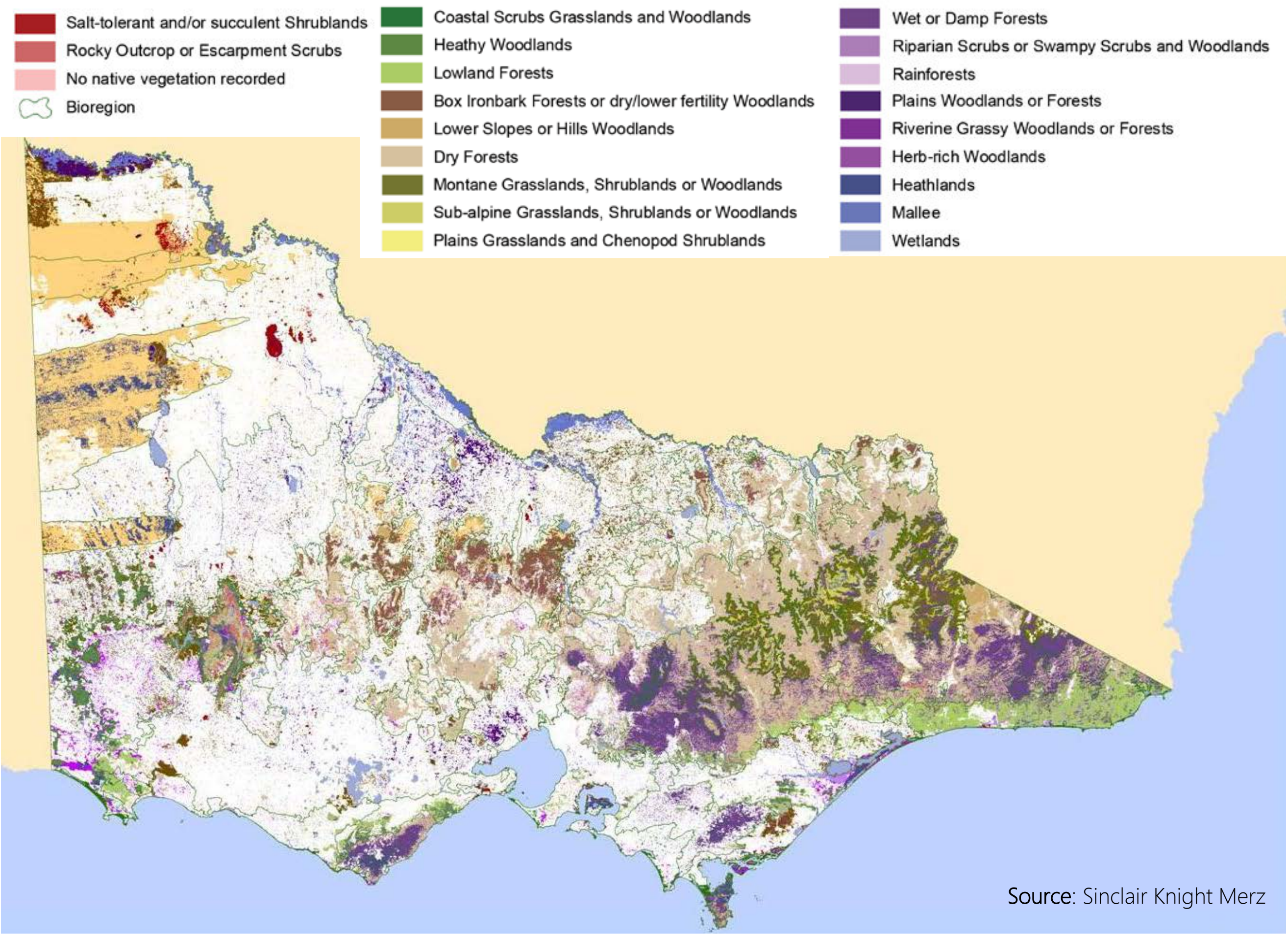
More than half (54%) of Victoria's native vegetation has been cleared.[55] Exceeding all other states for the proportion cleared, Victoria, with 3% of Australia's land area, has been responsible for 12% of the total clearing.[56] Of the remaining area with native vegetation (10.4 million hectares), more than half has been fragmented, leaving only 21% (4.9 million hectares) of Victoria's land area with largely intact vegetation.[57] Because of vegetation loss and degradation, almost half (48%) of Victoria's 28 subregions have been assessed nationally as having poor landscape condition.[58]

The losses have been greatest on private land, where 80% has been cleared, leaving about 2.9 million hectares of remnant vegetation. The most productive landscapes have been almost totally usurped for agriculture. More than 99% of remnant vegetation on private land is fragmented and about 60% is of a threatened vegetation type.[59]

The five most cleared subregions, covering 41% of the state, each have less than 25% native vegetation cover (almost all fragmented) and four have less than 10% of native vegetation in protected areas (Table 3.8, Figure 3.10). They are mostly flat, with fertile soils, under private tenure, and used for agriculture. Another eight subregions, covering 22% of land area, each have less than 50% native vegetation cover, almost all fragmented, and also mostly used for agriculture. Twelve subregions, covering 30% of the state, have more than 75% native vegetation cover. These least cleared areas are mostly mountainous and small, with a large proportion of land in public tenure.

Vegetation losses have been greatest in grasslands and woodlands, which occur on the most fertile lands targeted for agriculture.[60] Native grasslands are Victoria's most endangered vegetation type. Nine ecological communities have been nationally listed as threatened due to clearing (Box 3.2).[61]

Figure 3.9 Remnant native vegetation types (ecological vegetation class groups)[62]



Source: Sinclair Knight Merz

Box 3.1 Road reserves

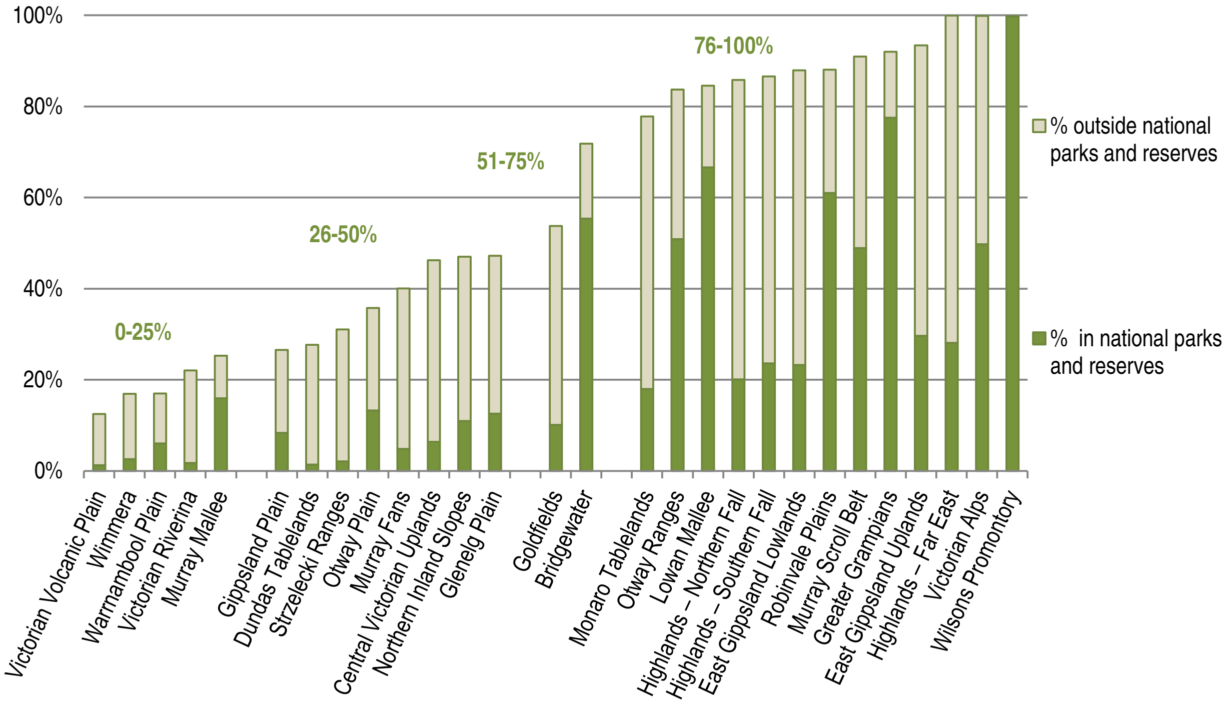
So extensive have been losses in Victoria's most cleared bioregions that road reserves now support a significant proportion of remnant vegetation: 9.4% in the Murray Mallee and 6.8% in the Warrnambool Plain. Statewide, 245,000 hectares of road reserves (used and unused) support native vegetation.[63] Their value as remnants and wildlife corridors is high but increasingly under threat. Pasture grasses (particularly Phalaris and Tall Wheat Grass) invading from adjoining farmland could destroy many over the next few decades. They are highly vulnerable to fire damage, 'cleaning up' for supposed fuel reduction, firewood pilfering, eutrophication, climate change, road construction and invasive species, and generally lack some critical habitat elements such as water (although they tend to have large trees, which have very high habitat values).[64]

Table 3.8 Subregional native vegetation cover, fragmentation and protection

Subregion	% native vegetation	% fragmented	% vegetation protected	Area (million ha)
Subregions with 0-25% native vegetation: 41% of the state (9.35 million hectares)				
Victorian Volcanic Plain	12	100	1	2.30
Wimmera	17	100	3	2.00
Warrnambool Plain	17	100	6	0.26
Victorian Riverina	22	100	2	1.89
Murray Mallee	25	90	16	2.50
Subregions with 26-50% native vegetation: 22% of the state (5.07 million hectares)				
Gippsland Plain	27	100	8	1.19
Dundas Tablelands	28	99	1	0.69
Strzelecki Ranges	31	100	2	0.34
Otway Plain	36	96	13	0.24
Murray Fans	40	100	5	0.43
Central Victorian Uplands	46	97	6	1.22
Glenelg Plain	47	100	13	0.40
Northern Inland Slopes	47	100	11	0.57
Subregions with 51-75% native vegetation: 6% of the state (1.34 million hectares)				
Goldfields	54	100	10	1.33
Bridgewater	72	100	55	0.02
Subregions with 76-100% native vegetation: 30% of the state (6.81 million hectares)				
Monaro Tablelands	78	64	18	0.07
Otway Ranges	84	68	51	0.15
Lowan Mallee	85	36	67	1.42
Highlands – Northern Fall	86	36	20	1.41
Highlands – Southern Fall	87	33	24	1.20
East Gippsland Lowlands	88	33	23	0.53
Robinvale Plains	88	65	61	0.06
Murray Scroll Belt	91	100	49	0.11
Great Grampians	92	40	77	0.24
East Gippsland Uplands	93	20	30	0.79
Highlands – Far East	100	1	28	0.07
Victorian Alps	100	2	50	0.71
Wilsons Promontory	100	2	100	0.04

Data Source: Department of Environment and Primary Industries, Victorian Environmental Assessment Council (2010)

Figure 3.10 Percentage of native vegetation in each subregion, within and outside protected areas



Box 3.2 Ecological communities threatened by clearing

Grasslands and grassy woodlands on Victoria's lowland plains (in the Mallee, Wimmera, Northern Plains, Grampians hinterland, Western Plains, Melbourne area and Gippsland Plains) used to cover about one-third of the state. Most have been cleared, leaving grassy ecological communities the most endangered in the state.[65] Less than 5% of the original extent of natural temperate grassland and grassy eucalypt woodland communities of the Victorian Volcanic Plain remain, and probably less than 1% is in good condition.[66]

Despite their great rarity, grasslands continue to be lost – due to agricultural intensification, urban expansion and weed invasion. About 3000 hectares were lost yearly in the decade to 2004.[67] The natural temperate grasslands to the west of Melbourne declined by at least 44% between 1985 and 2000, and further clearing has been approved for urban development. The proposed offsets are unlikely to compensate for losses, due to the difficulty of restoring degraded grassland communities.[68]

More than three-quarters of Victoria's woodlands (5.9 million hectares) have been cleared, leaving about 1.8 million hectares, two-thirds on private land.[69] About one-quarter of the woodland ecological vegetation classes are not represented in the national park and conservation system and more than three-quarters are inadequately represented.[70] One of the most important conservation decisions of the past decade was the declaration of box-ironbark national parks. But still only 2% of their original (pre-1750) extent is permanently protected.

The following nine ecological communities have been listed as nationally threatened under the Environment Protection and Biodiversity Conservation Act due mainly to clearing (two others are listed for other reasons).[71]

Natural temperate grassland of the Victorian Volcanic Plain	critically endangered	<2% remaining (5000 ha)
Grassy eucalypt woodland of the Victorian Volcanic Plain	critically endangered	<3% remaining (18,000 ha)
Natural grasslands of the Murray valley plains	critically endangered	<5-10% remaining
Seasonal herbaceous wetlands (freshwater) of temperate lowland plains	critically endangered	declined by ~ 44% in area
Gippsland red gum (*Eucalyptus tereticornis* subsp. *mediana*) grassy woodland and associated native grassland	critically endangered	~1-5% remaining (900 to 5600 ha)
White box–yellow box–Blakely's red gum grassy woodland and derived native grassland	critically endangered	<6% remaining (61,360 ha)
Littoral rainforest and coastal vine thickets of east Australia	critically endangered	279 ha remaining (plus areas in NSW & Qld)
Buloke woodlands of the Riverina and Murray-Darling Depression	endangered	
Grey box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of south-eastern Australia	endangered	~13% remaining (200,000 ha)

Native vegetation condition

Up to 2005, several thousand hectares – mostly in native grasslands – was estimated to be lost annually and there is no reason to believe that this rate of loss has slowed. More substantial now, however, is the effect of ongoing pervasive degradation – as a result of weed invasion, and activities such as stock grazing and removal of undergrowth and fallen timber – across the remaining remnant native vegetation.

Victorian Environmental Assessment Council, 2011[72]

Recent measures of native vegetation extent combine losses due to clearing and degradation by the habitat hectares method. The first and only state-wide account of vegetation using this method in 2008 estimated an annual loss of 17,410 habitat hectares, of which about 90% was due to decline in vegetation condition rather than extent, and a gain of 13,320 habitat hectares due to management and revegetation, leaving a net loss of 4000 habitat hectares.[73] This figure is not directly comparable with past measures, which are only of clearing. However, the habitat hectares method underestimates loss – for example, it does not count permitted clearing or logging as a loss because they are presumed to be compensated for by offsets and regeneration – and it overestimates gain by assuming that the condition of vegetation in protected areas automatically improves. [74] Although clearing is still causing substantial damage, particularly in highly endangered communities such as grasslands and buloke woodlands, the major cause of vegetation loss in Victoria is now chronic degradation – due to fragmentation, grazing, invasive species (plants, animals, diseases), firewood collection and regeneration failure.[75] Native vegetation on private land is generally in poorer condition than that on public land.[76]

Nearly 80% of Victoria consists of 'fragmented landscapes' (defined in Box 3.3), encompassing more than half (54%) the remaining native vegetation (Table 3.9, Figure 3.11).[77] Much native vegetation is in small patches: 88% of 2.72 million patches documented in 2010 are less than one hectare in size, while 68% of the total vegetation extent is in patches larger than 1000 hectares.[78] Vegetation fragments are often vital for biodiversity, as harbour for rare and declining species, and often highly biologically productive, as they are mostly in landscapes favoured for agriculture because of their high productivity. About 40% of Victoria's terrestrial vertebrates are virtually restricted to fragmented landscapes, and another 45% rely on fragmented landscapes across much of their range.[79]

Smaller habitat patches usually support fewer individuals because they have fewer resources and because increasing habitat patchiness disrupts multiple ecological processes. Patch isolation prevents species movements – for food and breeding, for seasonal migrations, to escape disturbance or in response to climate change. Fragmentation alters interactions between species – affecting competition, predation, parasitism and mutualisms. In Victoria, it has facilitated domination by invasive pasture grasses and aggressive (native) noisy miners for example (Box 3.7). As fragmentation increases, the resilience of native vegetation remnants to external pressures is lowered and they become increasingly influenced by processes and land uses in modified areas. Patches are subject to edge effects – changes in physical and biological conditions at a boundary, such as altered microclimates and weed invasion – which can penetrate metres to kilometres into patches.[80]

Small populations isolated in habitat patches are highly vulnerable to extinction from chance events and loss of genetic diversity.[81]

Box 3.3 Intact versus fragmented landscapes[82]

Largely intact landscapes are defined by the state government as contiguous areas of native vegetation greater than 20,000 hectares in good condition. The 'underlying stock' of native vegetation is stable; natural or semi-natural dynamics are the dominant drivers. They correspond closely with Victoria's major parks and state forests.

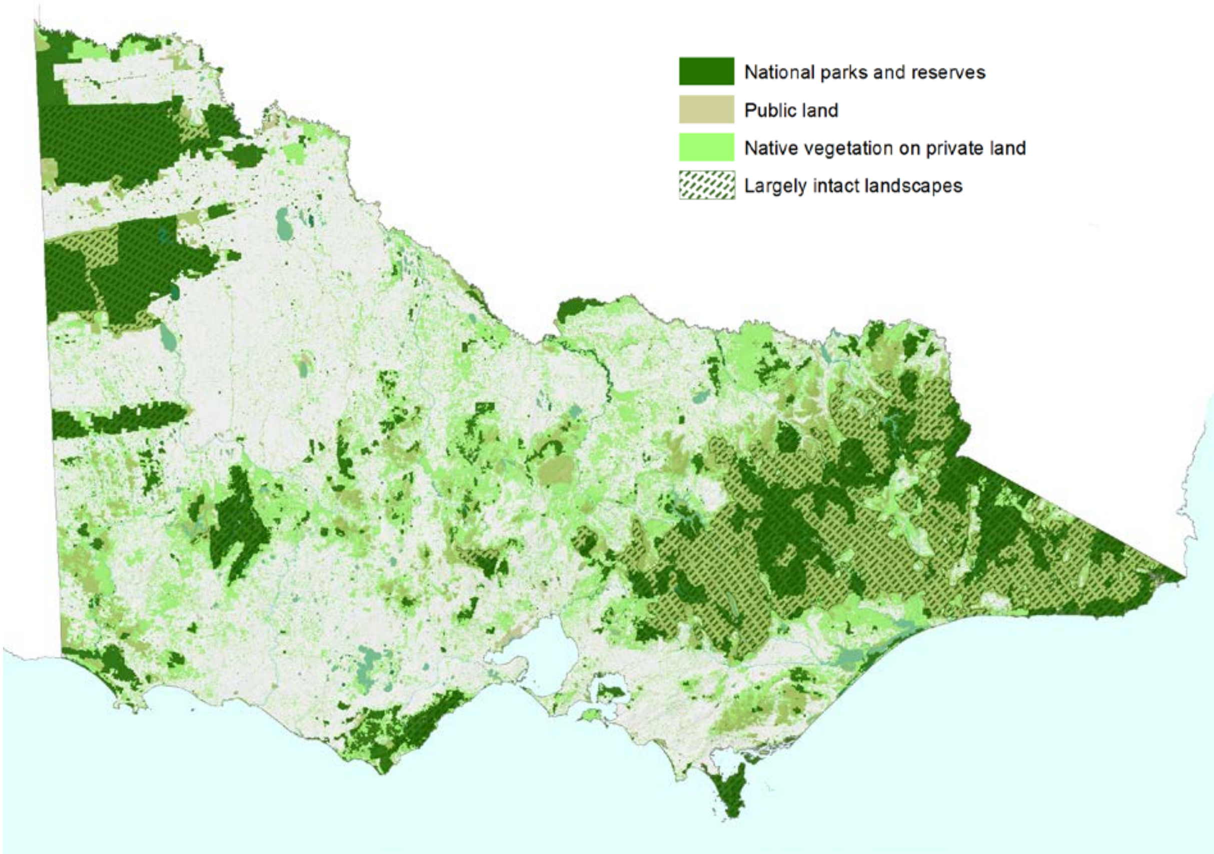
Fragmented landscapes are areas outside largely intact landscapes where there has been widespread removal and use of native vegetation for economic development. The 'underlying stock' of native vegetation is declining or at risk of decline; degradation and recovery from degradation are the dominant factors in vegetation change.

Table 3.9 Fragmented versus largely intact landscapes, public and private land[83]

	Fragmented (million ha)	Fragmented (%)	Largely intact (million ha)	Largely intact (%)	Total area (million ha)
Total land area	17.8	79	4.9	21	22.7
Private land	14.0	>99	0.02	<1	14.1
Public land	3.8	44	4.8	56	8.6
Native vegetation	5.6	54	4.9	46	10.5
Native vegetation on private land	2.8	97	0.1	3	2.9
Native vegetation on public land	2.8	37	4.8	53	7.6

Source: Victorian Environmental Assessment Council

Figure 3.11 Largely intact landscapes



Map: VNPA. Source: Department of Environment and Primary Industries.

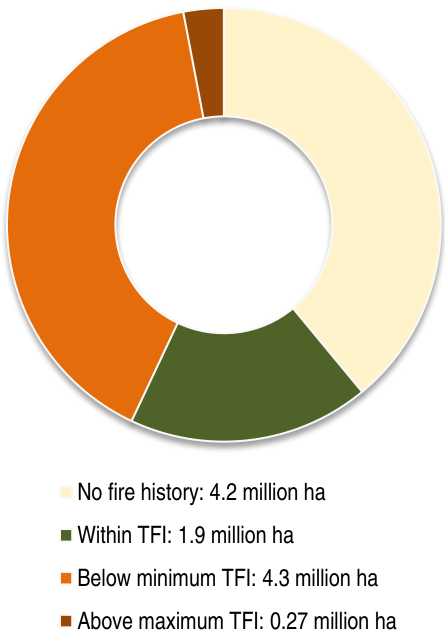
Native vegetation and fire regimes

[It] is likely that inappropriate fire regimes exist for the majority of Victoria's native vegetation.
Victoria State of the Environment 2013

Particular patterns of ecological disturbance – by fire, flood, wind, storms, droughts, for example – are essential for maintaining diversity in certain ecosystems. Fire is a particularly powerful disturbance in many Victorian ecosystems, shaping the structure and composition of habitats, and determining the availability of resources (nutrients, light, space). Too much fire or too little, the wrong type or wrong timing can drive species declines.

Many habitats in Victoria are subject to inappropriate fire regimes, which are skewing vegetation communities to domination by early growth stages and, in some cases, transforming them into different vegetation types. A 2012 assessment found that only 18% of the native vegetation assessed on public lands was within the 'tolerable fire intervals' needed to maintain the vegetation communities and 39% could not be assessed due to lack of knowledge of its fire history (Figure 3.12).[84] (The minimum tolerable fire interval for a vegetation type is set by the slowest plants to reach reproductive age and produce seed; the maximum is set by the earliest time when plants start to senesce.[85]) The large-scale bushfires of recent times have engendered domination by early growth stages over extensive areas. Of assessed native vegetation (excluding the area with an unknown fire history), 35% was found to be in early growth stages compared to 25% in 'mature' or 'over mature' stages. Much of Victoria's wildlife depends on older growth stages, which have already been much depleted by land clearing and forestry.

Figure 3.12 Tolerable fire interval (TFI) status of native vegetation on public land (% area, June 2012)[86]



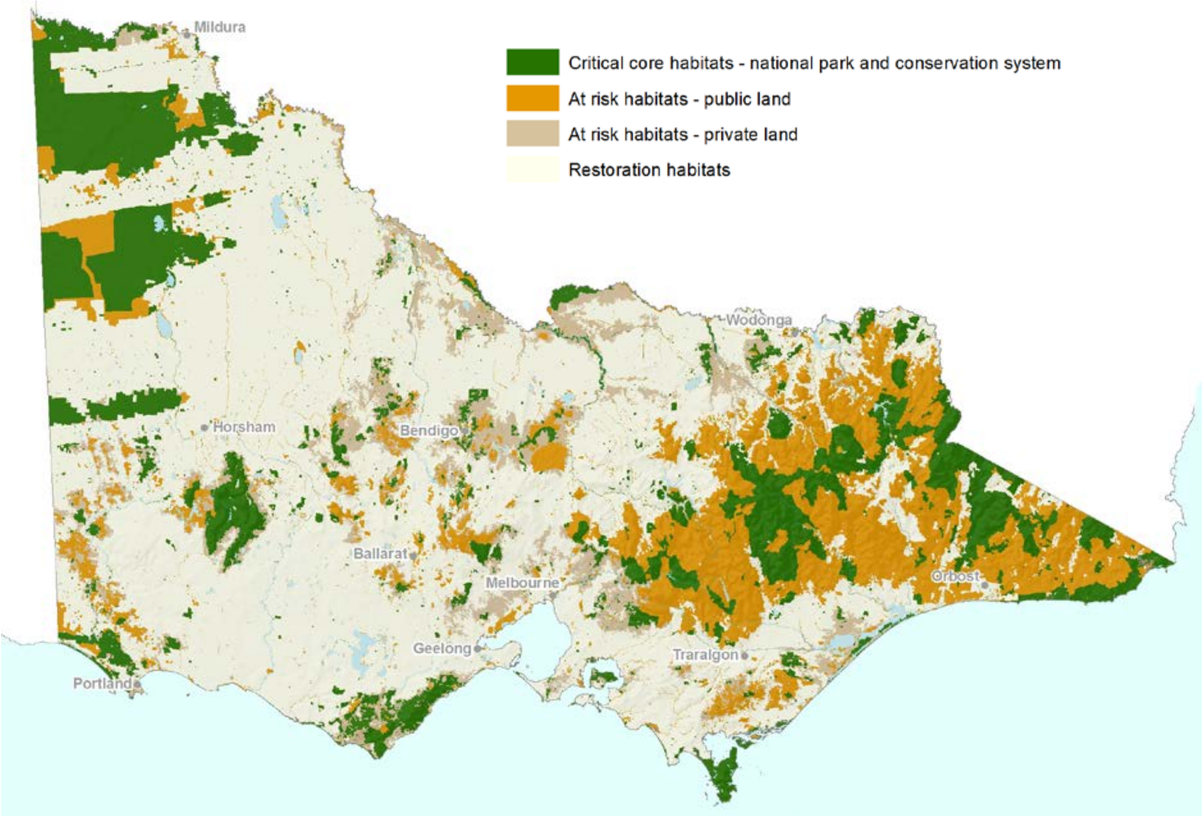
Data source: State of the Environment Victoria 2013.

VNPA habitat classification

The extent and condition of remnant vegetation is the major determinant of ecosystem health, and the stark differences in vegetation cover between different subregions imply very different conservation priorities. VNPA has developed the following three tier classification for habitats, based on condition and potential contribution to state-wide conservation objectives (Figure 3.13), as a framework for determining conservation priorities (discussed in section 5.3).

- **Critical core habitats** have largely intact vegetation with natural ecological processes still functioning. They are mostly larger properties or networks of smaller properties in the national park and conservation system (public or private tenure). The conservation goal is to maintain their biodiversity values and ecological processes.
- **At risk habitats** still have extensive areas of native vegetation but habitat values are declining or at risk because of unsustainable exploitation and lack of environmental management. Most occur on public lands outside the national park and conservation system and there are also some highly significant areas on private land. The conservation goal is to permanently protect them from further intensive land-uses and manage them for conservation.
- **Restoration habitats** are extensively cleared, often degraded and used primarily for economic purposes, but have some areas retaining important natural values. They are almost entirely on private land. The conservation goal is a net improvement in native habitat within a productive landscape by maintaining and improving the extent and quality of vegetation and habitats.

Figure 3.13 VNPA habitat classification: critical core, at risk and restoration habitats



Map & analysis: VNPA. Data sources: Department of Environment and Primary Industries; Trust for Nature. At risk habitats include vegetated public lands outside the national park and conservation system, and private lands outside the national park and conservation system that are within 'biodiversity priority zones' (as identified by the Trust for Nature in its *Statewide Conservation Plan 2013*). Restoration habitats are the balance of lands outside urban areas.

Native forests

A century and a half of bushfires and European forest management has left Victoria with a native forest estate that is returning decreasing yields of quality wood and pushing forest managers into more marginal country.

National Institute of Economic and Industry Research, 2010[87]

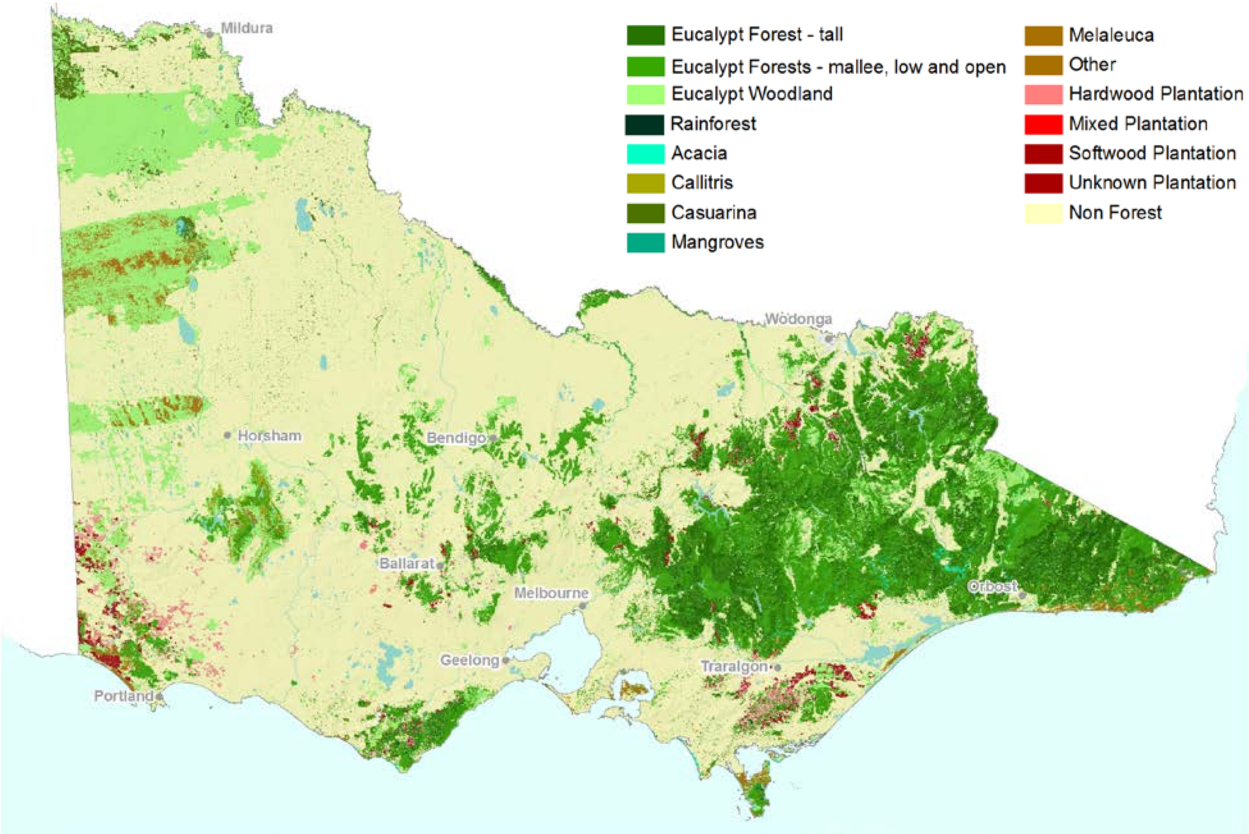
More than half of Victoria's forests have been cleared, leaving one-third of the state (7.8 million hectares, 35%) with native forest, most dominated by eucalypts (Table 3.11, Figure 3.14). The majority of forests (87%) are on public land, of which about 1.2 million hectares are available for commercial harvesting (Table 3.10). About 1 million hectares of native forest occur on private land. There are also more than 400,000 hectares of plantations in Victoria, 99% on private land, about half hardwood (eucalypt species) and half softwood (exotic pines).[88]

Table 3.10 Victoria's native forest tenures[89]

Forest tenure/use	Area (million ha)	% of native forest
Total native forest	7.85	100
Native forest on private land	1.02	13
Native forest on public land	6.83	87
Conservation reserves(1)	3.50	45
Leasehold land	0.11	1
Other crown land	0.03	<1
State forests	3.14	40
Timber production area (eastern Vic)	2.48	32
Available for harvesting(2)	1.20	15
Exempt from harvesting(3)	1.28	16

Sources: Department of Environment and Primary Industries, VicForests (1) These include national parks, nature reserves, state parks and other conservation areas managed by Parks Victoria, and reserves for the protection of water supply catchments. They differ in their level of protection, but more than 90% can be regarded as part of the national park and conservation system. (2) These areas are zoned general management or special management (the latter have conditions on harvesting to conserve particular species or features). (3) These areas are special protection zones and other reserves.

Figure 3.14 Victoria's forest types[90]



Map: VNPA. **Data source**: Australian Bureau of Agricultural and Resource Economics and Sciences 2008. Significant areas of native forest in the Strzelecki Ranges have been incorrectly designated by government as plantation (as noted in the 2001 nature conservation review).

Despite their high biodiversity values and extensive damage caused by historic over-logging and frequent fires, Victoria's native forests continue to be commercially logged, including clear-felling of about 5000 hectares a year, and also exploited for firewood (section 3.4.3). More than a century of logging and large wildfires have depleted most of Victoria's 'old-growth' forest. Just 1.2% of mountain ash forests – a highly fragmented 1885 hectares – are in an old-growth stage, down from an estimated 60-80% prior to European colonisation.[91] When Victoria's regional forest agreements were signed in 1997-2000, there was an estimated 842,000 hectares of old-growth (although what counts as old-growth is contested)[92] of which, by 2006, at least 5.3% (more than 44,000 hectares) had been lost to logging.[93] Fire has destroyed even larger areas – more than 100,000 hectares of old-growth forest between 2003 and 2006 – the impacts exacerbated by salvage logging (the removal of dead and live trees from burnt areas).[94] There is a risk that mountain ash forests will disappear over large areas due to a 'landscape trap' resulting from the combined effects of wildfire, logging and salvage logging.[95]

Many Victorian species rely on forests for all or part of their life cycle, including at least 37 frog species, 117 reptiles, 272 birds, 87 mammals and 2853 vascular plants.[96] More than a quarter of forest vertebrate animal species and about 10% of plants are considered extinct or threatened.[97] Wildlife dependent on old-growth forest have lost most of their habitat, including Leadbeater's possums and about 30 other species reliant on cavities in mountain ash, which take more than 120 years to develop.[98] With fewer than 2000 Leadbeater's possums left, there is a high risk this species will go extinct in the near future. In the 2009 fires, more than one-third of public land within its highland habitat range was burnt and logging continues to deprive it of existing and future regrowth habitat (Box 3.15).[99]

Little is known about the status of invertebrates, fungi and non-vascular plants. Ecological knowledge of forest species varies from 'comprehensive' for about 10% of birds and mammals, 40% of frogs, 2% of reptiles and 5% of vascular plants to 'poor' for 45% of vascular plants and more than 90% of invertebrates, fungi, lichen and algae.[100]

Table 3.11 Victoria's forest types and extent (million hectares)[101]

State forest	Parks & conservation reserves(1)	Other crown land	Private land	Leasehold land	Total area
Woodlands: *Acacia*, *Callitris*, *Casuarina*, eucalypt tall, eucalypt medium, eucalypt low, eucalypt mallee, other					
0.496	1.788	0.033	0.485	0.004	3.118
17.7%	63.7%	1.2%	17.3%	0.1%	100%
Forests: eucalypt tall open, tall closed, medium open, medium closed, low open & low closed; rainforest					
2.608	1.464	0.074	0.519	0.030	4.693
55.6%	31.2%	1.6%	11.0%	0.6%	100%
Total eucalypt woodlands and forests					
3.103	3.250	0.107	1.004	0.034	7.497
Estuarine or wetland forests: mangroves, *Melaleucas*					
<0.001	0.020	<0.001	0.005	<0.001	0.027
Total native forest area					
3.164	3.506	0.109	1.025	0.035	7.838
Total plantation area					
0.019	0.007	0.009	0.272	0.133	0.441
Total forest area					
3.184	3.513	0.118	1.297	0.168	8.278
38.5%	42.4%	1.4%	15.7%	2.0%	100%

Source: Department of Sustainability and Environment, with advice from The Wilderness Society. (1) Not all parks and conservation reserves are in the national park and conservation system.

3.2.4 Land managed for conservation

Victoria's terrestrial national park estate (national parks, state parks, wilderness parks and reference areas) covers about 3.3 million hectares (14% of Victoria's land area, about one third of the public land area) (Table 3.12). These properties are highly protected by virtue of their legislated security (they cannot easily be revoked), permanence and requirement that they be managed primarily for nature conservation. Nonetheless, some current and proposed activities in the national park estate, such as grazing, prospecting and resort development, are inconsistent with conservation (section 3.5.1).

An additional 600,000 hectares of private and public land are part of the national park and conservation system (see section 1.4 for an explanation of this term). These properties are generally smaller than those in the national park estate, averaging 150 hectares compared to 25,000 hectares, and have less rigorous legal requirements to manage them for conservation. IUCN protected area management categories 1-4 (nature reserve, wilderness area, natural monument or feature, national park or habitat/species management area) and properties described by the Victorian Environmental Assessment Council as part of the conservation reserve system are mostly consistent with VNPA's national park and conservation system category. The list of protected area categories in Victoria, their respective legislation and how VNPA classifies their level of protection is shown in section 1.4.

Victoria's national park and conservation system offers uneven and highly inadequate protection to its great variety of terrestrial ecosystems, as Figure 3.15 shows. In 2011 at a meeting of the Convention on Biological Diversity, the Australian government adopted the *Strategic Plan for Biodiversity 2011-2020* and its 'Aichi targets', which include a target to protect at least 17% of terrestrial areas. Only half of Victoria's subregions meet this target. Figure 3.15 also shows that a substantial proportion of remnant vegetation in the least protected subregions occurs on private lands.

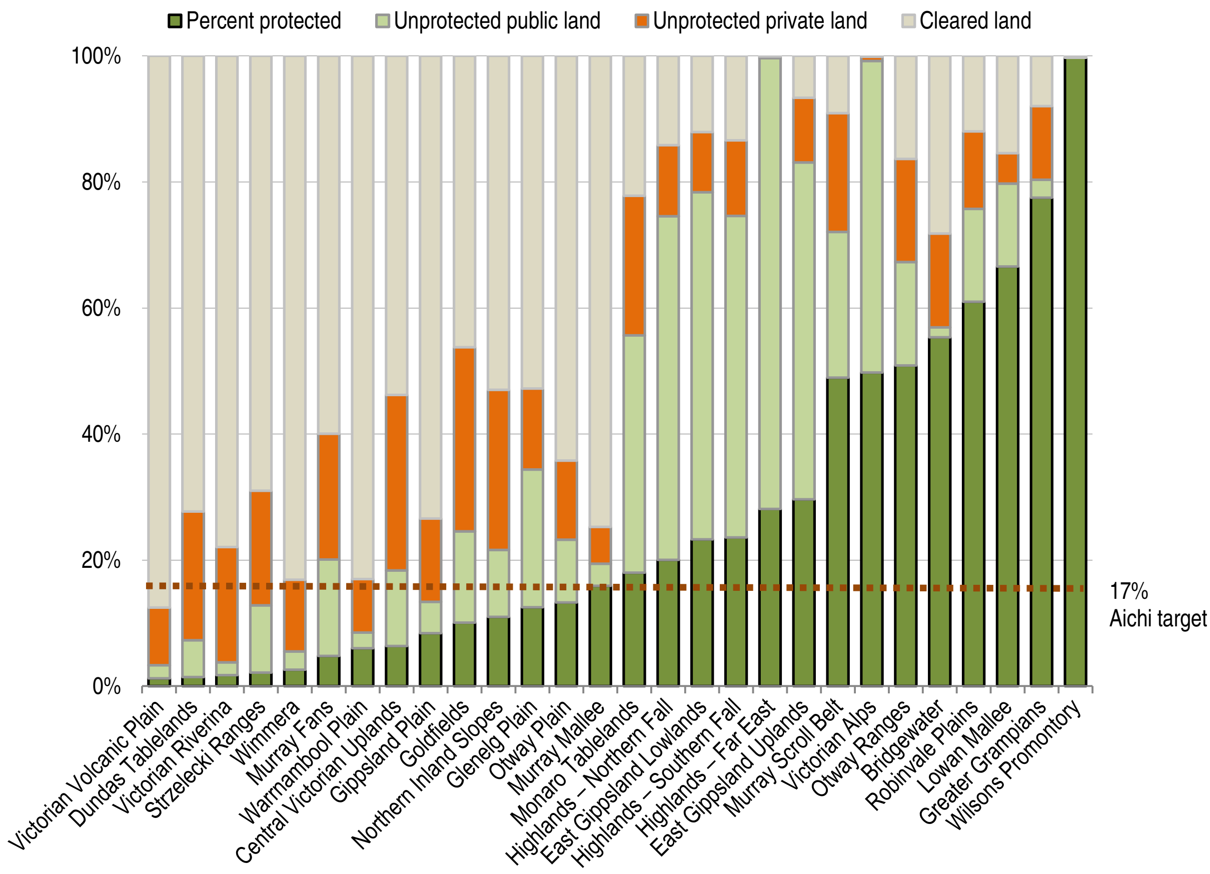
Section 3.3 provides much more detail on gaps in Victoria's national park and conservation system by analysing the extent to which it meets specific targets for comprehensiveness, adequacy and representativeness.

Table 3.12 Victoria's national park and conservation system[102]

Conservation property types	Legislation	Number	Area (hectares)	% of state
National park estate				
National parks(1)	National Parks Act	45	2,901,284	12.8
State parks(1)	National Parks Act	26	157,825	0.7
Wilderness parks(1)	National Parks Act	3	200,699	0.9
Reference areas (included in above)(2)	Reference Areas Act	105	89,369	0.4
Reference areas (additional to above)(2)	Reference Areas Act	54	22,636	0.1
Subtotal		128	3,282,444	14.4
Other conservation properties, public lands (as defined in table 1.3)				
Schedule 3 parks & reserves(1)	National Parks Act	18	76,555	0.3
Nature conservation reserves(2)	Crown Lands (Reserves) Act, Wildlife Act	259	130,725	0.6
Natural features reserves(2)	Crown Lands (Reserves) Act	2,496	315,900	1.4
Others		2	2,861	-
Other conservation properties, private lands				
Trust for Nature(3)	Conservation Trust Act	1,330	93,456	0.4
Subtotal public and private		>4,000	619,497	2.7
Total		**>4,000**	**3,901,941**	**17.2**

Data sources: (1) Department of Environment and Primary Industries (2013), (2) CAPAD 2012, (3) Trust for Nature (March 2014). Trust for Nature properties counted here include covenants, reserves and revolving fund purchases. The number of public 'other conservation properties' is higher than shown here because it relies on data from 2012.

Figure 3.15 The proportion of remnant, cleared and protected vegetation in each Victorian subregion



Private protected areas

As Figure 3.15 above illustrates, private protected areas will necessarily have an increasingly important role in Victorian conservation. The majority of land with remnant vegetation in the least protected subregions is privately owned. The Trust for Nature found that about 60% of the 452 subregional classes without any representation in protected areas have more than 70% of their remaining extent on private land.[103] A substantial proportion of this remnant vegetation has very high conservation value because it is of a threatened ecological vegetation class.

Only a few mechanisms provide protection on private land of sufficient security, permanence and conservation management focus to meet the criteria for the national park and conservation system. Of 16 mechanisms (under law or by contract) for protection of private land in Victoria identified in Table 3.16, only properties with Trust for Nature conservation covenants, Trust for Nature and some other non-government reserves meet the VNPA criteria (section 1.4).

The Trust for Nature plays a central role in private land conservation. Since 1972, it has secured the protection of about 100,000 hectares through conservation covenants, a revolving fund (land is bought, covenanted and sold), private reserves and the purchase and transfer of land to the state (Table 3.13).[104] Its role is particularly important in highly cleared areas such as the Victorian Volcanic Plains, the Warrnambool Plain and the Wimmera, where there are few national parks and mostly small vegetation remnants. In 2013, the organisation identified 12 'focal landscapes' that 'provide the best opportunities for maintaining priority ecosystems and species on private land' (Table 3.22, Figure 3.16).[105] These priority areas were determined by identifying connected landscapes of more than 20,000 hectares that integrate:

- large patches of land with consistently high biodiversity values of statewide significance (as identified in NaturePrint, see Figure 3.7)

- ecosystem replication at the bioregional or catchment scale
- landscape connectivity
- additional biodiversity assets of statewide significance on private land in the intervening landscape.

Apart from the mechanisms identified in Table 3.16, Victorian landholders are contributing to conservation in multiple ways, the extent of which is poorly documented. Much of it is outside formal programs. The extent of participation in a few programs is outlined in Table 3.14. The Land for Wildlife program, for example, recognises and supports landholders for maintaining and restoring habitat for wildlife. It is valuable for educating landholders and providing extension, with the potential to motivate participants to aim for more secure forms of biodiversity protection.

A small proportion of agricultural land is managed for conservation: 0.5% is under a conservation agreement, and activities such as protection of native vegetation, revegetation, and livestock exclusion are occurring on 1-2% of agricultural land area (Table 3.17). About 750 conservation agreements are in perpetuity.

Table 3.13 Private land permanently protected for conservation through Trust for Nature

Mechanism	Properties	Area (ha)
Trust for Nature covenants	1279	56,080
Trust for Nature reserves	44	36,093
Trust for Nature revolving fund purchases(1)	7	1,283
Total(2)	1330	93,456

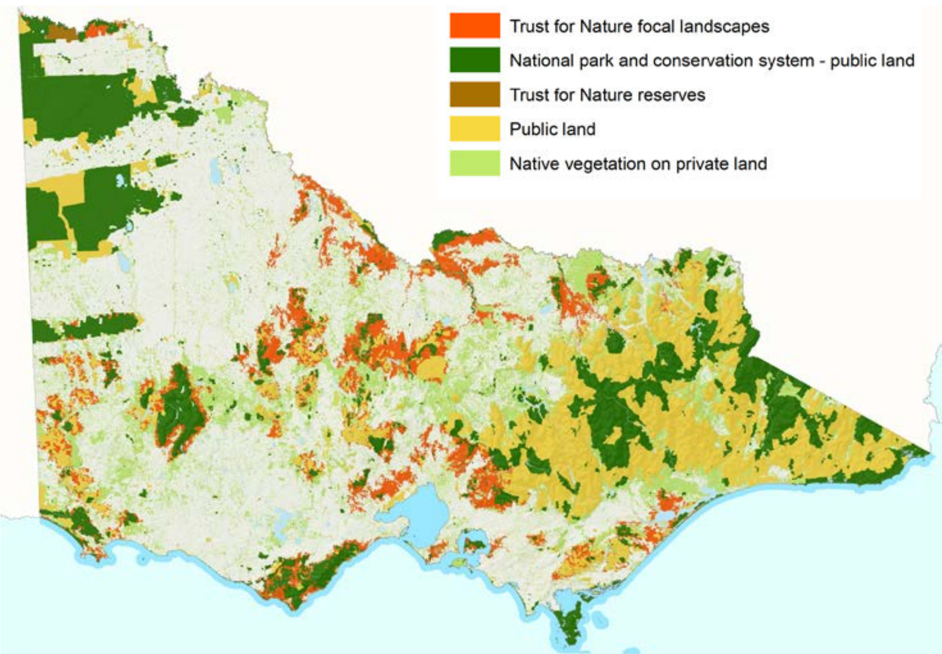
Source: Trust for Nature, 24 March 2014. (1) Addition of covenants to these properties is imminent, prior to resale. (2) In addition, Trust for Nature bought 65 properties (6744 hectares) that were transferred to the state, almost entirely for addition to the national park estate.

Table 3.14 Other private land managed for conservation (non-permanent protection)[106]

Mechanism	Properties	Area (ha)
BushTender & similar incentive schemes (2001 -2010)		26,000
National Action Plan & Natural Heritage Trust incentive schemes		35,500
Land for Wildlife (2014)(1)	5300	170,000

Sources: Department of Sustainability and Environment, (1)Personal Communication, Peter Johnson, Statewide Coordinator, Land for Wildlife.

Figure 3.16 Trust for Nature focal landscapes



Map: VNPA. Data Sources: Trust for Nature; Department of Environment and Primary Industries

Table 3.15 Trust for Nature focal landscapes[107]

Focal landscape	Significant biodiversity assets on private land (hectares)
Eastern Riverina	170,000
Gippsland Plain & Gippsland Lakes catchment	81,000
Murray Scroll Belt	52,000
Northern Inland Slopes	114,000
Otway Ranges & coast	80,000
Port Phillip & Westernport	25,000
South-West	179,000
Strzelecki Ranges & Plains	37,000
Victorian Midlands	567,000
Western Melbourne ranges & plains	57,000
Western Riverina	179,000
Yarra-Cardinia Catchments	157,000

Table 3.16 Mechanisms for private land conservation, and whether they meet criteria for the national park and conservation system[108]

Agreement / property type	Legislation	Secure?	Permanent?	Conservation management intent?	Meets criteria for the NP&C system?
Trust for Nature conservation covenants	Conservation Trust Act	✓	✓	✓	Yes
Trust for Nature reserves	Conservation Trust Act	✓	✓	✓	Yes
Trust for Nature revolving fund	Conservation Trust Act	✓	✓	✓	Yes
NRSP private protected areas[(1)]	N/A	✓	✓	✓	Yes
Land management cooperative agreements	Conservation, Forests & Lands Act	X	Depends on terms	Depends on terms	No
Wildlife management cooperative areas	Wildlife Act	✓	Depends on terms	Depends on terms	Depends on terms
Wildlife sanctuaries	Wildlife Act	✓	X	X	No
BushTender & similar agreements – *with covenant*	Conservation Trust Act	✓	✓	✓	Yes
BushTender & similar agreements – *permanent*	Conservation, Forests & Lands Act	X	Depends on terms	Depends on terms	No
BushTender & similar agreements –*fixed-term*	N/A	X	X	✓	No
Section 173 agreements	Planning & Environment Act	X	Depends on terms	X	No
Public authority management agreements	Flora & Fauna Guarantee Act	X	Depends on terms	✓	No
Interim conservation orders	Flora & Fauna Guarantee Act	X	X	Depends on terms	No
Indigenous protected areas	N/A	✓	✓	✓	Yes
Land for Wildlife properties	N/A	X	X	✓	No
Local government reserves	N/A	X	X	✓	No

Source: Fitzsimons (2006), with minor modifications. [(1)] NRSP is the National Reserve System Program. For properties purchased with funding from the NRSP, an agreement is signed with the federal government committing the landholder to manage the site according to guidelines and agreeing to it becoming a private protected area.

Table 3.17 Agricultural conservation activities[109]

Conservation activities per area of agricultural businesses	Area (ha)	%
Native vegetation protected for conservation	246,263	1.9
Total livestock exclusion	179,198	1.4
Controlled livestock access	210,389	1.7
Managed weeds	417,215	3.3
Managed invasive animals	514,703	4.1
Retained existing native vegetation	162,310	1.3
Revegetated with native vegetation	149,187	1.2
Wetlands protected for conservation	19,807	0.2
River or creeks protected for conservation	74,480	0.6
Total livestock exclusion to protect river or creek banks	32,670	0.3
Controlled livestock access to protect river or creek banks	22,746	0.2
Managed weeds to protect river or creek banks	150,892.5	1.2
Managed invasive animals to protect river or creek banks	52,151.5	0.4
Conservation agreement (1,829 holdings, average of 10.9 years, 732 perpetual agreements)	59,578.9	0.5
Trees and shrubs planted or sown for nature conservation	8,916	<0.1
Total agricultural area	12,697,842	
Conservation activity per number of agricultural businesses	**Number**	**%**
Member of a landcare group (29%) (number)	9,434	29.0
Participating in projects or receiving funding from Caring for our Country (including Landcare)	2,100	6.5
Participating in projects or receiving funding from non-government groups (number)	242	0.7
Participating in projects or receiving funding from Community Action Grants	282	0.9
Conservation agreements (total, averaging 10.9 years)	1,829	5.6
Conservation agreements in perpetuity	732	2.3
Total number of agricultural businesses	32,529	

Indigenous lands managed for conservation

Indigenous Victorians have had an intimate connection to the land, sea and natural processes reaching back tens of thousands of years. During most of the period of European colonisation, they were deliberately separated from their country, denied access to traditional foods and discouraged from maintaining their culture. After continual resistance and struggle this is changing, with Aboriginal culture becoming increasingly recognised and respected.

Through legal instruments associated with native title or by government agreement, some protected areas are being jointly managed by Traditional Owners and government agencies. Others are being managed under cooperative management agreements. The federal Indigenous protected areas program supports Traditional Owners to establish protected areas on their land, and the Indigenous Land Corporation assists Aboriginal people to acquire freehold lands. All offer a way for Traditional Owners to maintain connections with their country, practice their culture and contribute to the conservation of biodiversity. There is growing support for drawing on the skills and knowledge of Indigenous people to assist in management of the national park and conservation system.

The state government has six agreements regarding management of national parks and reserves with five Indigenous Owner groups over about 300,000 hectares of protected areas.[110] Three are for 'cooperative' management and three are for 'joint' management (Table 3.18). These agreements recognise the ongoing connection of Traditional Owners to their land and allows Indigenous owners and public land managers to share their knowledge to manage specific areas.[111] Under joint agreements, national parks and reserves within a Traditional Owner group's agreement area may be transferred to the Traditional Owner corporation as 'Aboriginal title'. Management rights for the land are then transferred back to the state, to be jointly managed in perpetuity by the state and the Traditional Owner land management board. Joint management is also possible without the granting of Aboriginal title, as is the case for the agreement with the Yorta Yorta people for Barmah National Park (Box 3.11).

In all cases, the cooperatively or jointly managed protected areas continue to be managed under the same legislation under which the parks and reserves were dedicated. Jointly managed lands are subject to a joint management plan developed by the Traditional Owner land management board (of which Traditional Owners have majority membership), and approved by the environment minister following public consultation.

An additional benefit of joint management arrangements is helping park visitors to learn more about the culture, history and aspirations of Traditional Owners.

Under the federal government's Indigenous protected area program, Indigenous landowners agree to manage their land or sea estate as a protected area in the national reserve system and receive support from the federal government to do so. Five Indigenous protected areas (declared under the federal program) have been established in Victoria (Table 3.19).

Table 3.18 Cooperative and joint management agreements

Agreements	Area (hectares)
Yorta Yorta Nation Aboriginal Corporation Cooperative Management Agreement (2004)	22,000
Barengi Gadjin Land Council Aboriginal Corporation Cooperative Management Agreement (2005)	194,000
Gunditj Mirring Traditional Owners Aboriginal Corporation Cooperative Management Agreement (2007)	8,000
Gunaikurnai Land & Waters Aboriginal Corporation Traditional Owner Land Management Agreement (2010)	46,000
Yorta Yorta Nation Aboriginal Corporation Traditional Owner Land Management Agreement (2010)	29,000
Dja Dja Wurrung Clans Aboriginal Corporation Traditional Owner Land Management Agreement (2012)	49,000

Table 3.19 Indigenous protected areas

Indigenous protected areas	Area (hectares)
Deen Maar (southwest coast, 1999)	453
Tyrendarra (near Portland, 2003)	248
Framlingham Forest (2009)	1,142
Kurtonitj (between Mt Eccles and the coast, 2009)	353
Lake Condah (next to Mount Eccles, 2010)	1,700

3.3 Gaps in the national park & conservation system

Although, Victoria has a fairly extensive national park and conservation system, particularly compared with most Australian states and territories, it offers very uneven protection to the great variety of terrestrial ecosystems in the state, and is far from being a comprehensive, adequate and representative system, the accepted national goal, explained in Box 3.4. There are various interpretations of what is needed to meet the goal. The targets adopted for this review – called the 'nature conservation review (NCR) reserve targets' – are based on subregional ecological vegetation classes and are slightly modified from targets developed in the *Nature Conservation Review 2001* (Box 3.4), which were modified from JANIS targets, adopted by governments for forest ecosystems in regional forest agreements. The NCR targets are defined and compared with the JANIS targets in Table 3.20. The NCR reserve targets range from 30% protection of the remaining extent of least concern ecological vegetation classes in fairly intact bioregions to 90-100% protection of endangered and rare vegetation classes and 100% protection of vegetation within 500 metres of the coastline.

Box 3.4 Targets for a comprehensive, adequate and representative reserve system

Since 1992, Australian governments have been committed to the development of a comprehensive, adequate and representative (CAR) reserve system, by which is meant the following:

- *Comprehensive*: the reservation of examples of regional-scale ecosystems in each bioregion.
- *Adequate*: the reservation of sufficient levels of each ecosystem to provide ecological viability and to maintain the integrity of populations, species and communities.
- *Representative*: the reservation of areas at a finer scale, to encompass the variability of habitats within ecosystems.

Reserve targets for a CAR system have changed over time as scientific understanding of and public and political support for the concept have grown. In 2011 the IUCN and the Australian government adopted the *Strategic Plan for Biodiversity 2011-2020* and its 'Aichi targets' at a meeting of the Convention on Biological Diversity, which include a target to protect at least 17 per cent of terrestrial and inland water and 10 per cent of coastal and marine areas by 2020 in an 'ecologically representative and well-connected systems of protected areas'. The Victorian government will need to consider how to apply the Aichi targets to Victoria.

The regional forest agreements have used the 'nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia' (known as the JANIS criteria or the national agreed reservation targets). JANIS targets for forest ecosystems are 15% of the pre-1750 extent of each forest ecosystem, except where ecosystems are endangered or vulnerable, in which case the targets are 100% and 60% respectively of the existing area (Table 3.20). There are also JANIS objectives for species, which are 'to maintain viable populations of native forest species throughout their natural ranges, and to maintain genetic diversity of native forest species'.[112]

VNPA's *Nature Conservation Review 2001* concluded that the JANIS targets were inadequate and developed more robust reserve targets for Victorian ecosystems (not just forests). The main changes were (1) a minimum target of 30% of the current extent of each 'least concern' ecological vegetation class (rather than 15% of their pre-European extent) to provide greater surety of protection and (2) higher targets for fragmented bioregions (defined as bioregions with less than 35% of remnant native vegetation) because of evidence of declines and extinctions of vertebrates, such as woodland birds, in fragmented habitats.[113]

This review recommends one addition to the targets: that 100% of coastal vegetation is reserved because of its vital role this in maintaining coastal processes and protecting the coastal environment.

These justified and achievable targets – known here as the 'NCR reserve targets' – are used in this review as the measure to assess progress towards a comprehensive, adequate and representative national park and conservation system. Many assessments use only partial measures and therefore do not provide a complete picture of the extent of reservation required to establish a comprehensive, adequate and representative system.

Table 3.20 Nature conservation review (NCR) reserve targets and JANIS targets for ecological vegetation classes (EVCs)[114]

Conservation status or location of EVC	NCR reserve targets	JANIS targets (for forests)
Extinct	Rehabilitate, revegetate, and reserve	No specific target
Endangered	90% (preferably 100%) of remaining extent	100% of remaining extent
Vulnerable	60% of remaining extent, 90% in fragmented subregions	15% of pre-1750 extent or 60% of remaining extent (whichever is largest)
Depleted	60% of remaining extent, 90% in fragmented subregions	No specific target
Rare	90% (preferably 100%) of remaining extent	100% of remaining extent
Least concern	30% of remaining extent, 50% in fragmented subregions	15% of pre-1750 extent, except where other targets apply.
Coastal	100% of remaining extent within 500 metres of coastline	No specific target
Wilderness	No specific target	90% of remaining extent
Old-growth	No specific target	60%-100% of remaining extent, depending on rarity
All other	Not applicable	15% of pre-1750 extent

Notes: The status of ecological vegetation classes is as defined by the Department of Sustainability and Environment. The NCR reserve targets are slightly modified from those of the 2001 VNPA nature conservation review by Traill and Porter.

Table 3.21, Table 3.22 and Figure 3.17 show the extremely uneven and inadequate protection for biodiversity (represented by subregional ecological vegetation classes) in Victoria's national park and conservation system. The least protected subregions typically have the highest proportions of vegetation loss, endangered ecological vegetation classes and unrepresented ecological vegetation classes (Table 3.21). They typically also have a high proportion of land in private ownership and high diversity (as represented by numbers of ecological vegetation classes). Eleven subregions have less than a quarter of remnant vegetation protected in the national park and conservation system, eight of which have had more than half their native vegetation cleared and nine of which have more than a quarter of their ecological vegetation classes endangered. The converse is also true: the least cleared subregions have the highest level of protection in the national park and conservation system and the fewest endangered ecological vegetation classes.

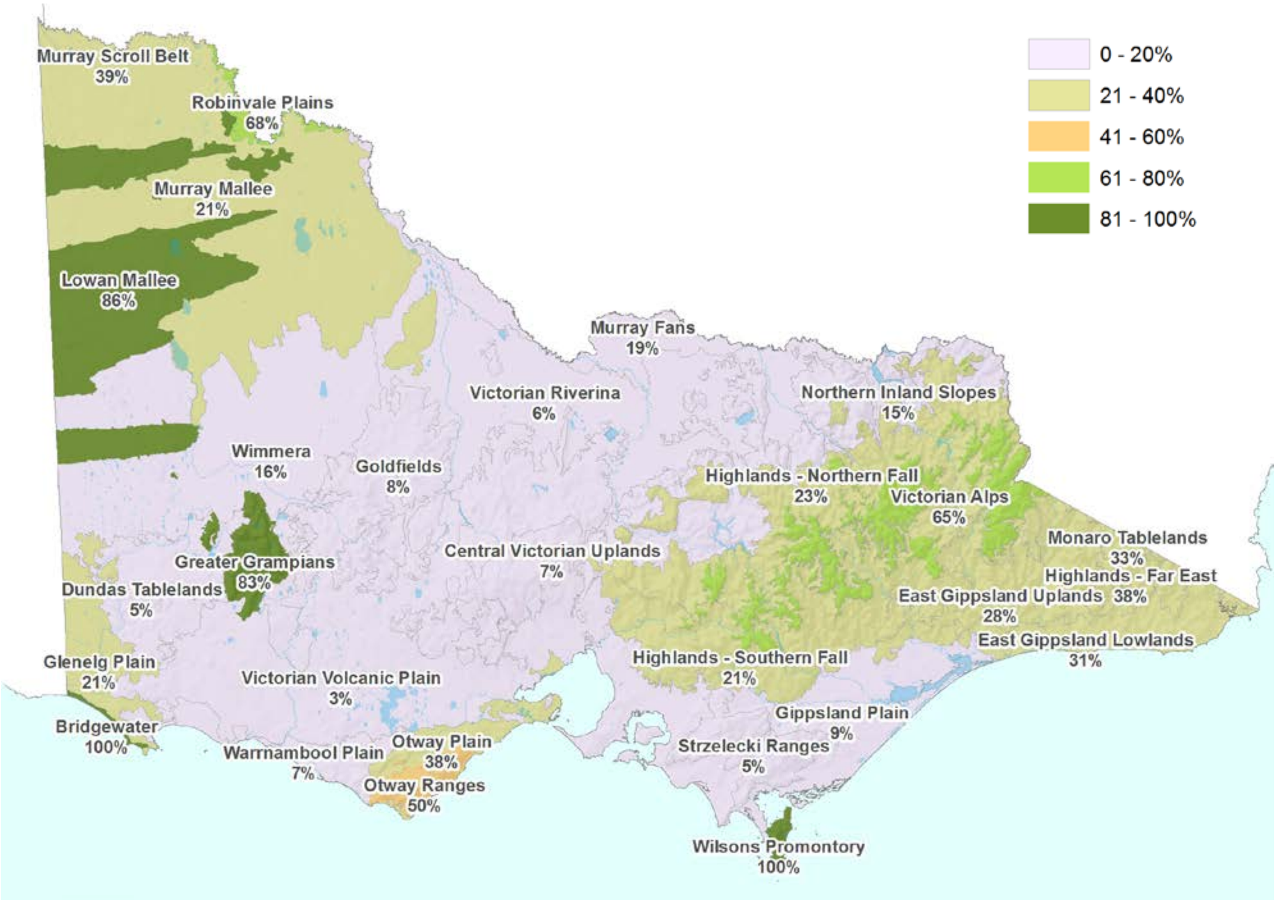
Only four of Victoria's 28 subregions have a high level of protection with at least three-quarters of their ecological vegetation classes achieving the NCR reserve target (the subregions marked green in Table 3.22) and another two subregions have more than half their vegetation classes meeting the NCR target (marked a paler green). But in more than three-quarters of subregions fewer than half the ecological vegetation classes meet the NCR target (subregions marked orange or pale orange). Overall, less than a third of subregional ecological vegetation classes meet either the NCR reserve targets or the JANIS targets (Table 3.22).

Only two of Victoria's 21 vegetation types (groups of ecological vegetation classes have more than half their ecological vegetation classes meeting the NCR reserve targets (Table 3.23). The seven least protected types, with less than a quarter of ecological vegetation classes meeting the NCR targets, are those that have been most heavily targeted for agriculture. Victoria's four most threatened vegetation types, with 15% or less of their original extent remaining, have less than one third of their remaining extent protected in the national park and conservation system (Table 3.24).

The gap analysis shows the importance of private land conservation. The five subregions with the lowest proportion of native vegetation have more than two-thirds of their area in private land tenure and in four of them more than a third of ecological vegetation classes are endangered (Table 3.21). Of the 50% of Victoria's subregions that are more than 50% privately owned, all but one have lost more than 50% of their native vegetation and all but one have less than 50% of their remnant vegetation protected.

In some categories, the NCR reserve targets are more demanding than the JANIS targets (which are now more than 15 years old) but, even so, a similar pattern applies for the JANIS targets, with only nine subregions having more than half their ecological vegetation classes meeting the targets (one fully) (Table 3.22). Other analyses also show that Victoria's national park and conservation system has substantial gaps. A WWF-Australia analysis based on the JANIS criteria (with a target of 15% of the pre-1750 extent of 'major vegetation groups' at a subregional scale) found that only 58% of the target area in Victoria was protected in the national park estate, with a gap of 1.4 million hectares.[115] In addition, only 30% of nationally threatened species had at least 30% of their distribution in the national park estate. Another gap analysis of Victoria's protected area in 2012 using a range of environmental variables that influence the distribution and abundance of many terrestrial species and ecosystems (rainfall, temperature, solar radiation, terrain wetness and radiometry) found that many environmental classes had little or no representation.[116] Thus, by multiple interpretations of what is needed to achieve a comprehensive, adequate and representative reserve system – including by targets adopted by the state government – it is clear that Victoria's national park and conservation system needs to expand, on both public and private land tenures (section 3.5.1).

Figure 3.17 The proportion of ecological vegetation classes in Victorian subregions that meet the nature conservation review reserve targets



Map & analysis: VNPA (See Table 3.21 for method). Data source: Department of Environment and Primary Industries.

Table 3.21 Victorian subregions: remnant vegetation, public tenure, vegetation protection, ecological vegetation classes (EVCs) and representation in the national park and conservation system

Bioregion	Protected (%)	Subregion	Public tenure (%)	Remnant vegetation (%)	Remnant vegetation protected (%)	EVCs (#)	Endangered EVCs (# / %)	EVCs with no protection (%)[3]
Australian Alps	50	Victorian Alps	99	100	50	48	6 / 12	2
Flinders	100	Wilsons Promontory	100	100	100	34	2 / 6	0
Murray Darling Depression	23	Lowan Mallee	80	85	79	35	8 / 23	3
		Murray Mallee	21	25	63	46	9 / 20	11
		Wimmera	7	17	15	135	60 / 44	19
Naracoorte Coastal Plain	14	Bridgewater	58	72	77	13	4 / 31	15
		Glenelg Plain	42	47	27	88	36 / 41	27
SW Slopes[1]	11	Northern Inland Slopes	24	47	23	70	42 / 60	35
Riverina	6	Murray Fans	22	40	12	127	35 / 28	22
		Murray Scroll Belt	50	91	54	21	2 / 10	5
		Robinvale Plains	76	88	69	29	4 / 14	7
		Victorian Riverina	6	22	8	125	62 / 50	38
South East Coastal Plain	9	Gippsland Plain	19	27	32	124	60 /48	24
		Otway Plain	30	36	37	50	21 / 42	12
		Warrnambool Plain	7	17	35	44	27 / 61	36
South East Corner	27	East Gippsland Lowlands	79	88	26	50	12 / 24	30
		East Gippsland Uplands	83	93	32	52	7 / 13	23
		Highlands – Far East	100	100	28	18	0 / 0	18
South Eastern Highlands	21	Highlands – Northern Fall	78	86	23	60	15 / 25	19
		Highlands – Southern Fall	76	87	27	72	18 / 25	18
		Monaro Tablelands	56	78	23	17	0 / 0	12
		Otway Ranges	70	84	61	27	9 / 33	8
		Strzelecki Ranges	19	31	7	30	17 / 57	18
Victorian Midlands	12	Central Victorian Uplands	22	46	14	93	44 / 47	40
		Dundas Tablelands	9	28	5	104	54 / 52	36
		Goldfields	26	54	19	74	39 / 53	48
		Greater Grampians	81	92	84	212	26 / 12	11
VVP[2]	1	Victorian Volcanic Plain	30	12	10	127	84 / 66	38

0-25%	26-50%	51-75%	76-100%	In public tenure, remnant vegetation, remnant vegetation protected, percentile for number of EVCs, percentile for number of endangered EVCs, percentile for % unrepresented ecosystems.

Notes: [1] NSW South Western Slopes. [2] Victorian Volcanic Plain. [3] No protection was defined as those with <1 hectare in protected areas as defined in methods. Methods: VNPA applied the NCR reserve targets to the EVC dataset supplied by the Department of Environment and Primary Industries (DEPI) (last updated March 2008) and as updated by Trust for Nature in 2011 to include Trust for nature covenants and reserves. Areas were considered 'protected' if they were designated as 'conservation reserve' by DEPI or protected by a Trust for Nature covenant or reserve. The NCR reserve targets were based on the criteria in Table 3.20. The conservation status of each EVC was based on the status assigned by DEPI in the EVC dataset. A fragmented subregion is defined as one that has less than 35% of its vegetation remaining. EVCs that are minor occurrences in a subregion were excluded from the analysis. A minor occurrence was defined as those subregional EVCs for which the pre-European extent in the subregion was less than 1% of the statewide extent of that class and less than 1000 hectares. EVC mosiacs, complexes, aggregates and wetland map units were included in the analysis since a conservation status was ascribed. Due to a lack of data it has not been possible to apply the targets comprehensively to freshwater systems or to the coastal zone. The analysis also does not take into account the spatial arrangement of reserves, the need to protect core habitats, corridors and isolated remnants, the specific needs of species and requirements for climate change adaptation.

Table 3.22 The extent to which Victoria's national park and conservation system meets the NCR reserve targets and JANIS targets for each subregion

Subregion	Remnant vegetation protected (%)	EVCs meeting NCR targets (%)	EVCs meeting JANIS targets (%)	Subregion	Remnant vegetation protected (%)	EVCs meeting NCR targets (%)	EVCs meeting JANIS targets (%)
Victorian Volcanic Plain	10	3	6	Highlands – Northern Fall	23	23	32
Strzelecki Ranges	7	5	17	East Gippsland Uplands	32	28	37
Dundas Tablelands	5	5	12	East Gippsland Lowlands	26	31	32
Victorian Riverina	8	6	10	Monaro Tablelands	23	33	59
Warrnambool Plain	35	7	16	Highlands – Far East	28	38	44
Central Victorian Uplands	14	7	11	Otway Plain	37	38	38
Goldfields	19	8	11	Murray Scroll Belt	54	39	57
Gippsland Plain	32	9	15	Otway Ranges	61	50	67
Northern Inland Slopes	23	15	11	Victorian Alps	50	65	60
Wimmera	15	16	20	Robinvale Plains	69	68	72
Murray Fans	12	19	28	Greater Grampians	84	83	78
Glenelg Plain	27	21	26	Lowan Mallee	79	86	71
Highlands – Southern Fall	27	21	31	Bridgewater	77	100	62
Murray Mallee	63	21	41	Wilsons Promontory	100	100	100
Statewide						29	32

0-25%	26-50%	51-75%	76-100%

Source: VNPA analysis of data from Department of Environment and Primary Industries (protection on public land) and Trust for Nature (protection on private land). See Table 3.21 notes for method.

Table 3.23 The extent of protection of ecological vegetation class (EVC) groups

EVC group	EVCs (#)	EVCs meeting NCR targets (%)	EVC group	EVCs (#)	EVCs meeting NCR targets (%)
Plains woodlands or forests	137	6	Coastal scrubs grasslands and woodlands	53	38
Plains grasslands and chenopod shrublands	22	14	Heathy woodlands	71	41
Rainforests	28	18	Salt-tolerant and/or succulent shrublands	29	41
Riverine grassy woodlands or forests	165	18	Mallee	29	45
Riparian forests or woodlands	37	19	Montane grasslands, shrublands or woodlands	22	45
Riparian scrubs or swampy scrubs and woodlands	113	20	Lowland forests	35	46
Box ironbark forests or dry/lower fertility woodlands	22	23	Wet or damp forests	45	49
Wetlands	185	28	Sub-alpine grasslands, shrublands or woodlands	16	50
Lower slopes or hills woodlands	82	28	Rocky outcrop or escarpment scrubs	47	53
Herb-rich woodlands	95	28	Heathlands	70	54
Dry forests	132	34	**Total**	**1435**	**29**

0-25%	26-50%	51-75%	76-100%

Source: VNPA analysis of data from Department of Environment and Primary Industries (protection on public land) and Trust for Nature (protection on private land).

Table 3.24 The extent of protection for Victoria's most threatened vegetation types

Ecological vegetation class group	Remaining pre-1750 extent (%)	Protected (%)	EVCs that meet NCR targets (%)
Plains grasslands and chenopod shrublands	6	18	14
Plains woodlands or forests	7	19	6
Lower slopes or hills woodlands	11	19	28
Herb-rich woodlands	15	26	28

Source: VNPA analysis of data from the Department of Environment and Primary Industries (protection on public land) and Trust for Nature (protection on private land).

3.4 Major threats

Victoria's terrestrial ecosystems suffer from a multitude of human-driven extinction processes. Listed under the Flora and Fauna Guarantee Act, for example, are about 30 'potentially threatening processes' affecting terrestrial habitats, ranging from the very specific, such as collection of native orchids and disturbance from marble mining, to the very broad, such as climate change.

Following is a focus on the four major threats or threat categories: climate change, habitat loss and degradation, invasive species and inappropriate fire regimes. They are each pervasive, affecting virtually all Victoria's habitats to some degree, and have multiple, complex and interacting (often synergistic) impacts on biodiversity.

Protection of assets will not be effective unless the ecological processes that sustain them are maintained.

Andrew Bennett and others, 2009[117]

As well as directly affecting specific sites and species ('assets'), these threats disrupt natural ecological processes, thereby compromising 'the interactions and connections between living and non-living systems' (or more colloquially, 'the natural machinery that connects living and non-living things and keeps nature healthy').[118] Table 3.25 lists seven categories of ecological processes with examples of processes and the ways they are disrupted by these and other threats.

Table 3.25 Categories and examples of ecological processes and process-disrupting threats[119]

Ecological processes category	Examples of ecological processes	Threats that disrupt natural ecological processes	Examples of priority actions
Climate	Natural patterns of rainfall, temperature and extreme events	Climate changes exceeding the capacity of organisms to adapt, increasing frequency of severe fire weather	Protect natural carbon sinks, promote resilience and adaption (chapter 5)
Primary productivity	Water, nutrient and soil cycles	Clearing, agriculture, weed invasion	Stop clearing, promote natural regeneration, restore riparian zones, control weeds
Hydrological processes (chapter 4)	Stream flows and connections between surface and groundwater flows, flood events that carry water across floodplains	Dams and other barriers to stream flow, clearing, altered soil conditions affecting runoff, pollution, coal seam gas extraction	Deliver environmental flows, reinstate natural flooding regimes
Formation of biophysical habitats	Soil crust formation, accumulation of leaf litter, decomposition of organic matter, soil turnover due to animal digging	Soil compaction, erosion, salinity, loss of animal diggers	Protect and restore native vegetation, retain woody debris and litter, restore populations of native digging animals
Interactions between organisms	Pollination, seed dispersal, predation, competition, parasitism	Invasive species, loss of pollinators, decline in top predators	Manage invasive weeds, animals and diseases, restore populations of top predators
Movements of organisms	Seasonal migrations, searches for food and shelter, dispersal of propagules	Fragmentation, barriers (fences and roads), droughts	Restore aquatic-terrestrial links, remove barriers to movement, link isolated vegetation remnants
Natural disturbance regimes	Patterns of fire, floods, droughts, storms, extreme temperatures	Altered fire regimes and increases in extreme events due to climate change	Implement ecologically appropriate fire regimes

3.4.1 Climate change

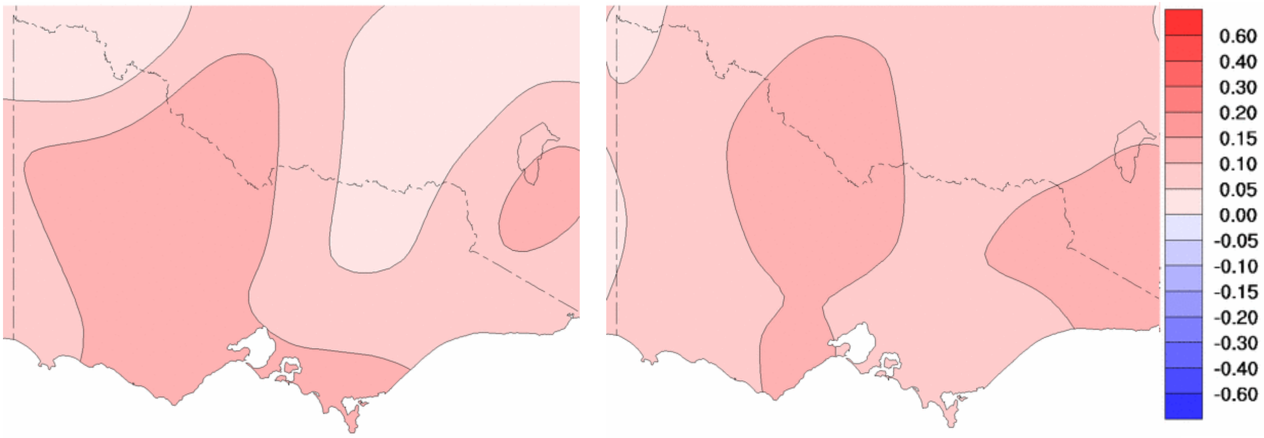
Climate change will lead to most places in Australia having, by 2070, environments that are more ecologically different from current conditions than they are similar.

Mike Dunlop and others, 2012[120]

Like the rest of the world, Victoria has been heating up: in the past century the state's average annual mean temperature has increased by 0.9°C.[121] Some of the most severe impacts of climate change are being manifested in more extreme or more frequent weather extremes, as exemplified by recent heatwaves:[122]

- In the last week of January 2009, record high temperatures were set at several places, along with an unprecedented three days above 43.0°C in Melbourne.
- On 7 February 2009, Victoria recorded its hottest ever temperature of 48.8°C at Hopetoun (1.6°C above the state's previous record). Of the 35 long-term temperature-recording stations in Victoria, 24 recorded their hottest temperature that day.
- On 29 November 2012, Victoria recorded its highest spring temperature on record (45.8 °C at Ouyen) and it was the hottest November day on record over a third of the state.
- Victoria had its warmest winter on record in 2013.
- In January 2014, Victoria had its hottest four-day period on record for maximum and daily mean temperatures. The statewide average maximum temperature exceeded 41°C on four successive days from 14 to 17 January, another record.

Figure 3.18 Trends in maximum (left) and mean (right)temperatures, 1910-2013[123]



Source: Bureau of Meteorology, Australian climate variability and change trend maps

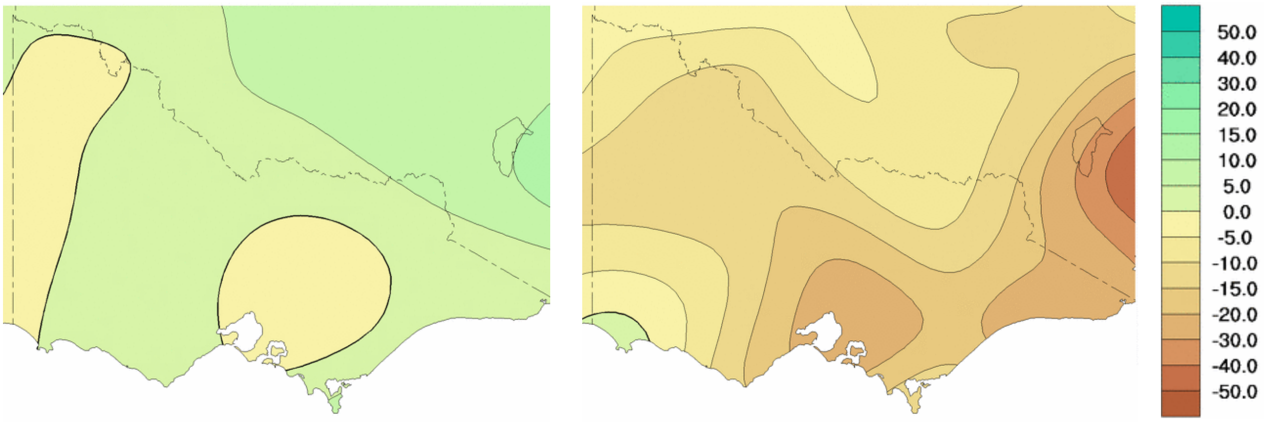
Victoria's rainfall has experienced large yearly and decadal variations over the past century, and there have been no clear trends. During the 1997–2010 drought, the longest and worst on record for south-eastern Australia, Victoria's average rainfall declined by about 15%. By 2009, stream-flow volumes in Victoria were 32% of the long-term average, and the total water storage for Victoria by mid-2009 was 17% of capacity. The drought ended with the fifth wettest year on record, when rainfall was 31% above average.

The drought was associated with higher fire danger, with unprecedented fire risks in several places in February 2009, due to a combination of record high temperatures, very low relative humidity, high wind speeds and a lack of rain. The Black Saturday bushfires burnt 430,000 hectares and killed 173 people. Fire danger and the length of the fire season have increased in Victoria in recent decades.[124]

South-Eastern Australian Climate Initiative researchers have found a strong relationship between climate change and the millenium drought, via the influence of a high pressure belt known as the subtropical ridge, which is strengthened by warmer temperatures. The strengthening of the subtropical ridge accounted for an estimated 80% of the recent rainfall decline in south-eastern Australia.[125]

It is predicted that Victoria's mean temperature will rise by 1.4°C by 2050 (under a mixed fossil and renewable fuels scenario), within a range of 0.9°C to 1.9°C.[126] The rainfall trend is less predictable, but the state is likely to become drier while extreme events (intense bursts of rainfall and heatwaves) become more common. The most likely change by 2050 is a 6% reduction in mean rainfall (under a mixed fossil and renewable fuels scenario). The extent and frequency of droughts may more than double by 2050.[127] Bushfire vulnerability will increase.

Figure 3.19 Rainfall trends in Victoria, 1900-2013 (left) and 1960-2013 (right)[128]



Source: Bureau of Meteorology, Australian climate variability and change trend maps. Rainfall trends as a change in millimetres per decade. Brown indicates a drying trend and green indicates a wetting trend.

Box 3.5 Impacts of climate change on biodiversity[129]

Primary impacts: Habitat for particular species is rendered unsuitable due to changes and extremes in temperature, rainfall, soil or air moisture levels, availability of free water, hydrology, wind and seasonal conditions.

Secondary impacts: Changes in fire regimes (particularly high intensity megafires), increased flooding, waterlogging and erosion, sea-level rises, and changes in competition from other species, including exotic species and overabundant native species.

Tertiary impacts: Resulting from human responses to climate change, eg shift of intensive agriculture into new areas, increased fire hazard reduction activities, development and introduction of 'climate change adapted' plants and animals including biofuels.

The different processes of ecological change, each driven by climate change, will combine to make prediction about the details of change and likely loss of biodiversity very difficult.

Michael Dunlop and others, 2012[130]

Predicting the consequences of human-caused climate changes is a great ecological challenge for they will involve changes in 'species distributions and abundances, interactions between species, ecological processes, threats to biodiversity, the rates of ecological change, and the role of habitat and landscape diversity in mediating changes'.[131] Changing land use by humans will add to the complexity.132 Most Australian species have endured great climatic swings over the past few million years, but in many respects future climatic changes will be unlike any previous because of the extensive loss and fragmentation of habitat, the presence of exotic species, and human domination of many resources (all at their extreme in Victoria).

A 2008 national assessment of climate change impacts on the National Reserve System cautions that people 'run the risk developing one simple mental model of what changes will occur based on a single type of impact, and using that implicitly to drive expectations and proposed management actions'.[133] The researchers described three models of change for populations, all of which will occur to varying degrees. All three models 'should be regarded as equally important for the purposes of designing monitoring programs, interpreting observed changes, anticipating future changes, assessing conservation implications and considering management options'.

Changes in abundance: Under this model, climate change will result in changes to ecosystem structure and function and species abundance. Dramatic changes could result – restriction of fire-sensitive species to fire refuges, increases in sleeper populations of invasive species and replacement of dominant species. Outcomes will be the result of many interacting factors and hard to predict.

Long-distance or rapid distribution change: Under this model, changes lead to opportunities for a small proportion of species to establish beyond their current distributions – for example if higer carbon dioxide levels increase their competitive ability or if reduced frost and snow open up new habitat or if they are dispersed by more extreme floods or storms. This could have dramatic impacts on ecosystems if the newly establishing species have a major impact on other species or ecosystem structure or function, such as some invasive species have had.

Gradual distribution shift: Under this model, species gradually change their distribution, in different directions and at varying rates – some expand, others contract, some disappear and others don't change. Ecosystem composition, structure and function also gradually change, with novel ecosystems forming and some current ones disappearing.

Climate change is already affecting biodiversity due to higher temperatures, drier conditions and more frequent extreme events (although the degree of contribution by climate change to specific events is difficult to say).[134] At particular risk in the near term are alpine, moist and coastal habitats. Species with low ecological tolerances and specialised requirements, low genetic variability, long generation times, poor dispersal ability and narrow geographic range are likely to have the greatest difficulties adapting to climate change.[135] Other species will benefit and become more abundant, some adding to threats faced by others if they are predators, competitors, pathogens or parasites (Box 3.7).[136] Because of the complex changes that will result, climate change will undoubtedly produce 'surprises and nasty synergies'.[137] Other threats – particularly altered fire regimes, invasive species, altered hydrology and changing land use – are likely to be amplified under climate change. There has already been a reported shift in land use from sheep grazing to dryland cropping in south-west Victoria due to drier conditions, and conversions of now rarely inundated wetlands to crops or exotic pastures.[138]

Box 3.6 Interactions of habitat loss and a changing climate – collapsing bird populations[139]

The climatic conditions expected under rapid climate change render [bird] populations even less resilient to land-use change than previously thought. … The urgency and magnitude of remedial action required are many-fold greater than current practice.

Ralph Mac Nally and others, 2009

Bird surveys in central Victoria (over 15 years to 2008) have revealed major declines in about two-thirds of bird species. The 30,000 km^2 area retains only 17% of its original vegetation cover of mostly box and ironbark forests and woodlands. The decline was similar in largely intact native vegetation (including in national parks) and in heavily cleared landscapes, and occurred for all types of birds. There was almost no breeding detected in the last survey period and eucalypt flowering had significantly declined over 12 years of drought. The collapses are thought to be due to a crash in availability of all types of food due to drought exacerbating losses due to past clearing and ongoing habitat degradation. Most remnant vegetation is on sites with shallow, infertile soils. On the better soils of the plains, remnant vegetation is scarce and highly fragmented.

Enhancing resilience of birds in the box and ironbark system in the face of climate change will require improving habitat quality in remnant forest, retaining large old trees, protecting fallen timber from firewood harvesting and recreating spatial patchiness in ground layers. The greatest gain will come from restoring more fertile areas, where tree growth is faster and warm-season flowering species will provide more year-round food resources.

3.4.2 Dysfunction of biological interactions – invasive species

[The] most widespread mammals and vascular plants in the state are all non-natives.

Viridians Biological Databases[140]

The cornucopia of exotic plants and animals inhabiting Victoria cause immense damage to terrestrial biodiversity and ecological processes, as reflected in the 17 listings of various invasive species as potentially threatening processes under the Flora and Fauna Guarantee Act, and as stressed also in the last two VNPA nature conservation reviews. In the 2001 review, Traill and Porter said: 'After direct destruction of habitat, existing environmental weeds and feral animals are probably the current most important cause of habitat loss and degradation in Victoria. In the long-term they may become the most important cause.'

Many of Victoria's most widespread species are exotic, most deliberately introduced for agriculture and gardens. A smaller proportion are accidental introductions, arriving with traded goods. Most still have much potential to spread and increase, and new species keep arriving, which means invasive species' impacts will worsen unless laws, policies and programs are greatly strengthened. Information about their extent and impacts is patchy and particularly sparse for groups like invertebrates, microbes and fungi.[141]

Invasive plants

Of about 1000 exotic plants established in native vegetation in Victoria, about 580 are known to threaten biodiversity, landscape or social values, 129 seriously so.[142] Environmental weeds in general, as well as each of blackberry, tall wheat grass and *Spartina*, are listed as potentially threatening processes. The days of irresponsible introductions haven't passed – new agricultural plants are being bred to be more drought-resistant and tolerant of low nutrients, for example, and there are almost no restrictions to prevent introductions of new plants known to be weedy elsewhere in Australia.[143] From 1970 to 1995, an average of more than seven new plants (mostly garden escapees) established in the wild in Victoria each year, and the rate was increasing.[144]

Weeds cause major damage by:[145]

- outcompeting or shading out other plants and creating weed monocultures (eg invasive pasture grasses, blackberry, willows)
- intensifying fire regimes by adding flammable biomass (eg gorse and large grasses like phalaris)
- swamping waterways with dense plant mass, depleting oxygen (eg *Sagittaria* species and alligator weed)
- transforming ecosystem processes (eg willows alter stream hydrology and marram grass alters sand dune dynamics)
- providing havens for damaging invasive animals (eg blackberry and gorse shelter rabbits and foxes)
- hybridising with native plant species.

Severe weeds like blackberry, English broom, phalaris and tall wheat grass can completely transform ecosystems by replacing almost all native plants.[146]

Invasive animals

At least a dozen invasive animals rate amongst Victoria's most serious threats. Cats and foxes have contributed to several extinctions and threaten many more: foxes are known to threaten 91 Victorian vertebrate species and cats at least 27.[147] Large hard-hoofed creatures – feral goats, horses and deer among them – are causing widespread degradation and loss of rare plants. Rabbits, another major cause of degradation, are on the increase. Invertebrates like feral European honeybees, European wasps, English wasps, Argentine ants and unknown numbers of others are competing with native animals and compromising ecological processes such as pollination in mostly undocumented ways. A new amphibian – the smooth newt – was recently found in Melbourne's south-eastern suburbs and may pose a serious threat to aquatic biodiversity.[148] Argentine ants, feral cats, foxes, rabbits, sambar, horses and goats are each listed as potentially threatening processes. The impacts of invasive animals are too variable to list. For feral deer alone, which are accorded protected status under the Wildlife Act for the benefit of hunters, impacts include the following:[149]

- damaging and eating rare plants (due to browsing, grazing or antler rubbing)
- altering the structure and composition of vegetation communities

- disrupting ecological processes, especially in rainforest
- facilitating access for introduced predators by creating paths in dense vegetation
- competing with native herbivores
- causing erosion, which affects water quality
- trampling sensitive areas (such as alpine bogs, mossbeds, wetlands)
- spreading weeds
- hindering revegetation efforts
- maintaining elevated populations of wild dogs (which feed on carcases dumped by hunters).

Invasive pathogens

Invasive pathogens of native plants and animals are an alarming and escalating threat. *Phytophthora cinnamomi* (a water mould) infects a wide variety of native plants and could occur over 60% of Victoria.[150] Many habitats of threatened plant species are in areas classified as high risk. So far, *Phytophthora* dieback has been concentrated in ash and stringybark trees in coastal forest in east and south Gippsland. Heathlands and coastal forest communities are particularly susceptible. Infections can dramatically alter species composition and vegetation structure. Myrtle rust, which arrived in Victoria in 2011, infects plants from family Myrtaceae, the dominant plant family in Victoria (and Australia) that includes eucalypts, paperbarks and teatrees.[151] It could substantially alter composition and structure of some plant communities and threaten highly susceptible species. Several new plant pathogenic fungi establish each year in Australia.[152]

Of animal diseases, chytrid fungus is the most severe (probably responsible for the greatest disease-caused loss of global biodiversity in recorded history), lethally infecting several Victorian frog species in montane and foothill forests (see section 4.4).[153] It is listed as a potentially threatening process. Pigeon paramyxovirus, which arrived in 2012 (probably via smuggled racing pigeon eggs), could infect several bird species but its potential impacts are unknown.

Much of the damage caused by invasive species is synergistic with other threats such as habitat fragmentation and degradation, inappropriate fire regimes and climate change. Three invertebrate invaders likely to affect alpine and subalpine ecosystems have recently been recorded for the first time above 1500 metres in the Victorian Alps – European honey bees, grey field slugs and European wasps – exemplifying one of the greatest threats to alpine habitats under climate change.[154]

Harmful native species

Several native species have also become invasive or threats to other wildlife, when introduced outside their natural range or because they benefit from human-caused changes such as altered habitats, altered fire regimes and soil disturbance. Coast tea-tree, coast wattle and sweet pittosporum (the last listed as a potentially threatening process) are three examples of native plants that threaten rare vegetation communities in Victoria. Landscape changes now favour native noisy and yellow-throated miners, which tend to monopolise habitats at great cost to many other species (Box 3.7).[155] Most remaining box woodlands in northern Victoria are thought to be dominated by noisy miners, which are listed as a potentially threatening process. Disturbances such as logging and thinning are thought to have significantly increased the incidence of myrtle wilt, a fungal disease that kills mature myrtle beech trees in cool temperate rainforests.[156] It has reached epidemic levels only in the past 40 years, and is listed as a potentially threatening process.[157]

Box 3.7 Climate change and noisy miners

Changing interactions between species will be one of the most influential impacts of climate change. Noisy miners, a native honeyeater, have been recognised as a potentially threatening process in Victoria because they aggressively exclude other birds from their territory.[158] They are a major threat to woodland birds across eastern Australia. Noisy miners have benefited enormously from fragmentation of woodlands, and are likely to gain even more habitat under climate change due to more droughts killing trees. By excluding migratory and nomadic honeyeaters, which carry pollen large distances, noisy miners are also likely to undermine the capacity of eucalypts to adapt to climate change via cross-pollination.[159] Because eucalypt seeds don't disperse far, they rely on nectar-eating birds and bats to spread adaptive genes via their pollen. Protecting long range pollinators and managing noisy miner populations therefore should facilitate eucalypt adaption to climate change.[160]

3.4.3 Habitat loss and degradation

Continued degradation of remaining native vegetation is currently the major threat to Victoria's biodiversity.

Victorian Environmental Assessment Council, 2010[161]

Clearing, fragmentation and degradation

The clearing of more than half of Victoria's native vegetation cover has been the major cause of biodiversity decline. The losses have been compounded by their concentration on the most fertile and productive soils and the destruction of particular habitat elements such as tree hollows and logs.[162] The fragmentation (break-up of continuous habitat into patches), and degradation (gradual deterioration of quality) of what remains – 'a long-drawn-out version of clearing' – is now the greater threat.[163] About 40% of grassland remnants around western Melbourne were lost between 1985 and 2000 due to degradation through weed invasion.[164]

Patterns of loss have changed over time. From 1972 to 1987, an average 15,000 hectares or so of woody vegetation was cleared yearly, mostly for agriculture.[165] Rules introduced in 1989 (requiring a planning permit to clear native vegetation) slowed the clearing of woody vegetation to about 1600 hectares a year (estimated in 2005).[166] Grassland clearing during the same period was much greater, about 3000 hectares a year, mostly due to intensification of agriculture.[167] According to the habitat-hectares method, decline in habitat condition has accounted for nine times greater loss of habitat than clearing in recent years (but the clearing counted in the method did not include that under permit due to an assumption that it is compensated for by offsets or regeneration). The annual loss due to both clearing and degradation was estimated in 2008 at about 17,000 habitat-hectares a year.[168]

Most losses, of extent and condition, have been on private land. Victoria's 2013 state of the environment report concluded that losses of native vegetation on private land are most likely still exceeding gains (those due to revegetation and natural regeneration).[169] Recent drivers of loss have been urban expansion to accommodate population growth, agricultural intensification and clearing to reduce bushfire risk. Threats will be exacerbated by the recent weakening of vegetation laws (section 3.5.2). Peri-urban areas are at particular risk of further clearing, especially in the state's most heavily depleted bioregion, the Victorian Volcanic Plain, north and west of Melbourne, including endangered ecological communities.[170] Clearing for agriculture is due to the conversion of grazing lands to cropping, and the use of larger machinery and centre-pivot irrigation.

The extensive fragmentation of habitat in Victoria disrupts ecological processes (such as wildlife movement and seed dispersal), and increases exposure to other threats such as invasive species and changes in the microclimate (eg drying and exposure to wind). Some of Victoria's most valuable remnants are roadsides, road reserves and stream reserves, which are highly fragmented and vulnerable to degradation, including due to fuel reduction burning, ploughing to create firebreaks, invasive species, grazing, firewood collection and climate change.[171] Victoria's 2.4 million patches of native vegetation less than one hectare in size are at great risk.[172]

Forest exploitation – logging

In the past decade, some 40,000 to 50,000 hectares of native forest have been clearfelled, for production of about 10 million m3 of pulpwood and 5 million m3 of sawlogs.[173] Additional areas have been subject to 'thinning' or 'single tree selection' or post-fire salvage logging. Over the five years to mid-2012, 7900 to 11,600 hectares of state forest were logged each year, about half of it clearfelling of ash forests and including post-fire salvage logging on areas burnt in 2006–07 and 2009.[174] Logging also occurs to an unknown extent on the 1 million hectares of privately owned land with native forest.

Although considerably lower than historical rates, logging is occurring in forest ecosystems already much depleted by past logging and fires, affecting habitats for a growing number of threatened species and undermining ecological processes (such as fire regimes, hydrology and climate).

Clearfelling is highly destructive, with complete or partial clearing of coupes of up to 40 hectares, aggregated up to 120 hectares, following by burning and aerial seeding. Direct impacts of clearfelling include loss of hollow-bearing trees and their dependent fauna (Box 3.8), and changes in plant composition such as depletion of epiphytic and some ground ferns and long-lived, slow-growing and slow-to-recruit species such as tree ferns and resprouting shrubs.[175] Vegetation changes have many flow-on impacts – for example, loss of tree ferns reduces foraging sites for mountain brushtail possums and other mammals, and old-growth forest remnants become isolated, reducing habitat availability for wide-ranging species such as sooty owls and yellow-bellied gliders, and fragmenting populations of animals such as mountain brushtail possums and greater gliders in these refugia.

Logging undermines the recruitment, decay and collapse of large old trees, a key ecological process in forests.[176] Large old mountain ashes are predicted to decline from 5.1 per hectare in 1997 to 0.6 by 2070.[177] Endangered Leadbeater's possums are on an extinction trajectory as they continue to lose this habitat from fire and logging (Box 3.15).[178]

Logging alters fire regimes and changes the way fires spread in the landscape. Research in moist forests around the world suggests that logging can increase susceptibility of young regenerating forests to burning: (1) large quantities of logging slash can sustain fires for longer than fuels in unlogged forest, (2) lightning strike ignition is more likely to occur in harvested stands where there are fine fuels of logging slash, and (3) the removal of trees creates microclimatic conditions that dry the understorey vegetation and forest floor.[179] Logging creates drier forests for at least some forest types in the short to medium term when damp ferny understoreys are converted to more flammable shrubs.[180]

There is a risk that large areas of mountain ash forests will disappear due to a 'landscape trap' resulting from the combined effects of wildfire, logging, and salvage logging. Young regrowth forest is more fire prone than old-growth forest, and the increased risk of severe repeat fires in young forest due to a drying climate, logging and previous fires 'decreases the probability that the landscape can return to its former mature state'.[181] If fires occur in intervals of less than 20-30 years, the period required for mountain ash trees to begin bearing seed, wattle and other species are likely to take over. The more widespread that young regenerated forest becomes, the greater is the risk for the spread of wildfire through landscapes. Although tens of thousands of hectares of mountain ash forest were burned in the 2009 fires, there has been no reduction in logging targets. 'This has ramped up pressure on the reduced available green (unburned) mountain ash forest, making over-cutting inevitable.'[182]

Conversion of mature forests to commercial forestry has climate change implications, resulting in a 40% loss of stored carbon (which also has an economic value) (Box 3.16).[183]

For several years, commercial native forest logging in Victoria has only occurred east of the Hume Highway (in Gippsland and the Central Highlands) but the Victorian government has recently re-opened Mount Cole State Forest (near Beaufort) to logging and signalled it may do so elsewhere in western Victoria.[184] Mt Cole has substantial conservation values that warrant protection in the national park estate (as a state park), as recommended by VNPA in 2010. Most of its ecological vegetation classes (87%) are under-represented in the national park and conservation system and it has already been over-logged.[185] Resumption of logging in western Victoria's highly fragmented and high conservation value forests is a major backward step for conservation.

It is preferable to focus commercial forestry on plantations, but plantations too can have detrimental environmental impacts unless they are established on already cleared land, use non-invasive species and are sited to limit their hydrological impacts on wetlands and native vegetation.[186] Hydrological impacts may be significant in the west and south-west of the state, where plantations are in close proximity to extensive wetland and groundwater-dependent systems.[187] Diverse plantings using local plant materials are likely to deliver greater biodiversity benefits than monocultures of non-local origin.

Box 3.8 Losses of big old trees

Victoria is losing big old trees – to logging, land clearing, agricultural intensification, fires and fire management, and concerns for human safety. On current trends, within 50 to 100 years southeastern Australia's grazing lands are likely to have no more than 1.3% of the historical densities of large old trees.[188] Many currently common birds and bats would decline because of their dependence on resources provided by farmland trees. The loss of old trees is a particularly grave threat to the many birds, mammals, reptiles and invertebrates that rely on tree hollows, which take 100 years or more to form.[189]

Long-term studies in Victoria's mountain ash forests, where cavities in large living and dead trees are critical nesting and denning sites for 40 species of native vertebrates, have revealed 'an ecosystem-wide large tree crisis'.[190] Hollows start to develop in mountain ash trees after 120 years but the large hollows essential for many birds and mammals usually take at least 190 years. Most of the large trees survive now in the less than 1.2% of mountain ash forest that is old-growth (less than 2000 hectares of a total forest area of 160,000 hectares). About 99% of the forest area is dominated by trees less than 75 years old, with scattered large trees that suffer high rates of mortality. These forests need at least another 50–120 years for development of habitat hollows.

Extensive young forest is 'susceptible to a feedback process between logging and fire', leading to an altered fire regime with more frequent and more severe fires. Forests burned less than 20–30 years after logging or a previous fire may be replaced by wattles or other vegetation.[191] Within the past century there have been five major and three substantial fires in the mountain ash forests. State government intentions to log more than 17,000 hectares over five years (2011 to 2016) will put 'considerable harvesting pressure on existing areas of unlogged and unburned 1939 regrowth forest'.[192] The ecological consequences of loss of large trees include lack of habitat for cavity-dependent animals, reduced levels of carbon storage and impaired ecosystem processes such as recruitment of large logs to the forest floor. Needed are continued protection of all remaining unlogged and unburned forest, continued exclusion of salvage logging in burnt old-growth forest, protection of much of the 40,000 hectares of remaining unburned areas of 1939 regrowth forest, exclusion of logging where there are large trees in forests of 1939 regrowth, exclusion of logging from areas likely to be fire refuges and avoidance of processes that increase fire risk (such as building new roads).

Forest exploitation – firewood collection

Also threatening forest biodiversity is excessive collection of firewood.[193] Victorians burn an estimated 600,000 cubic metres of wood each year, a volume comparable to the amount of wood harvested annually for woodchips (750,000 cubic metres in 2012-2013). About 14% of firewood is thought to come from public land – mostly state forests, forest parks and regional parks.[194] An additional amount due to illegal collection is likely to be 'considerable'.[195] Much of the rest comes from native forests in NSW or from Victorian private lands. The amount from public forests is likely to grow with the state government's removal in 2011 of a requirement for a licence for personal collection in state forests.

Firewood collectors are only supposed to take fallen wood, and not logs with hollows or those growing moss and fungi. But over the long term, the continual removal of fallen wood and the illegal removal of live and dead trees will deplete the numbers of old fallen logs, one of the critical habitat elements in forests.[196]

That extensive firewood collection is harmful to biodiversity is recognised by the listing of the loss of coarse woody debris (standing dead trees, stumps, dead branches, fallen trees, coarse roots and wood pieces) as a potentially threatening process under the Flora and Fauna Guarantee Act. Coarse woody debris is vital habitat for many plants, animals and microorganisms, and vital for ecological functions including nutrient cycling and energy flows, carbon storage, soil conditioning, moisture reservoirs and refugia from environmental extremes.

Nine state-listed and three nationally listed vegetation communities, about 60 threatened plant species and several animal species are likely to be detrimentally affected.[197] There may also be impacts due to soil disturbance and changed light regimes, for example encouragement of weeds. Nineteen Victorian bird species are considered to be threatened by firewood collection nationally. Brown treecreepers, for example, forage mostly amongst standing dead trees and logs and their densities are higher where fallen timber loads are high. In Victorian box-ironbark forests, bird numbers were nine times greater, and bird species diversity three times greater, in areas containing piles of coarse woody debris than where it was lacking. About 10% of Australian reptiles use hollows either for shelter or for hunting for prey, including the endangered inland carpet python, which uses hollows in large logs and large trees in the 'firewood' regions of Victoria. Fallen wood often serves as fire refuges. Too little is known about the impacts of firewood collection on invertebrates, flora and cryptogams, and ecosystem processes such as nutrient, carbon and energy cycling.

Agriculture

Agriculture dominates the land area of Victoria (56%), centred on the most fertile soils, and consuming two thirds of allocated water. It has transformed the landscape and caused great damage through habitat destruction (removal of plants, woody debris, logs, rocks), introduction of invasive organisms, over-exploitation of rivers, drainage of wetlands, use of fertilisers and pesticides and various impacts of livestock on soils, water and vegetation.[198] While the days of broadscale clearing have gone, due to the conversion of most suitable land and vegetation regulations, agricultural use is intensifying in many areas: conversion to cropping, greater fertiliser use, pasture improvement (sowing exotic plants), rotational grazing and higher stocking rates.[199] The introduction of centre-pivot irrigation for broadacre cropping has driven losses of 'paddock trees' and small woodland patches.[200] (It requires removal of all trees within reach of the irrigation arm, which can be 600 metres long.) A study in the western Wimmera found large numbers of buloke paddock trees had been removed for irrigation between 1997 and 2005.[201]

Rural landscapes and agricultural practices have changed considerably over the past few decades and will continue to do so (chapter 1). There are now fewer and larger farms in Victoria, and production is intensifying and diversifying.[202] In some areas, traditional farms are increasingly being replaced by hobby farms, rural residential properties, weekenders and conservation properties.[203] Land within commuting distance of urban centres is being subdivided. Climate change is already driving change in agricultural production patterns, including movement of cropping into wetter areas. There is likely to be development of markets for new goods and services such as carbon sequestration plantings, soil carbon sequestration regimes and biofuels.[204] Other drivers of agricultural change will be increasing world demand for food, especially a demand for protein in large, rapidly developing countries such as China, and increasing competition for resources such as water.[205]

Restoration activity is increasing in agricultural districts, focused largely on tree planting. Restoring ecological processes, including recovering soil structure and biota, re-establishing native ground cover and restoring water flows, will require much more effort and expertise.

3.4.4 Changes to disturbance regimes – fire regimes

Failure to address the needs of biodiversity in fire management will potentially result in a drastic and permanent loss of biodiversity values in Victoria.

Ecology Australia, 2011[206]

Destructive fire regimes are a major threat for many species and habitats in Victoria.[207] This is especially true for fragmented or isolated ecosystems, where post-fire recolonisation by species can be impeded and invasion by weeds and feral animals exacerbated. Inappropriate fire regimes can radically change vegetation structure and distribution, reduce resources for particular species, and alter soil structure and chemistry (nutrient availability, pH, moisture) and water run-off. Current threats arise from a lack of fire management or poorly informed management (due to a lack of research on fire impacts on most organisms) or fire management that ignores ecological goals (eg Victoria's annual burning target of 5% of public land and frequent burning to protect assets).

Within any single locality there are species with vastly different fire sensitivities or requirements. Plants are much affected by the length of time between successive fires but favourable intervals differ between species. If the interval between fires is too short, some plants are not be able to mature and produce seeds to provide for post-fire generation, a problem for many heathland plants, but if the interval is too long, species dependent on fire for regeneration may die out.[208] Some ecological communities such as grasslands or heathlands seem adapted to frequent burning but rainforests, many wetlands, Raak saline shrublands and inland woodlands dominated by she-oaks are highly sensitive to fire.[209]

Species vulnerable to inappropriate fire regimes include:

- rare species vulnerable to destruction or loss of habitat, eg mallee emu-wren, Leadbeater's possum
- animals vulnerable to predation after fire, eg small, ground-dwelling mammals
- plants sensitive to fire, eg many rainforest species and annual species unable to set seed
- aquatic species sensitive to sedimentation from erosion.

For invertebrates, there are vast numbers of species that could be affected 'combined with massive ignorance over the nature and consequences of those impacts'.[210] Many natural areas with value as refugia or reservoir habitats for invertebrates are susceptible to fire and tend to be ignored by fire planners because they are small or isolated fragments or in urban areas where public safety concerns increase pressure for planned fires. Fire impacts on fungi are also poorly understood, a substantial knowledge gap because of their diversity and importance in ecosystems as symbiotic partners, decomposers, nutrient cyclers and as a food resource for vertebrates and invertebrates.[211]

Lack of knowledge about appropriate regimes

Disturbance regimes (ie. the combination of frequency, duration, intensity and extent of disturbance) have greater long-term influence than single events.

Andrew Bennett and others, 2009

All fires are different, all species and habitats respond differently to fire, and responses vary over space and time.[212] It is the patterns of fire frequency, intensity and regularity across space and time – fire regimes – that shape ecosystems more than single fires. But there is scant knowledge of which regimes are beneficial for biodiversity. Fire responses have been documented over only short periods compared to the decades or centuries over which post-fire changes occur, and mostly over small areas.[213] A few vegetation communities such as heathlands and mountain ash forests have been well studied but, even for them, information on long-term impacts are limited.[214] With such limitations, 'generalisations and simplifications about relationships between disturbance regimes and biodiversity ... should be treated as hypotheses to be tested.'[215]

A major limitation is that most ecological fire management is vegetation focused, based on some knowledge of how some plants, but not animals, respond to fire. Much has been assumed, with the dominant assumption being that 'if you look after the vegetation the fauna will be accommodated'.[216] But it is doubtful that the response of animals to fire parallels those of plants (Box 3.9).[217] The understanding that plant species will be lost from a community if fires are either too frequent or too infrequent has led to the calculation of 'tolerable fire intervals' for various plant communities as the basis for ecological fire management.[218] In Victoria, tolerable fire intervals are calculated using the vital attributes of a few fire-sensitive species ('key fire response species') within 32 broad vegetation communities.[219] However, this system relies on simplifications and assumptions which require testing, including that the plant focus provides for the needs of other species.[220]

The diversity of responses to fire has led to the general axiom that 'pyrodiversity begets biodiversity' but the extent to which it is true in Victoria and the types of regimes favouring particular habitats and species are as yet poorly understood. A recent finding that many mallee birds, including threatened species, prefer older vegetation – rather than a good mix of age classes – 'highlights the risk of a blanket application of the "pyrodiversity begets biodiversity" paradigm'.[221]

Box 3.9 Differences between fire responses of plants and animals[222]

Plants that have evolved in fire-prone ecosystems have different strategies for persisting at a site or recovering after fire:[223]

- 'Seeders' die when fully scorched but survive as seeds. Release of seed can be stimulated by the heat of fire and germination can be stimulated by smoke. *Callitris* species and some eucalypts store seed in woody fruits; some wattles store seed with thick coats in the in the soil; others such as mistletoes rely on seed from outside the burned area. Fire can threaten obligate seeders (plants that only produce seeds and do not resprout) such as ash eucalypts if it is too frequent to allow for maturation and seed release.
- 'Sprouters' regenerate after fire from below-ground tubers or from live tissue protected by bark.
- 'Fire ephemerals' are not visible at the time of fire but respond to it by germinating, growing, flowering and fruiting, mostly or entirely before the next fire.

Very few studies have examined the response of animals. Of 82 field-based studies in temperate Australia on vertebrate animals published up to 2009, half were focused on mammals and a quarter on birds, none dealt with the full range of groups, most looked at low-intensity planned fires, and none examined scale or patchiness as factors.[224]

Mobile animals may be able to avoid incineration, but may suffer increased predation due to lack of shelter or a shortage of food after fire. Less mobile animals may become temporarily extinct after fire and rely on recolonisation from another area – provided there are sufficient source populations within dispersing distance, and provided essential habitat features recover. In contrast to plants, some animals need to range over several habitat types with different fire histories to meet their daily or seasonal resource requirements.

There are four broad response types for vertebrate animals.[225]

- Species that quickly benefit from fire, mostly those that move into the burnt area and remain until resources that attracted them decline (eg flame robin and some raptors).
- Species that initially decline but then increase (eg New Holland mouse, marbled gecko, black wallaby).
- Species that show a long-term decline (eg scarlet robin, buff-rumped thornbill, spotted quail-thrush and red-necked wallaby). Fire often reduces the shrub layer, making favourable habitat for these species in the short term, but also promotes prolific regeneration of shrubs that renders habitat unsuitable after a few years.
- Species that decline immediately post-fire and do not recover for very long periods (eg black-eared miner, mallee emu-wren). Repeated burning could produce this response if the fire frequency does not allow the habitat to persist, or the fire intensity removes habitat elements that take a long time to be replaced (e.g. hollow-bearing trees).

Interactions with climate change and other threats

Fire threats are exacerbated by interactions with other threats – habitat fragmentation, invasive species and climate change. Fragmentation is a barrier to species recolonising isolated vegetation remnants destroyed by fire. Weeds can increase fuel loads (eg. pasture grasses such as Phalaris) and dominate after fire; and some animals become more vulnerable to invasive predators in burnt areas through loss of cover. It is predicted that climate change will increase fire frequency and intensity, and increase the risk of megafires.[226] The number of extreme fire danger days in southeastern Australia is projected to increase by 5-40% by 2020 and 15-230% by 2050.[227] Climate change is also likely to undermine post-fire regeneration due to lack of moisture, or increase post-fire erosion by extreme rainfall events.

A drying climate has recently generated fires at a frequency and scale hitherto unknown in Victoria, with close to 3.6 million hectares burnt in bushfires since 2001-02, most in three megafires:

- 2003 alpine fires: 1 million hectares
- 2007 Great Divide fires: 1.1 million hectares
- 2009 Black Saturday fires: 0.4 million hectares.

Megafires have a major impact, resulting in soil loss due to breakdown of soil structure and organic matter, loss of soil-stored seed-banks, loss of habitats, and inability of species to recolonise burnt areas. Major erosion resulting from heavy rainfall on exposed soil can have landscape-scale impacts, and seriously degrade waterways. The threat of megafires has led some authors to suggest 'spreading risk' by retaining some reserves in isolation from others to quarantine them from simultaneous destruction.[228]

3.5 Gaps and Priorities

3.5.1 Victoria's national park and conservation system

Priorities for expanding the national park and conservation system

The analysis in section 3.3 showed that Victoria has substantial gaps in its national park and conservation system, particularly of the vegetation communities most depleted by clearing and subject to degradation. Despite the state government's long-held goal to achieve a comprehensive, adequate and representative reserve system[229] and despite significant progress – mostly resulting from regional investigations by the Victorian Environmental Assessment Council and its predecessors – about three-quarters of Victoria's subregions remain poorly protected. Statewide, less than a third of subregional ecological vegetation classes meet the NCR reserve targets or the JANIS targets adopted by Australian governments for forest ecosystems (Table 3.22). This is consistent with other gap analyses as well (as described in section 3.3).

Table 3.26 shows the extent of native vegetation needing protection to meet the NCR reserve targets and the area available on public lands to potentially meet the targets. To achieve comprehensive, adequate and representative protection will require an additional area of 3.1 million hectares. This does not fully account for the need to protect wetlands, the coastal zone, and habitats for threatened species. About half of the additional area needed can potentially be achieved by upgrading the tenure of about 40% of vegetated public lands. However, in some of the least protected subregions, a substantial proportion of the additional area needed will have to come from private land, either secured by permanent conservation covenants or, for high priority areas, by buying land for the national park estate. Meeting the NCR reserve targets would increase the total land area protected to about 31% of Victoria.

Because of the large gaps in the national park and conservation system, coupled with escalating threats to nature, the Victorian government should commission a state-wide assessment by the Victorian Environmental Assessment Council to determine the most efficacious way for the state to achieve reserve targets. The investigation should prioritise the least protected subregions, and encompass public and private lands.

The Victorian Environmental Assessment Council has already identified six priority subregions for assessment – (a) Wimmera (south), Dundas Tablelands and Glenelg Plain, (b) Gippsland Plain and Strzelecki Ranges and (c) Central Victorian Uplands (Table 3.26).[230] These subregions have highly inadequate protection and suitable areas of public land (larger or intact blocks not already tightly committed to a specific use).

The analysis in Table 3.26 shows there are 12 high priority subregions for a public land investigation based on need (less than half the ecological vegetation classes meet the NCR reserve targets) and opportunity (there are substantial areas of public land potentially available). There are also 11 high priority subregions for protection on private land (half of them overlapping with public land priority subregions). These are subregions where there is insufficient public land to meet the NCR reserve targets. The priority subregions are mostly consistent with the 12 focal landscapes identified as priorities by the Trust for Nature (also shown in Table 3.26).

In a separate analysis (done in conjunction with this review and outlined in section 5.3), VNPA has identified five priority clusters for conservation action, which encompass or partly encompass 12 subregions. They were selected for their high-value intact vegetation, high biodiversity values and poor representation in the national park and conservation system. Recommendations for new protected areas in these priority clusters are shown in Table 3.27. They are mostly consistent with the priority recommendations for investigation proposed by the Victorian Environmental Assessment Council.

Conservation of some public lands can be improved by upgrading protection for some reserves under the Crown Land (Reserves) Act. These reserves, including those designated as nature conservation reserves, currently do not meet criteria for the national park and conservation system because there is no requirement to manage them to any particular standard and mining may be permitted. They should be transferred for protection under the National Parks Act, which provides a stronger statutory basis for conservation management and for preventing damaging activities.

Table 3.26 Priority subregions for expanding the national park and conservation system[231]

Subregional EVC status		Area (ha) needed to meet NCR targets[(2)]			Public land priorities		Private land priorities		
% EVCs not meeting NCR targets[(1)]		Total area (left), public land potentially available (middle), private land to make up the balance (right)			NCR protection priorities[(3)]	VEAC assessment priorities[(4)]	% EVCs needing >50% protection on private land[(5)]	NCR protection priorities[(6)]	Trust for Nature focal landscapes[(7)]
Victorian Volcanic Plain	97	182,619	35,573	218,192			86	High	SW, ORC, VM, WMRP, YCC
Strzelecki Ranges	95	88,495	36,341	52,154	High	Priority	74	High	GPGLC, PPW, SRP
Dundas Tablelands	95	156,551	37,888	118,663	High	Priority	62	High	SW, VM
Victorian Riverina	94	343,342	37,259	306,083	High		84	High	ER, NIS, WR
Warrnambool Plain	93	25,395	6,448	18,947			89	High	SW, ORC
Central Victorian Uplands	93	281,192	114,319	166,873	High	Priority	79	High	NIS, VM, WMRP, YCC
Goldfields	92	327,778	162,444	165,334	High	Recent investigation	76	High	VM
Gippsland Plain	91	181,204	58,195	123,009	High	Priority	75	High	GPGLC, PPW, WMRP, YCC
Northern Inland Slopes	85	124,513	49,249	75,264		Recent investigation	82	High	ER, NIS, WR
Wimmera	84	240,929	53,050	187,879	High	Priority (south of Little Desert)	76	High	SW, VM, WR
Murray Fans	81	109,736	50,279	59,456	High (implement)	Recent investigation	22		ER, NIS, WR
Glenelg Plain	79	69,513	52,548	16,965	High	Priority	40		SW
Highlands – Southern Fall	79	215,603	194,537	21,066	High		37		YCC
Murray Mallee	79	219,053	85,370	133,683			59	High	SW, MSB, WR
Highlands – Northern Fall	77	276,466	269,428	7,039	For review		33		NIS, YCC
East Gippsland Uplands	72	109,529	92,805	16,725	High		14		
East Gippsland Lowlands	69	104,271	102,280	1,991	High		16		
Monaro Tablelands	67	14,066	11,408	2658	High		33		
Highlands–Far East	62	4,610	4,610	0			0		
Otway Plain	62	26,736	15,022	11,714		Recent investigation	57	Medium	ORC, WMRP
Murray Scroll Belt	61	15,811	13,676	2,135			0		MSB
Otway Ranges	50	4,886	3,308	1,578			50	Medium	ORC
Victorian Alps	35	13,276	12,990	286			8		YCC
Robinvale Plains	32	3,971	2,878	1,093			14		
Greater Grampians	17	4,697	895	3,801			91		VM
Lowan Mallee	14	691	170	521			100		SW
Bridgewater	0	NA							SW
Wilsons Promontory	0	NA							
Totals		3,180,505	1,502,970	1,677,535			61%		

76-100%	51-75%	Subregions with a high proportion of EVCs not meeting the NCR targets or with a high proportion of EVCs needing >50% protection on private land.

Notes for Table 3.26

(1) The percentage of ecological vegetation classes (EVCs) within each subregion that do not meet the NCR reserve targets as outlined in Table 3.22. Different colours identify the degree to which the targets are not met for each subregion.

(2) For each subregion, the top figure (uncoloured) is the total area of land required to meet the NRC reserve targets for all EVCs. The second figure (green background) is the area of public land available to meet the NCR targets for that subregion, based on public land within each EVC that is not already within the national park and conservation system. The third figure (orange background) is the area of private land required to reach the balance of the NCR reserve targets.

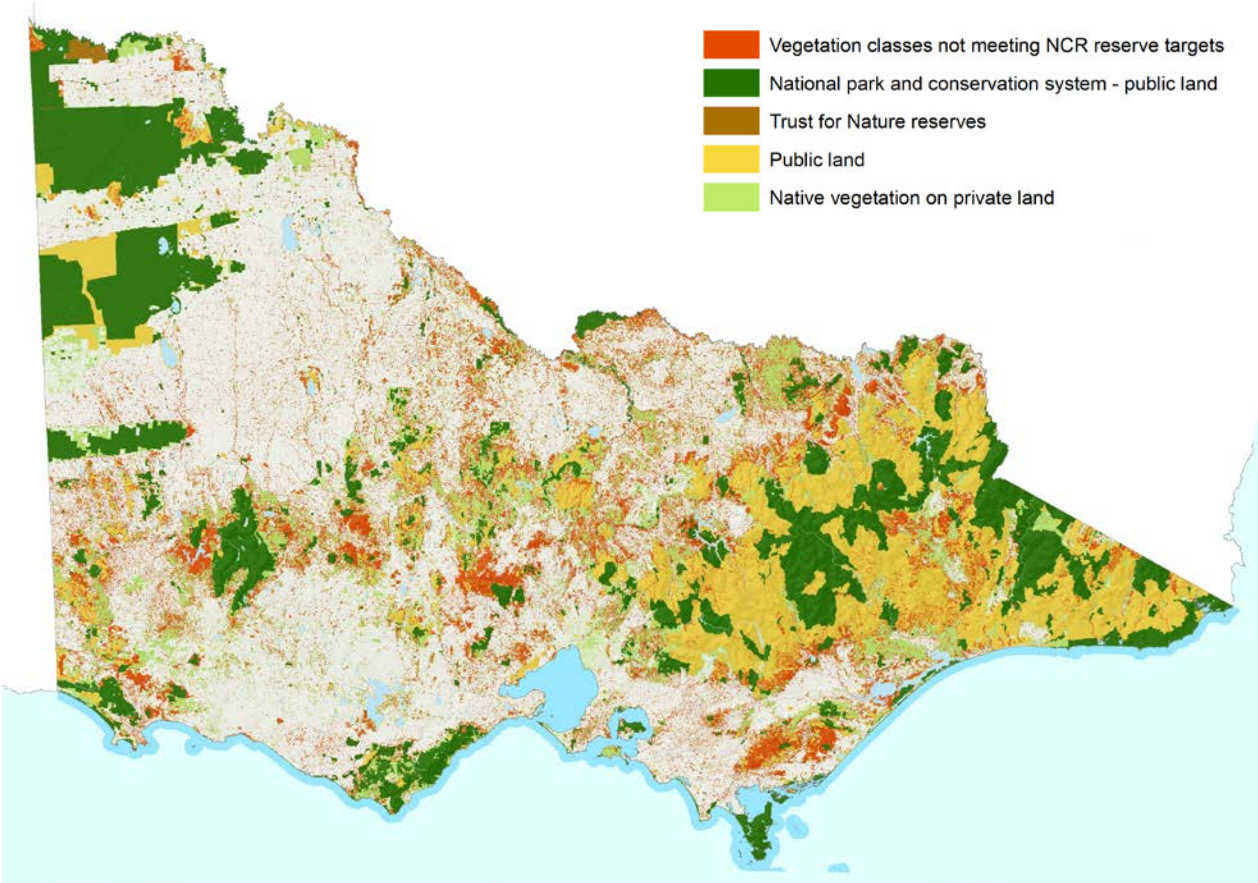
(3) Priorities for public land protection are subregions where less than 50% of EVCs meet the NCR reserve target and where there are substantial areas of public land available to help meet that target.

(4) The percentage of EVCs in each subregion that do not meet the NCR reserve targets and which will depend mainly on private land conservation to meet the NCR targets (ie. at least half of the area required to meet the NCR target will have to be on private land).

(5) High priorities for private land conservation are subregions where 0 to 25% of EVCs meet the NCR reserve targets and where at least 50% of EVCs needing protection will need to be conserved on private land. Medium priorities are those where 26 to 50% of EVCs meet the NCR reserve targets and at least 50% of EVCs needing protection will need to be conserved on private land.

(6) Trust for Nature focal landscapes: Eastern Riverina (ER); Gippsland Plain & Gippsland Lakes Catchment (GPGLC); Murray Scroll Belt (MSB); Northern Inland Slopes (NIS); Otway Ranges & Coast (ORC); Port Philip & Westernport (PPW); South-West (SW); Strzelecki Rangers & Plains (SRP); Victorian Midlands (VM); Western Melbourne Ranges & Plains (WMRP); Western Riverina (WR); Yarra–Cardinia Catchments (YCC).

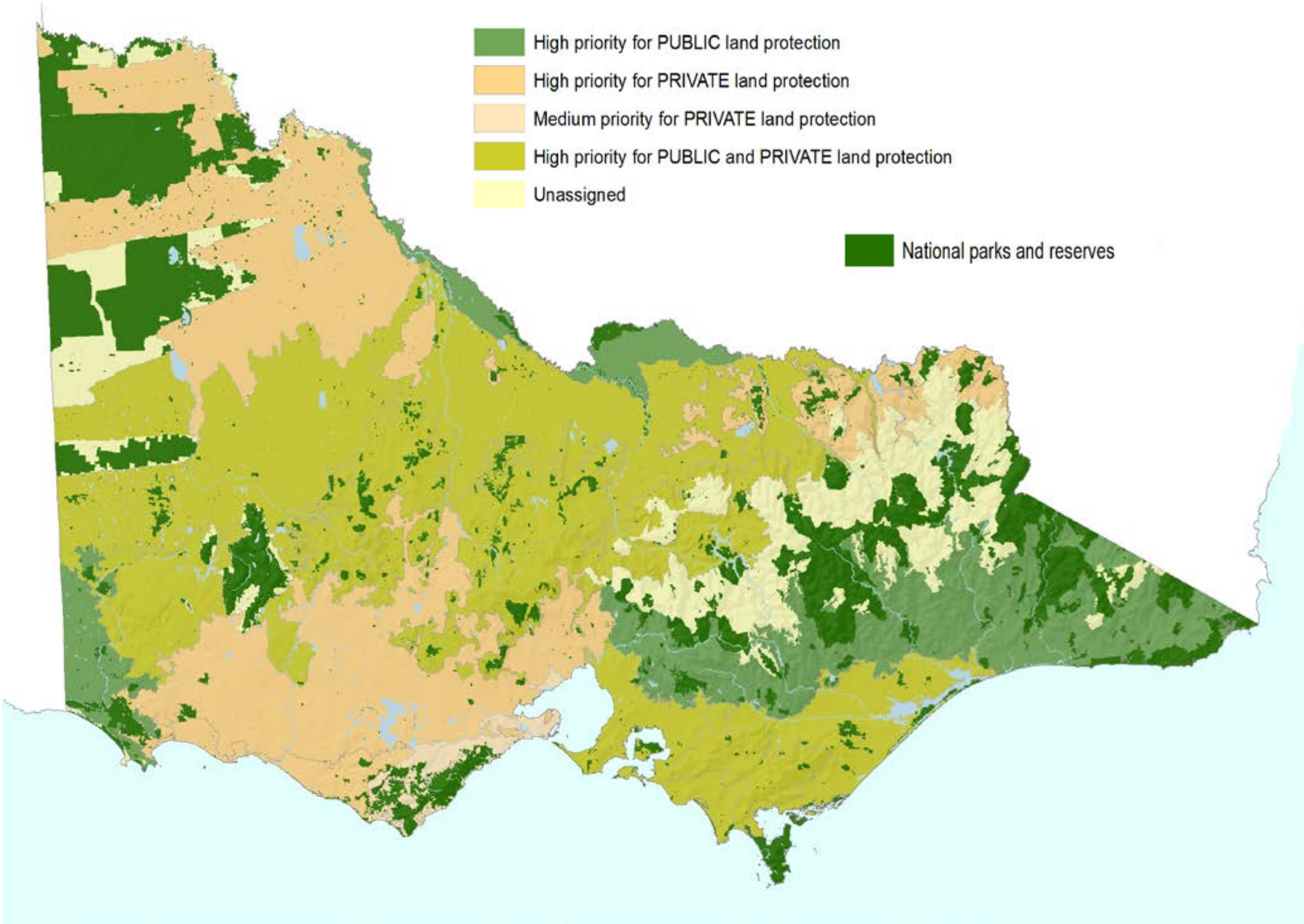
Figure 3.20 Location of ecological vegetation classes needing increased protection to meet the NCR reserve targets for a comprehensive, adequate and representative national park and conservation system



Map & data analysis: VNPA. Data sources: Department of Environment and Primary Industries, Trust for Nature.

Note: As explained in Table 3.21, the analysis on which this is based does not take into account the spatial arrangement of reserves, the need to protect core habitats, corridors and isolated remnants, the specific needs of species and requirements for climate change adaptation.

Figure 3.21 Priority subregions for improved protection to achieve the NCR reserve targets for a comprehensive, adequate and representative national park and conservation system



Map: VNPA. Based on analysis in Table 3.26 of priority subregions to achieve the NCR reserve targets.

Table 3.27 VNPA priority areas for expanding the national park and conservation system

Region	Proposal
Central Victoria	Protect 20 areas in small parks, recommended in VNPA's Small Parks report (**Error! Not a valid result for table.**).
Melbourne Metro & Catchments	Create a Great Forests National Park. Protect Wombat Forest (this is also in Central Victoria). Create a Western Melbourne grassland reserve and a network of smaller grassland reserves.
East Gippsland	Create new national parks from state forest areas.
South West Victoria	Create a Greater Glenelg National Park west of the Grampians between Princes Highway & Little Desert National Park.
South Gippsland & Strzelecki Ranges	Create new national parks from state forest areas.
Riverina	Create red gum parks as previously recommended by the Environmental Assessment Council – the Murray River park and the Leaghur-Koorangie, Loddon and Avoca River floodplains

Note: More details of VNPA's priority clusters are in section 5.4.

Box 3.10 Central Victorian small park proposals[232]

In a 2010 assessment, VNPA identified 20 public land sites in central Victoria (from Stawell in the west to Alexandra in the east) warranting greater conservation protection, most involving a tenure upgrade from state forest to state park or additions to existing national parks and reserves. The box and ironbark forests of central Victoria have suffered great losses and damage since European colonisation and much of the remaining public land exists in blocks of less than 20,000 hectares. Less than 10% of the ecological vegetation classes in the Goldfields and Central Victorian Uplands subregions meet the NCR reserve targets.

The process involved (1) nominations by environment groups and individuals of 61 sites thought worthy of improved management or protection, (2) assessment of natural values and threats for each site, (3) scoring and prioritisation by an expert panel resulting in the section of 20 sites, (4) on ground assessment of some sites and (5) tenure and management recommendations.

Of the 115,000 hectares of public land recommended for improved management, and tenure change in some cases, 111,000 hectares is state forest. Timber and firewood harvesting are a threat to some areas – including at Mt Cole, which is being re-opened to commercial logging – as are pests and weeds, uncontrolled recreation, and inappropriate fire regimes. The sites are proposed as the foundation for a large-scale biolink from the Grampians to the Alps (Figure 3.22).

Priorities for private protected areas

Because of the historical tendency to establish protected areas in 'leftover' areas – mostly rugged, dry or infertile areas not favoured for development – the most cleared subregions of Victoria generally have the smallest proportion of native vegetation in protected areas, the highest numbers of endangered vegetation communities and high rates of private land ownership (Table 3.21). All except one of the 10 subregions with more than 30 endangered ecological vegetation classes have more than two-thirds of land area in private tenure (Table 3.21). Much of the 2.9 million hectares of native vegetation remaining on private lands has very high conservation value as a rare or threatened ecological vegetation class, as habitat for threatened species or in maintaining ecological processes. About three-quarters of it is part of an ecological vegetation class inadequately protected in the national park and conservation system and about 60% is a threatened vegetation class (Table 3.21).[233]

Although about 100,000 hectares of private land, including some very high value areas, have been securely protected, mostly by perpetual covenants or Nature Conservation Trust reserves, the overall contribution of private lands to the national park and conservation system so far is small (about 2.5% of the network). With less than 4% of native vegetation on private lands securely protected, there is great potential to expand private land conservation. In many highly cleared landscapes, private protected areas offer the best or only means to secure essential elements of biodiversity and provide a core for future restoration efforts. This effort will be greatly aided by the Trust for Nature's identification of 12 focal landscapes (Figure 3.16) that 'provide the best opportunities for maintaining priority ecosystems and species on private land'.[234]

Assuming that all potentially suitable public land is protected, about 1.7 million hectares of private lands (58% of the vegetated area) needs to be securely protected to meet the NCR reserve targets (Table 3.26; Figure 3.21). This would require a 20-fold increase in the area of private land protected, either by perpetual conservation covenants (or similar secure mechanism) or by purchase for the national park estate.

To meet the NCR reserve targets, the conservation focus on private lands will need to extend beyond the 12 focal landscapes to include other areas in 41 biodiversity priority zones identified by the Trust for Nature, and other areas of high quality habitat or with habitat suitable for restoration of poorly protected ecological vegetation classes.

As proposed above, the role of the Victorian Environmental Assessment Council should be expanded to include investigation of priorities for improving the national park and conservation system on private as well as public lands. As proposed in chapter 2 for coastal lands, a land acquisition fund is needed to assist with the purchase of private land for addition to the national park estate when land of high conservation priority is available for sale and when its conservation would be best achieved in this way.

Managing protected areas, whether on private or public land, requires commitment, knowledge and resources. Managers need support such as the regular contact and advice provided by the Trust for Nature for managers of covenanted properties, and as is being fostered through 'conservation management networks'. There is potential for fruitful collaboration between non-government organisations (Trust for Nature and Bush Heritage Australia) and government conservation and land management programs.

Except for specifically exempt areas, including national parks, state parks and wilderness areas, all areas in Victoria are open to mining exploration and mining licence applications.[235] A perpetual covenant requires landholders to manage the covenanted site for conservation but doesn't preclude mining even if it will destroy the site's values. All properties in the national park and conservation system, including on private land, should be protected from activities inconsistent with maintaining their conservation values. The Nature Conservation Trust Act should be strengthened to prohibit mining exploration and mining.

Given the importance of private land to Victoria's conservation future, there needs to be a concerted focus on optimising incentives for and removing impediments to private land conservation. This review recommends that the Victorian Environmental Assessment Council be commissioned to investigate barriers to private land conservation and how best to facilitate private conservation through incentives and technical and logistical support.

Priorities for Indigenous land managed for conservation

Indigenous lands will become increasingly important for biodiversity conservation, including as part of Victoria's national park and conservation system. Currently, there are management agreements (joint or cooperative) over about 300,000 hectares of protected areas (Table 3.18). The recognition of Indigenous ownership of protected areas and agreements for their joint or cooperative management are beneficial for maintaining Indigenous connections to their land, incorporating traditional knowledge into management and building respect for and awareness of Indigenous culture. The management arrangements for particular protected areas vary depending on the nature of the agreement and the desires of the Traditional Owners (section 3.2.4).

This review recommends that the government actively engages with Traditional Owner representative bodies to negotiate agreements for management of protected areas (Box 3.11), provide ongoing financial support for joint and cooperative management agreements and work with Indigenous representatives to determine how to better support Indigenous aspirations for conservation management.

Box 3.11 Joint management of national parks

I think the forest is like a human body. The Murray River is the spine, and the Barmah and Moira Lakes are the kidneys on both sides. That is how the old people used to look at it. They would say – 'this is our life'. It is a living thing. We are the land, and we are mother earth. We fit in like that.

Yorta Yorta elder Colin Walker[236]

The creation of the red gum parks recognised traditional ownership over these lands and enacted a new era of joint management of national parks. In November 2010 a Traditional Owner Land Management Agreement was made between the state and the Yorta Yorta People for joint management of the newly established Barmah National Park. This agreement under the Traditional Owner Settlement Act was reached outside the native title process and enabled the establishment of the Yorta Yorta Traditional Owner Land Management Board (appointed in 2013) with majority membership by Yorta Yorta representatives and the development of a joint management plan.

It followed an agreement in October 2010 with the Gunaikurnai people after the Federal Court recognised they held native title rights over areas of crown land in Gippsland. The state entered into a Recognition and Settlement Agreement to transfer 10 parks to the Gunaikurnai as Aboriginal Title, including Tarra-Bulga, Mitchell River and The Lakes national parks. They are jointly managed by the Gunaikurnai and the state under a Traditional Owner Land Management Board appointed in 2012.

Management issues and priorities in the national park estate

As pressures on nature are growing, law and policy changes and inadequate resources are at the same time undermining the capacity of park managers to protect the national park estate. Imposition of a damaging annual burning target for public lands (section 3.5.3), limited resources for invasive species management, commercial tourism development (Box 3.12), expansion of fossicking access, the attempt to reintroduce grazing in alpine parks and the potential to allow logging under the guise of ecological thinning are incompatible with maintaining conservation values and focusing on conservation priorities.

A stronger commitment to managing the national park and conservation system to optimise resilience to existing and emerging threats is needed (chapter 5). This is compatible with promoting use of national parks for physical and mental well-being and deriving economic benefits from nature tourism. Incompatible activities such as commercial tourism development, grazing and fossicking should be explicitly forbidden. Also needed is a role for the federal government to ensure that any activities likely to damage protected areas are assessed under the Environment Protection and Biodiversity Conservation Act (discussed in section 5.2.3)

Box 3.12 Private commercial developments in national parks

The Victorian government has passed legislation to allow developers to hold leases for up to 99 years in national parks, and has invited applications for developments in two-thirds of Victoria's national park estate. This will undermine the primary aim of park management of protecting natural values. The IUCN guidelines for national park management specify that visitor use should be managed 'for inspirational, educational, cultural and recreational purposes' without causing 'significant biological or ecological degradation'.[237]

Developers but not most visitors and not the parks usually benefit from private developments – 'the attraction, infrastructure, operational management costs and marketing are all publicly subsidised'.[238] There is no credible evidence in Australia or overseas of commercial developments in parks benefiting conservation.[239] To the contrary, they often divert resources from conservation management and amount to revocation by stealth. History has shown that what starts as small eco-accommodation tends to grow over time – with the addition of more beds and carparks, a café, a shop or two, roads, sewage treatment works etc. There is ample opportunity on nearby private land and in surrounding towns for development of tourism infrastructure.

The guidelines issued by the government are vague and unmeasurable, and the process for approval lacks opportunities for the community to comment on ecological impacts.

Unless shortcomings in invasive species management in the national park estate are addressed, inexorable deterioration in some of Victoria's finest natural environments will result.[240] Shortcomings include limited knowledge of the distribution and impacts of weeds and pests in parks, inadequate resources for control programs, and a lack of monitoring to measure their effectiveness. While successes have been achieved in individual programs, many manageable threats are neglected because of a lack of funds. There is currently a reliance on short-term (3-4 years), species-specific initiative funding, which precludes long-term strategic multi-species control programs. Reliable recurrent funding is essential. State-wide, there is need for more focus on prevention of new weed threats and development of biological controls for environmental weeds as the only potential long-term solution for many threats.

Because of a lack of monitoring, it is not possible to 'provide an overall consistent state-wide assessment of the condition of land and water resources' in Victoria's parks and reserves.[241] Knowledge gaps identified in the 2007 state of parks report included appropriate water and fire regimes, viability of threatened species populations, effective weed and pest management techniques, methods to restore degraded landscapes, impacts of visitor activities and urban growth, impacts of climate change and techniques for assessing threats and trends in park condition.[242] A long-term monitoring program to address such knowledge gaps is a pre-requisite for effective management of the national park and conservation system. The results of this monitoring should be published in regular state of parks reports (last published in 2007).

Managing threats and monitoring trends in national parks requires high level expertise. With much of the required expertise outside the parks agency, arrangements such as expert advisory bodies are needed to ensure that park managers have ready access to the best available advice. But nothing can replace a high level of in-house knowledge and experience. Staff training and the recruitment of highly qualified staff to replace lost expertise should be a high priority for the parks agency. Fire management, in particular, requires expert advice, for inappropriate regimes are a major threat to many parks and fire management is fraught with knowledge gaps, and technical and social challenges. The current state-wide burning target needs to be replaced with site-based ecological fire management informed by advice from an expert panel (see below).

Park planning

This review recommends the development of a strategic plan for the national park estate to assist in planning for its future, to refocus efforts and resources on the priority conservation tasks such as building resilience to climate change, and to communicate its great environmental, social and economic importance.

National park plans of management are vital documents specifying management objectives, priorities and performance indicators. In 2011-12, only 65% of properties managed under the National Parks Act (schedules 2, 2A, 2B, 3, 4, 7 & 8) had approved management plans less than 15 years old (down from 85% two years previously).[243] Park planning should be the responsibility of a revitalised parks agency with expertise in managing ecological systems (see section 5.2.2 for a proposal to establish a statutory government agency known as Nature Victoria with responsibility for national parks among others).

The agencies jointly responsible for park planning – Parks Victoria and the Department of Environment and Primary Industries – are developing a series of landscape-wide management plans which allow for management programs to be implemented across all land tenures. While this approach is sensible in theory, it has mostly been poorly implemented. With a history of non-cooperation, the two agencies do not agree on the nature of a landscape approach, and there is confusion between a 'tenure blind' approach to planning (where little or no regard is given to tenure type) and a 'cross tenure' approach (where management strategies and plans can be cooperatively applied but with regard for legislated levels of protection). The landscape-wide management plans in preparation, such as for South West Victoria and the alpine region, are broad strategic documents which do not fulfil legislated obligations for national park and state park plans. There is a commitment to correct this through a series of 'implementation plans' but there are currently no such plans in the public domain and no clear indication of how or when they will be developed. Worryingly, the lengthy but selective community consultation in the early stages of planning leads to very long development times, often with minimal input from many with relevant knowledge and experience.

Protected areas and climate change

Protecting habitat is probably the best way to conserve species under climate change. While the species and ecosystems in any one area will change over time, the greater the total area of habitat available, and the more diverse that habitat, the greater the number of ecosystems and species that will be able to survive. The bioregional framework … is therefore very well suited for building a robust reserve system…

Dunlop & Brown 2008[244]

In the face of climate change, the national park and conservation system is more important than ever. Protecting ecosystems and the variation within each ecosystem maximises the potential for species to adapt to and survive future climates.[245] The national park and conservation system is critical for reducing threats to habitats and species vulnerable to climate change, for maintaining ecological processes central to adaptation (such as pollination, seed dispersal and species movement), and for safeguarding climate refuges, including sites that provide temporary refuge during climatic extremes and ecological disturbance and sites that provide long-term refuge for contracting species.[246]

A 2008 assessment of the implications of climate change for protected areas found that the bioregional approach used to develop the national reserve system (protecting a diversity of habitat types at multiple scales) is ideal for 'strategically developing a system of protected areas that will remain effective under climate change'.[247] To increase the effectiveness of the national reserve system under climate change, priority areas for protection include:[248]

- large areas of habitat at risk of fragmentation or degradation
- refuges from disturbance, especially associated with climatic extremes, and areas that may provide long-term refuge from changing climate
- areas with high connectivity between diverse habitats, including areas with steep environmental gradients
- areas that reduce the largest gaps between existing protected areas
- areas that support landscape-scale ecological processes, including hydrological processes (eg water sheds, floodplains, wetlands, free-flowing rivers).

National park management will need to adapt to climate change to accommodate high levels of change, loss and uncertainty.[249] Planning is needed to develop adaptation pathways with a long-term outlook 'so that early actions are effective stepping stones to more transformative adaptation actions that can be implemented if required as new information becomes available'.[250] Various recommendations to promote resilience and adaptation to climate change are outlined in chapter 5, including the development of regional climate adaptation plans, targets for biodiversity and land health that drive investment in resilience, monitoring programs and investment in carbon sequestration opportunities that foster biodiversity protection and restoration.

3.5.2 Native vegetation

By far the strongest consensus on any issue in the scientific literature is that for the retention of existing native vegetation.

Victorian Environmental Assessment Council, 2010

Report after report has identified loss and degradation of native vegetation as the major cause of declining environmental health in Victoria.[251] With more than half the state cleared of native vegetation and much of the rest degraded, the priority must be to protect what remains and work to reverse degrading processes, while embarking on restoration of high priority areas.

Priorities for law and policy reform

Primary responsibility for assessing clearing applications rests with local government, under planning laws, and has been guided by the 2002 policy *A Framework for Action: Native Vegetation Management in Victoria.* About one-third of applications – larger projects or those involving higher conservation significance – have been referred to the state government for assessment and much other clearing (such as for mining, logging and urban development in outer Melbourne) is assessed under other legislation. Application of the native vegetation policy has been less-than-rigorous – it is only a 'consideration' for decisions – and some types of clearing (eg for reducing bushfire risk) are exempt from assessment. Very few applications have been refused. In 2010-11 councils refused just 3.6% of applications and the environment department refused 4.5% of applications referred.[252] Those approved frequently included vegetation of 'high' or 'very high' conservation significance.[253]

Instead of strengthening native vegetation protection, the Victorian government has recently weakened the regulations. The objective has been altered from a 'net gain' of native vegetation to the confusing, weaker and unmeasurable 'no net loss in the contribution made by native vegetation to Victoria's biodiversity'.[254] Instead of aiming to improve the extent and condition of native vegetation, this 'effectively acquiesces to continued long-term decline'.[255]
The requirement to prioritise avoidance of clearing (in the hierarchy of avoid, minimise and offset) has been abandoned in favour of a risk-based approach in which most clearing is approved by default except if it cannot be offset.

The impact on biodiversity is to be measured by simplistic site-focused indicators – native vegetation extent, quality and value for threatened species – ignoring impacts on all other aspects of biodiversity.

Avoidance and minimisation apply only if the cost of offsets is higher than the value of the proposed land use. The highly dubious assumption is that offsets deliver a neutral outcome for biodiversity. The 2013 state of the environment report cites concerns from academic institutions and catchment management authorities that the changes focus on reducing cost to government and landowners rather than on maintaining and improving Victoria's biodiversity.[256]

Under the new approach, the state has been mapped into three categories (A, B and C) that supposedly reflect 'the likelihood that removing a small amount of native vegetation at a location could have a significant impact on the habitat of a rare or threatened species'.[257] This focus just on listed rare or threatened species undermines the responsibility of government to protect biodiversity more generally – 'the variety of all life forms, the different plants, animals and microorganisms, the genes they contain and support, and the ecosystems of which they form a part', according to the government's own definition – including many other threatened biota (eg ecological communities and threatened species not formally listed). Mapping has placed more than 95% of native vegetation on private land in category A, 'low risk', which allows as-of-right clearing of any area less than one hectare if offsets are provided. For category A clearing, there is no longer a requirement for on-ground assessment of site values. Less than 2% of private land area has been identified as 'high risk'. Preliminary analysis of the mapping shows many errors that would permit clearing in areas well-known to have high conservation values.[258] Information about the occurrence of threatened species is heavily biased towards public land, which means that where knowledge of biodiversity is poorest – on private land – is also where native vegetation has been most depleted and will be subject to further clearing pressure. Unless these changes are reversed, clearing and biodiversity loss will inevitably escalate.

The extent of illegal clearing in Victoria is unknown. In a 2012 review, Victoria's auditor general strongly criticised the state government for its lack of a compliance framework, including for vegetation laws. The audit concluded that the compliance deficiencies of the then Department of Sustainability and Environment were 'substantial' and included a 'lack of accountability, oversight and risk-based compliance planning needed to drive a robust and consistent approach across the department'.[259] Local governments also have deficient compliance, with too few resources and too little expertise (section 5.2.2). The system of native vegetation management is opaque, with no public reporting on permits issued, permit conditions, offsets, compliance and monitoring.

Because vegetation protection is so foundational to ecosystem and landscape health, and fraught with governance challenges, it needs new legislation and an independent regulator. As proposed by the Victorian Competition and Efficiency Commission, an independent statutory authority should be responsible for operational functions – assessment of clearing applications, offsets regulation, monitoring and compliance, administration and providing expert advice – while policy-making should be retained by the environment department. This review proposes a Native Vegetation Regulator (further detailed in section 5.2.2). Rather than being part of the Planning and Environment Act, controls on vegetation clearing should be part of a new Victorian Environment and Conservation Act, proposed in section 5.2.1. To improve transparency, a public register of documents – including clearing permits, assessment reports, offset agreements and plans, monitoring and audit reports – is essential.

Making offsets work

[H]abitat offset aimed at achieving and detecting no net loss can only be successful where the offset ratio is large, monitoring is long-term, robust and precise and funding is available to substantially increase the amount of habitat if monitoring indicates that this is necessary.

Evan Pickett and others, 2013[260]

The Victorian government relies on offsets to neutralise permitted clearing of native vegetation, with approved offsets including: [261]

- management actions taken since 1989 that have maintained or improved the quality of native vegetation
- increasing the security of native vegetation to prevent future clearing (eg. a covenant or land transfer to a reserve)
- maintaining the quality of native vegetation by foregoing entitled uses and preventing weed spread

- improving the quality and extent of native vegetation or revegetating cleared areas.

As long as the avoidance hierarchy (avoid adverse impacts, minimise impacts and offset impacts) is strictly applied, with clearing permitted only in exceptional circumstances, the principle of offsetting is sound. But in the absence of this, offsets are likely to be used to facilitate clearing, often in return for trivial, uncertain or non-permanent compensation, and result in net vegetation loss (Box 3.13).

Thus far, the area of native vegetation protected and restored through offsets is small and less than what has been lost.[262] Some offsets deliver only paper gains (eg where a change in tenure does not result in greater protection because the vegetation was not under threat or there is little improvement in management). Gains from restoration and management are often uncertain and require long-term commitment, but typically only 10 years of active audited management is required.[263] In the vast majority of cases, offset sites are not monitored, so confirmation of the 'gains' these offsets are meant to have provided are rarely verified. The protection of offsets made under the Planning and Environment Act (section 173 agreements) is inadequate, and they do not meet criteria for the national park and conservation system for there are no management standards specified and they can be altered. Other offsets agreements made under the Conservation Forests and Land Act (section 69 agreements) are more secure but the lack of transparency about offset arrangements make it impossible to assess their adequacy. A central registry with full details of offset agreements is an essential accountability mechanism.

An independent audit is needed to assess the extent to which offset targets are being achieved, their degree of permanence, and how the system can be reformed to deliver genuine compensation for vegetation destroyed or damaged. Offsets should be required for all threatened biodiversity, as identified on government advisory lists. Long-term monitoring is needed. Offset requirements should be reformed to deliver the best value biodiversity outcomes, including requiring fixed rate payments for low risk activities in low value areas to fund protected areas and accrediting services that pool funds to source offsets.

Box 3.13 Issues with offsetting

Offsetting generally involves trading a biodiversity loss in one place with an equivalent gain in another, with the aim being 'no net loss' of biodiversity. The crucial question is 'no net loss *compared to what*?' Compared to biodiversity before the impact? Generally not. For most offsets, the intention is to achieve no net loss *compared to what would have happened in the absence of the impact and the offset*.[264]

Biodiversity offsets can be achieved in two main ways.[265] 'Averted loss offsets' protect existing habitat from ongoing or anticipated degradation or loss. It begs the question of why loss should be permitted to occur in the first place, and is 'an admission that ongoing decline is the norm'.[266] 'Averted loss offsets only work if biodiversity keeps declining' so can entrench the baseline rate of decline.

The second type is 'restoration offsets', which create new habitat or improve existing habitat, and are 'necessary if a cessation or reversal of biodiversity decline is to be achieved.'[267] Creating habitat is difficult because of uncertainties about the outcome and often long time-lags. 'Though created habitat can resemble the composition of existing habitat, certain ecological processes can be difficult to restore, possibly reducing the compatibility for the target species or community.'[268] A high offset ratio, where much more habitat is created than lost, is recommended where there is a risk of failure.

Under the federal government's offsets program (under the Environment Protection and Biodiversity Conservation Act), the permitted destruction of threatened vegetation has been substantial, including 7.2% of the critically endangered natural temperate grasslands of the Victorian Volcanic Plains, and 1.4% to 4.6% of the critically endangered grassy eucalypt woodlands of the Victorian Volcanic Plains. The approved offsets are western grasslands reserves of more than 15,000 hectares and a 1200 hectare grassy eucalypt woodland reserve. But whether they can effectively compensate for the losses is dubious, due to a high level of uncertainty about the ability to manage and improve degraded grassland communities. The Threatened Species Scientific Committee said that regeneration of the grasslands ecological community 'is unlikely within the immediate future, even with positive human intervention.'[269]

Offset programs frequently fail to monitor and report the effectiveness of offsets and apply excessively lenient criteria to determine success.[270]

Stewardship and restoration

In heavily cleared landscapes small remnants have heightened value, as a resource to be protected and as the foundation for improving biodiversity outcomes in the future.

Saul Cunningham and others, 2012[271]

Many of Victoria's 'at risk' habitats and the majority of 'restoration' habitats (based on VNPA's framework, section 3.2.3) are on private land. A high proportion of endangered vegetation types are also on private land (section 3.3) but only 0.4% of private land is securely and permanently protected, in contrast to more than 40% of public land. Private land conservation is an immensely challenging policy area because of the rights afforded property owners and the commercial focus of much land use. It requires motivating and supporting thousands of landholders to adopt new management practices.

Victoria has been a leader in ecomarket schemes (eg BushTender, EcoTender, CarbonTender, WetlandTender), which provide landholders with income for protecting biodiversity and providing ecosystem services. To achieve more private land conservation, these ecomarket schemes will need to be expanded. Public funds for conservation activities should be directed to achieve clearly articulated priorities, monitored to assess outcomes and, wherever feasible, they should be secured by mechanisms such as permanent conservation covenants. Permanent on-title conservation covenants substantially increase the likelihood that remnant or restored habitat will be retained and maintained in the long-term.

The voluntary Land for Wildlife program is another way to foster private landholder's willingness to protect and restore native vegetation. While the program has been popular, involving about 6000 properties, and is valuable for education and outreach, Land for Wildlife agreements are neither binding nor permanent, and there has been no assessment of outcomes. The program needs reviewing to determine how to expand its reach and improve environmental outcomes.

A substantial proportion of remnant vegetation in Victoria's most cleared and damaged landscapes is in multiple small patches on public land – road reserves, stream frontages, and small reserves.[272] There are insufficient public resources to manage each of these patches 'individually to the level that their scarcity and fragility warrants'.[273] As recommended by the Victorian Environmental Assessment Council, organisations and individuals could be encouraged and supported to enter into stewardship agreements to manage these small public land reserves.

To meet its conservation goals, Victoria faces an immense restoration task. Under the VNPA habitat framework (section 3.2.3), restoration is the conservation priority for the majority of Victorian landscapes. Many thousands of Victorians are already engaged in restoration, mostly on private property, under programs including Landcare, Bushcare and various incentive schemes.

There is a lack of long-term data on restoration outcomes, and few long-term studies assessing biodiversity benefits.[274] The lack of demonstrated high biodiversity benefits is in part due to the long time lag between the intervention (such as planting trees) and expected outcomes (eg hollows can take more than 100 years to form).[275] Some shorter-term evaluations suggest that common plants and animals are the immediate beneficiaries.[276] But strategic interventions can help prevent further degradation and loss of ecological function, for example by fencing mature trees in agricultural landscapes to promote recruitment, or connecting areas of isolated habitat to allow recolonisation and outbreeding. Restoration activities are often most beneficial where they enhance already existing biodiversity values, rather than attempting to recreate them from scratch.[277] Sometimes overlooked is that much restoration requires resources for ongoing, long-term maintenance – for example, protection from stock, control of weeds, invasive animals and pathogens, and fire management. These limitations should not discourage investment in restoration, but rather encourage research, monitoring and use of best-practice techniques. All projects should be considered 'experimental', with evaluation of outcomes informing the design of future projects.[278] Goals should be defined and realistic, and take into account potential future changes – such as climate change, impacts of invasive plants and animals, and alterations in hydrological and soil conditions. The issues mentioned here are being addressed in recent projects that aim to create landscape-scale 'biolinks' to connect large areas of high-quality intact vegetation for multiple outcomes, including carbon sequestration, restoration of ecological function and revegetation.[279]

In some regions passive regrowth may be able to deliver conservation benefits over far larger scales, and at far lower costs, than intentional restoration activities, although this remains to be demonstrated.

Luke Geddes and others, 2011[280]

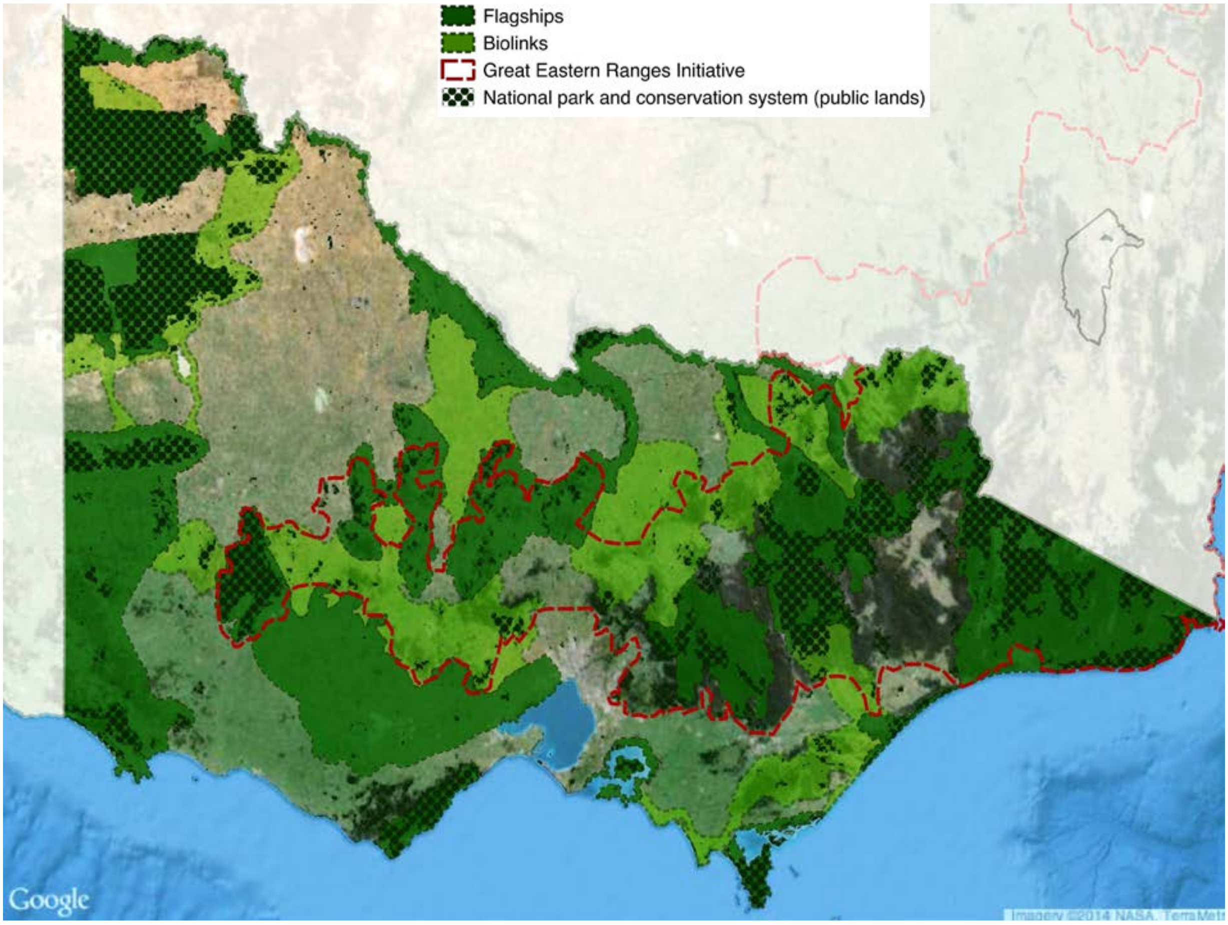
In Victoria, natural regeneration on abandoned or little-used farmland is believed to account for most of the gains in native vegetation extent.[281] A study in a 'rural amenity' area (the Rushworth-Nagambie-Heathcote region) in central Victoria found that 12% of private land had naturally regenerated with native shrubs and trees, mostly since the 1960s.[282] The extent of natural regeneration is far greater than has been achieved from intentional plantings in other similar-size regions. Most natural regeneration (94%) in the region has occurred on low fertility soils – probably because more fertile areas have been retained for agricultural use or because regeneration by woody plants occurs more rapidly on infertile soils due to lower competition from herbaceous species. On current trends, regrowth will occur on 20% of infertile soils on private land in this region by 2025. Techniques to encourage natural regeneration should be used wherever feasible in preference to more technical and expensive interventions.[283] However, there is little information about habitat values provided by large regrowth areas and successional dynamics. It is not known whether the regrowth shrublands (mostly of *Cassinia arcuata*) in central Victoria will eventually resemble intact box-ironbark forests or instead form 'novel ecosystems'. [284]

The Victorian government has noted that levels of investment in restoration are 'well below the size of the task, even just for priority locations'.[285] Restoring ecosystem health will require considerably more investment at a landscape level combining strategic revegetation and management, with covenants on private properties and acquisitions for the national parks estate. It also requires greater knowledge of how to increase the resilience of native vegetation in the face of climate change, including the benefits and risks of greater connectivity in the landscape.

In the 2009 *White Paper for Land and Biodiversity at a Time of Climate Change*, the Victorian government proposed to instigate 'a system of regional-scale biolinks to focus activity on restoring local and regional connectivity, ecosystem function and resilience'.[286] The white paper scientific reference group advised that communities should aim to restore at least a third of the landscape in biolink areas. The white paper also identified 13 flagship areas, as areas to prioritise for 'protection and enhancement'. The areas proposed for biolinks and flagships encompass both public and private lands, as shown in Figure 3.22.

By providing a framework to maximise potential conservation gains, including enhancement of core habitat areas and improved connectivity, a biolinks program would build on the excellent restoration work already being done by many groups and individuals, and focus support and monitoring on the highest priority areas. Biolinks have great potential as a communications and community engagement tool, fostering a positive spirit of contribution to an ambitious landscape-focused program and engendering partnerships across different sectors and land tenures. Despite strong community enthusiasm and much effort being devoted to connectivity projects, the current government has abandoned support for a biolinks policy. This should be reconsidered. The 2013 state of the environment report has recommended that the government 'sponsor efforts to develop biolinks at different scales'.[287] It is recommended here that a statewide biolinks plan be developed to build on the flagships and biolinks identified in the white paper and incorporate the focal landscapes and priority biodiversity zones identified by Trust for Nature.

Figure 3.22 Biolink and flagship proposals



Map: VNPA. Data sources:: Google; Flagships and biolinks data from the 2010 biodiversity white paper (supplied by the Department of Environment and Primary Industries); Great Eastern Ranges (GER) Initiative data from the GER Initiative. This initiative is a national partnership to connect landscapes and ecosystems along 3600km of Australia's eastern seaboard from the Grampians to Cape York

Priorities for forest protection

The current state of Victoria's mountain ash forests is a result of decades of unsustainable forest management practices. There is an urgent need for reform.

David Lindenmayer and others, 2013[288]

Logging advocates talk of a balance between conservation and timber and pulpwood production and point to the reservation of 45% of Victoria's remaining native forests as justification for continued logging. But this ignores the already much depleted state of forests, the continued decline of many forest-dependent species and the impacts of logging beyond logged sites due to compromised ecological processes (eg fire regimes, water flows). There is a strong conservation case to transition from logging of native forests to plantations. In 2006 the Victorian Forest Alliance proposed the exclusion of logging from 970,000 hectares of public forests to protect high conservation values, old-growth forests, water catchments and other non-timber values, leaving a quarter of a million hectares of 'the most productive commercial forest' for logging.[289]

The economic case for a transition is also strong. Forestry on public lands suffered cash and investment losses of about $22 million from 2005 to 2012, equating to a loss of about $1.50 per cubic metre of wood harvested.[290] Typically, about two-thirds of wood harvested from native forests is sold for woodchips, which bring low economic returns.[291] (In 2012-13 VicForests sold 751,000 cubic metres of pulpwood, about 60% of wood sold.)[292]

Victoria receives no payments from VicForests for access to public forests, and its customers pay lower prices because VicForests is subsidised by the state not requiring a commercial return for the use of public assets. If Victoria's public forests were run on the same basis as commercial plantations, the state should receive an income of more than $200 million a year from wood sales.[293] This greatly disadvantages plantations, which are extensive enough to replace the bulk of wood products obtained from Victoria's forests. Harvesting of public native forests is 'no longer necessary'.[294]

VicForests gets free access to Victoria's forest assets and its customers get the benefit of prices that are lower than would be the case if VicForests was required to pay a commercial return for the use of these assets. This both distorts the market by advantaging VicForests and its customers over plantation forestry (in terms of price) and, represents a subsidy that is neither transparent nor accounted for in the State's finances.

National Institute of Economic & Industry Research, 2010

Economic analysis commissioned by the Victorian Forest Alliance found that within 10 years of implementing a transition to plantations and increasing protection of native forests, Victoria would be better off economically than the base case, with more jobs and greater commercially valuable carbon stores (the analysis is sensitive to the price of carbon).[295]

Forestry enjoys exemptions from laws and standards that apply to other industries – harvesting under five Victorian regional forest agreements is exempt from the federal Environment Protection and Biodiversity Conservation Act and from Victorian planning laws, which means there are no requirements for environmental impact assessments when new areas are logged (Box 3.14). Forestry laws and policies are also poorly enforced and lack transparency. Breaches are often reported but seldom acted on.[296] A review of the federal environment laws found that 'the current process for review and auditing [of regional forest agreements] is neither independent nor transparent, and more importantly, in most cases, required reviews are not being undertaken'.[297]

The new Allocation Order provides VicForests with access to all of the timber resources in the General Management and Special Management Zones in State forest in eastern Victoria, on an ongoing basis.

VicForests, 2013[298]

Recent changes to Victoria's Sustainable Forests (Timber) Act have further undermined the potential for sustainable forestry and enforcement of forestry rules.[299] The changes entrench the long-term logging of native forests and remove much of the government's oversight of logging practices – for example, VicForests will no longer need to seek government approval for timber release plans and logging operators will not need to obtain licences. There will be no limit on the lifespan of allocation orders, allowing the government to essentially gift current and future forests to VicForests. It will lock in logging in native forests for the indefinite future.[300]

Another major backward step is the re-opening of western forests (west of the Hume Highway) to logging, with a decision in September 2013 to grant a three-year licence for logging in Mount Cole State Forest. A 2013 government-commissioned review of commercial forestry opportunities in western Victoria imply an intention to also re-establish logging in other forests.[301] In recognition of the conservation values of the greatly depleted and fragmented western forests, most logging in western Victoria (which occurred largely in the Otways) was phased out a decade ago with millions of dollars paid in industry compensation. Rather than returning to exploitation of these highly fragmented and degraded forests, the focus needs to be on securing the protection of high value forests and reversing degradation. In a 2010 assessment, VNPA found that Mount Cole State Forest has high conservation significance and warrants protection as a state park.[302] The Central Victorian Uplands subregion (in which Mount Cole is sited) has less than 10% of ecological vegetation classes adequately protected (Table 3.22). In 2011 the Victorian Environmental Assessment Council recommended that the Central Uplands subregion be the focus of a study to assess options for conserving forests and other public lands in protected areas. A 2010 independent review of regional forest agreements recommended that the agreement for western Victoria be cancelled.[303] Both of these recommendations should be implemented.

Large areas of old-growth forest have been protected informally in 'special protection zones' under the regional forest agreement process and subsequent forest management plans rather than in the national park estate. This is in breach of the regional forest agreements and the JANIS criteria, which state that 'all reasonable effort should be made to provide for biodiversity and old-growth forest conservation and wilderness in the dedicated reserve system on public land'. These informal reserves are not secure as they can be swapped for other sites and logged, provided that there is no perceived net loss of conservation values, and they can also be mined and grazed. Many are fragmented and vulnerable to edge effects (resulting in weed invasion and drying) and fire. Yet they are counted as protected under the regional forest agreement criteria, contributing to the minimum 60% old-growth protection required. These areas warrant permanent and secure protection under the National Parks Act. In the light of climate change and intense environmental stresses on forest ecosystems, the extent of public forest protected in reserves under regional forest agreements needs reviewing.[304]

Under what it calls the 'new strategic approach to biodiversity management' project, the Victorian government is developing a new framework for the management of threatened fauna in state forests based on identifying key habitat areas for 10 species.[305] While the research on these priority species is generating important information, there is concern that it will be used to exempt the forestry industry from threatened species requirements under the Flora and Fauna Guarantee Act, as proposed in 2011.[306] It is unclear how the new information will be used and whether it will reduce the impacts on these species given the current government's unwillingness to reduce timber quotas to protect threatened biodiversity (Box 3.15). As the researchers commissioned to investigate the 10 priority species comment, there is a lack of knowledge on the status, distribution and habitat requirements of many other threatened species besides the 10 priority species in forests subject to timber harvesting. Better knowledge of 10 species won't substitute for knowledge of other species.

Forestry operations on public and private land, including plantations of native and exotic species, do not adequately address the risks of invasive species, pathogens and hybridisation with plants in the wild. Although the principles under which forests are managed, under the code of timber production, require monitoring and management to 'reduce pest plant and weed impacts', only the relatively few weed species listed under regulation (which bind all landholders) are addressed; further measures are advisory only.[307] Similarly, there is a lack of regulation over what can be planted in plantations – any species is permitted, whether weedy or likely to breed with native species, other than the relatively few expressly prohibited – and there are no requirements for plantation owners to control escapes. This is likely to become a more significant issue as potentially weedy biofuels are promoted as alternative energy sources. There is need for duty-of-care provisions for plantations to require control of wildings (from plantations of exotic species) and prevent hybridisation with plants in the wild (from plantations of native species).

The impacts of plantations on hydrology, wetlands and other groundwater-dependent communities are not given adequate consideration under forestry codes and regulations. The native vegetation management framework commits to 'develop an improved understanding of the water yield impacts of private forestry enterprises on wetlands and associated aquatic vegetation and develop guidelines for plantation establishment to avoid further impacts'.[308] This issue requires further investigation and action.

Native vegetation on private land of medium or low conservation significance subject to timber harvesting is considered under the native vegetation management framework to be subject to temporary loss only, and the framework's former net gain requirements were considered to be met by 'regeneration'. This does not accurately reflect the consequences of forestry, which is likely to degrade vegetation quality through weed invasion, alteration to soil and drainage conditions, changes in species age and composition, impacts on habitat and loss of large old trees. The framework should apply to private forestry.

There is insufficient control over firewood collection to prevent adverse impacts on biodiversity. In 2011, the state government removed the need for permits to collect firewood from public land for private use. This decision should be reversed so that the collection of firewood and the impact on the forests can be properly monitored and controlled. Although the firewood strategy, applied to commercial collection on public land, requires retention of sufficient coarse woody debris for biodiversity and prohibits removal of hollow logs or logs with moss or lichen, there is no indication of the process by which areas are selected and assessed. Areas designated for firewood collection should at a minimum be subject to the same biodiversity criteria as other timber production methods. It is also vital to examine the impact of firewood removal on the biodiversity values of private land, where 87% of collection occurs. This is an as-of-right use for domestic purposes, although commercial firewood harvesting is subject to the national vegetation management framework and its offset requirements. Much of the need for firewood could be met from plantation forests. The collection of firewood from public land should be phased out with a new licence system introduced in the interim to limit impacts. This review recommends a regional development program to provide incentives for farm forestry production of firewood.

Box 3.14 Regional forest agreements (RFAs)[309]

With the exception of the Tasmanian RFA, there are no obligations within the RFAs imposing a legally enforceable obligation upon the state to ensure the protection of species or ecological communities listed in the [Environment Protection and Biodiversity Conservation Act].

Federal Department of Agriculture, Fisheries and Forestry 2009

RFAs are 20-year agreements between the federal and state governments outlining responsibilities for native forest management, which aim to protect some forest areas through the forest reserve system while maintaining and developing native forest logging industries that are ecologically and economically sustainable. Forestry activities covered by a regional forest agreement (approved under the Regional Forest Agreements Act) are not required to obtain approval under the federal Environment Protection and Biodiversity Conservation Act (strictly speaking, the development of an RFA constitutes a form of assessment and approval for the purposes of the act). There are five RFAs in Victoria: East Gippsland (1997), Gippsland (2000), Central Highlands (1998), North East (1999), West (2000).

The main advantage of RFAs is the incentive they have provided for conservation of a proportion of state-owned forests to meet requirements for a comprehensive, adequate and representative reserve system.

The 'sustainable' forestry regime accredited under the Victorian RFAs has three main environmental elements: forest management plans, the *Code of Practice for Timber Production* and threatened species laws (the Flora and Fauna Guarantee Act). The code of practice requires compliance with forest management plans and action statements prepared under the Flora and Fauna Guarantee Act for species identified in the areas proposed for logging. The state-owned business enterprise VicForests does most native forest logging in Victoria and, in an inherit conflict of interest, is also responsible for conservation measures, such as pre-logging surveys and forest coupe plans.

In Victoria, action statements for threatened species listed under the Flora and Fauna Guarantee Act are the principal mechanism for protection under the forest management regime. But threatened species listings are not comprehensive, fewer than half the listed species have action statements, and many action statements are out-of-date or of poor quality. Compliance with forestry laws has been highly inadequate, as revealed in numerous examples identified by community groups, in audits by the Environmental Protection Authority and in a 2009 review by the Victorian auditor general of administration of the Flora and Fauna Guarantee Act.[310] Climate change is ignored under the RFAs and there is no requirement to take into account the loss of forest resources due to bushfires. Some of the RFA failings are exemplified in Box 3.15..

Box 3.15 Leadbeater's possum – a case study of RFA failings[311]

Leadbeater's possum is at 'very high risk of extinction in the next 20-30 years' due to the rapid loss of large hollow-bearing trees from bushfire, logging and natural attrition. Forestry results in their losses due to removal (including from salvage logging), incineration from high-intensity fires to regenerate logged stands and accelerated rates of collapse in forest adjacent to logged areas. Logging also changes fire regimes in wet forests, rendering them more fire prone and more likely to burn at high severity. The 'fundamental ecological importance of large old hollow-bearing trees' needs much greater recognition in forestry management. Existing strategies to conserve the species are more than 15 years old and were watered down, leading to logging of suitable habitat areas.

The 2009 fires burned 42% of the known habitat of Leadbeater's possum, and they no longer occur in those burned areas. Populations were lost from extensive areas such as the Lake Mountain region. But there is no requirement under the RFA for this to be taken into account in forestry decisions. In a 2012 case brought by *MyEnvironment*, the Supreme Court found that despite the changed circumstances since the 2009 fires, VicForests was not required to apply any higher standard than that accredited in the existing RFA.[312] Sustainable yields had not been re-assessed, and the rate of logging of green forest was higher than before the fires.

Most logging in montane ash forests is by clearfelling, which means that logged areas will take almost 200 years to develop suitable habitat for Leadbeater's possum. VicForests has refused to adopt 'retention harvesting' (retaining patches of undisturbed forest) as an alternative more sustainable approach.

Box 3.16 Carbon value of Victoria's forests[313]

Victoria's native forests are rich stores of carbon. Any decisions about their future should take into account their value for mitigating climate change. Natural forests in southeast Australia store an average 640 tonnes of carbon per hectare (360 tonnes biomass carbon plus soil carbon) and each year they absorb a net average 12 tonnes of carbon. The highest biomass carbon stocks are in the mountain ash forests of Victoria's Central Highlands and Tasmania, with an average of more than 1200 tonne of carbon per hectare. The majority of biomass carbon in natural forests resides in the wood of large old trees. By reducing the average age of trees, commercial logging reduces the amount of stored carbon. 'The result is a significant (more than 40%) reduction in long-term average standing stock of biomass carbon compared with an unlogged forest.'

The commercial value of these carbon stores depends on the carbon price. On a $25/tonne price, logging of undisturbed forests in East Gippsland, based on the average harvest area in the years to 2007, would amount to a loss of almost half a million tonnes annually of carbon costed at $40 million. The loss to Victoria of logging this forest (after allowing for stumpage income of about $6 million) would be $33 million annually.

3.5.3 Bushfire management

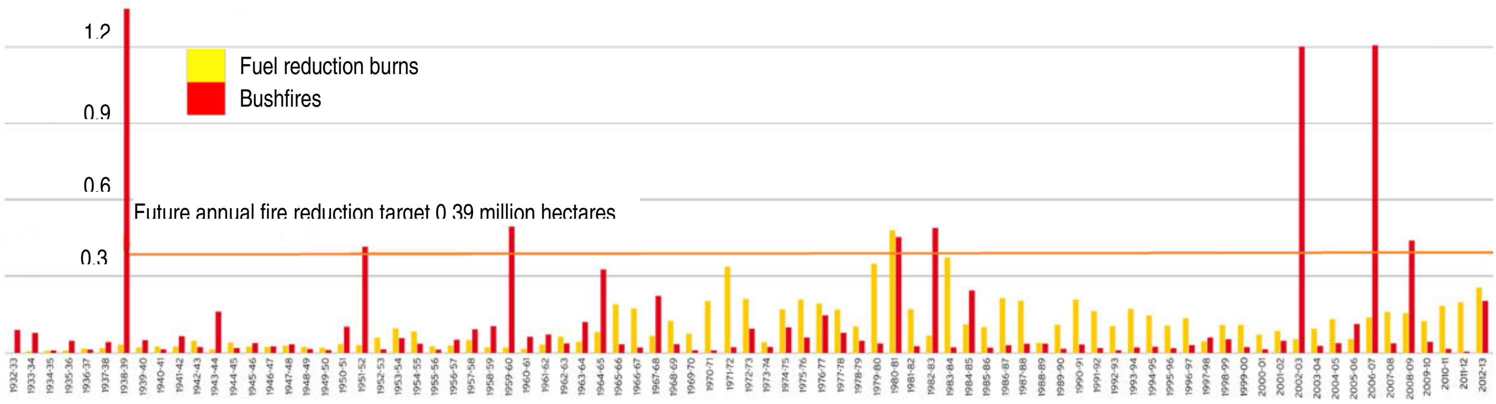
Unfortunately, with many major wildfires in recent years there is increased public pressure on politicians and agencies for more extensive prescribed burning to protect assets, particularly during droughts when flammability levels are high. Such pressure creates an urgency for burning simply to 'meet the targets' or so as to be 'seen to be doing something', irrespective of whether or not such burning will actually protect assets or achieve ecologically desirable outcomes.

Michael Clarke, 2008

In 2010, the Victorian government adopted a recommendation by the Victorian Bushfires Royal Commission to increase 'planned burning' to a minimum annual target of 390,000 hectares (5% of public land). But there is no credible evidence that the program can achieve the goal of significantly reducing risks to life and property. There has been no cost-benefit analysis of fuel reduction burning in relation to other life-saving measures and no rigorous assessment of the effectiveness of prescribed burning, including under climate change, which is predicted to increase the frequency of extreme fire weather.[314] Losses of houses and human lives generally occur only under severe fire conditions, when weather (strong winds, high temperatures, low humidity) rather than fuel loads exerts the main influence over fire severity.[315] A recent analysis of the 2009 Victorian fires found that the effect of weather is so dominant that fuel reduction burning is ineffective under 'very high' or 'catastrophic' weather conditions. Only relatively small amounts of fuel are needed to generate high fire intensity in these conditions.[316] The probability of crown fires was found to be 'higher in recently logged areas than in areas logged decades before, indicating likely ineffectiveness as a fuel treatment.' This and other studies have found that while fuel reduction does reduce risk under some conditions, a prescribed annual level of 5% is 'likely to result in considerable residual risk', and that a large (unrealistic) increase in rates of treatment may be required to substantially reduce risk and to counteract the effects of climate change.[317]

An 80 year history of fuel reduction burning and bushfires on Victoria's public lands shows that they have not been subjected during this time to the extreme level of fuel reduction burning currently intended by the state government (Figure 3.23). Only in one previous year, in 1980-81, was the current target of 390,000 hectares reached, and that was likely to be an overestimate, extrapolated from a pattern of ridge burning.

Figure 3.23 Area burned (million hectares) by fuel reduction burning and bushfires on public lands in Victoria over 80 years, from 1933-34 to 2012-13



Sources: Compiled by VNPA from figures for fuel reduction burns and bushfires on public land published in the annual reports of the Forests Commission of Victoria, and its successors, or from the Department of Sustainability and Environment.

In 2013, the implementation monitor for the Victorian Bushfires Royal Commission, whose job it is to review progress in implementing the recommendations of the bushfires commission, reported he was 'not convinced' that the annual rolling target of 5% minimum of public land (390,000 ha) is 'achievable, affordable or sustainable'.[318] He quoted fire ecologist Malcolm Gill: 'The real issue with targets is not the total area per year burned by prescription: it is the effect of fire regimes, including prescribed fires, on assets (human, property and biodiversity). There is a possibility that in meeting targets, the real issue of meeting ultimate objectives is overlooked.'[319]

This has already become clear in the Mallee area, where extensive planned burns are neither useful for public safety nor for biodiversity protection. Indeed, planned burning designed to reach the annual target is compromising biodiversity objectives in many areas, including reference areas normally excluded from management burns. It may also be compromising public safety. A high annual target skews burn plans towards the more remote areas, where large burns are easier and cheaper to achieve, but the most effective burns for public safety are the smaller but more difficult burns close to communities.[320]

As well as being a major drain on public resources for no clear benefit, the 5% target is likely to cause considerable harm to biodiversity.[321] The 2009 Victorian Bushfires Royal Commission endorsed the need for an improved 'understanding of the effects of different fire regimes on flora and fauna' so that 'prescribed burning regimes could meet conservation objectives as well as accommodating bushfire safety considerations'.[322] The recent increased frequency and scale of fires (megafires) under a drying climate challenge long-established tenets and require a different approach to protect human life, assets and biodiversity. The simplistic and ecologically irresponsible 5% target needs to be replaced with regional operational plans that focus on risk reduction for human assets in high risk areas and apply targets appropriate to particular ecosystems.

Because is not feasible to eliminate risks in many areas under the extreme circumstances that led to the Black Saturday bushfires, revised planning rules and building codes are required to avoid placement of assets in high-risk areas. In some forest types, such as tall ash forests, it will be more useful and cost-effective to fund fire shelters or strategies for people to leave the fire danger area rather than focus on fuel reduction. Wide-ranging comparative analyses (including cost-benefit analyses) are required to determine the best strategies to reduce risks for people, assets and biodiversity. There is a great need for public education on fire safety and fire management for conservation.

Most decision-making about ecologically appropriate fire regimes is driven by knowledge of a subset of vegetation, and a hope that the rest of the biota will follow. But the impacts of fire on most species are unknown, a knowledge deficiency that will be exacerbated by climate change.[323] Researchers have attempted to identify 'natural fire regimes', with limited success, in part because of limited knowledge of pre-European fire regimes. There is an urgent need for research to provide a stronger evidence base for ecological fire management, including the long-term effects of different fire regimes on wildlife in different parts of the landscape and interactions with invasive species. Long-term monitoring is essential.

3.5.4 Invasive species management

Effectively, [Victoria holds]that the desire of some citizens to shoot deer on public land for sport is of greater value than the conservation of our natural heritage and the burden imposed by deer on farmers.

Roger Bilney, 2013[324]

Victoria's already dire invasive species problems will continue to worsen unless there is substantial reform of laws, policies and programs to prevent the introduction of new harmful species, eradicate newly established species, and more effectively contain and control established threats. New stand-alone biosecurity legislation is warranted. Recognising that invasive species are both an environmental and agricultural problem, equivalent powers should be accorded to the relevant ministers to implement measures to protect the environment and economy respectively.

There is a well-accepted hierarchy of responses to invasive species starting from the most effective and least costly: prevention, eradication, containment and control. The only sensible approach to prevention is to ban the entry of new taxa (species, subspecies and variants) unless they are assessed as low risk (a 'permitted-list' approach). Risk assessments should be precautionary and account for the risks and uncertainties of invasive species under climate change conditions. Currently, Victoria takes the opposite approach with plants, which is to allow all species in unless they have been specifically prohibited. This means that invasive species management is inevitably reactive and piecemeal and more costly as the numbers of deliberately introduced weed species grow. There also needs to be a greater focus on systematically identifying priorities for eradication, containment and control. Many opportunities have been lost to remove newly established species.

The reactive approach also leads to lack of action on environmentally harmful invasive species with economic or social value. Feral deer, for example, are protected for the benefit of hunters under the Wildlife Act rather than managed as a highly damaging environmental and agricultural pest species – despite one of the species, sambar, being listed as a potentially threatening process. And the government continues to promote tall wheat grass as a pasture grass despite it being listed as a potentially threatening process. Strong duty of care obligations and polluter pays provisions are needed to require land managers to take responsibility for the spread of invasive species.

Effective control of entrenched invasive species requires collaborations, planning, government support and monitoring. This can be facilitated by the establishment of regional weed committees involving government, community representatives and land managers to develop strategies and allocate resources. Training is needed for all workers and contractors undertaking weed control on public lands. More research is required on ecological solutions for entrenched invasive species.

3.6 Future Directions

With less than half the state retaining native vegetation and only a quarter of that area having largely intact vegetation, major challenges lie ahead to avert degradation and loss of biodiversity and restore health to Victoria's landscapes. For a great many reasons – environmental, social and economic – this mission is worthy of a concerted state-wide effort. A great many Victorians have embraced it and are contributing in multiple ways – for there is much to treasure about Victoria's terrestrial ecosystems: diverse landscapes, an outstandingly rich array of wildlife, and a plenitude of nature-based recreational opportunities. They also provide essential ecosystem services of great economic value.

The recognised mega-diversity of Australia is amply represented in Victoria. Although only 3% of the continent's land mass, the state has more than a quarter of Australia's mammals and lichens, about a fifth of vascular plants and about half of its bird species. Many species and ecological communities are unique to Victoria, including about 10% of plants, and hundreds of invertebrate animals and fungi. But a dire number are threatened – about a fifth of terrestrial vertebrates and plants and more than half the ecological vegetation classes.

Over large areas, the damage from extensive land clearing and logging, a multitude of invasive species and altered fire regimes has been severe. With climate change already pushing out the extremes of heat, drought and fire, reducing these existing threats to nature has become more urgent, to foster resilience and adaptation to further inevitable changes.

Securely protecting land in the national park and conservation system, on both public and private land, and optimising conservation management in these core habitats is more important than ever as a core conservation strategy, important also to maintain ecosystem services and low-impact recreational opportunities.

Victoria still has a substantial way to go to achieve its goal of a comprehensive, adequate and representative protected area network. High priorities for improved protection include areas with high biodiversity values and low levels of protection, threatened ecological communities and climate change refugia. There need to be stricter safeguards against harmful exploitation of the national park and conservation system and more focus on conservation priorities such as implementing beneficial fire regimes and controlling harmful invasive species.

The future of many species and ecological communities relies on increasing the extent and quality of private land conservation. This warrants an independent investigation into conservation barriers and priorities for private land.

Protecting and restoring native vegetation is the essential foundation to environmental health in Victoria, and its continued loss and degradation show the need for stronger and independently administered vegetation laws, and expanded stewardship programs. Victoria's remaining native forests should all be protected, with a transition within 10 years to a sustainable plantations industry and a phase out of firewood collection on public lands

With both human safety and biodiversity at stake, it is vital that burning regimes in Victoria are based on sound science and take account of future climate change. The state-wide target of 5% prescribed burning on public lands should be replaced by a risk-based approach and locale-specific objectives to reduce risks to life, property and biodiversity. Strong planning rules, building codes and cost-benefit assessments of different safety measures are essential to avoid future risks and unnecessary loss of vegetation.

With invasive species having caused many extinctions and declines and widespread degradation, much higher priority needs to be given to preventing new harmful introductions and managing existing threats. With invasive species having caused many extinctions and declines and widespread degradation, much higher priority needs to be given to preventing new harmful introductions and managing existing threats. Stronger laws are needed – to require risk assessment of all proposed introductions, duty-of-care obligations and more systematic regulation of the use of harmful species.

Following is a summary of reforms recommended as high priorities over the next decade to make substantial progress on the protection and restoration of Victoria's terrestrial ecosystems.

Victoria's national park and conservation system

Comprehensive, adequate and representative protection

T1 Commission the Victorian Environmental Assessment Council to investigate how to most effectively achieve a comprehensive, adequate and representative national park and conservation system in Victoria across both public and private lands. High priority areas for protection include:

- Central Victoria: 20 areas recommended in VNPA's Small Parks report[325]
- Melbourne Metro and catchments: a Great Forests National Park, Wombat Forest, a western Melbourne grassland reserve and a network of smaller reserves
- East Gippsland: forest reserves (transfer state forest to the national park estate)
- South West Victoria: a Greater Glenelg National Park (west of the Grampians between the Princes Highway and Little Desert National Park)
- South Gippsland and Strzelecki Ranges: forest reserves (transfer state forest to the national park estate)
- Riverina: Red gum parks as previously recommended by the Environmental Assessment Council – the Murray River park and the Leaghur-Koorangie, Loddon and Avoca River floodplains.

T2 Upgrade protection for conservation reserves listed in schedules of the Crown Land (Reserves) Act:

- Transfer nature conservation reserves to schedule 2C (with protection equivalent to that for properties under schedules 2, 2A and 2B) of the National Parks Act.
- Transfer all other relevant reserves – cultural and natural heritage reserves, natural features reserves, historic and cultural features reserves, regional parks, miscellaneous reserves, water reserves and forest parks – to the National Parks Act, listing them temporarily as a new schedule.
- Commission the Victorian Environmental Assessment Council to assess the most appropriate future management arrangements for these properties.

T3 Establish an acquisition fund for the purchase of high priority lands for addition to the national park estate.

Indigenous land conservation

T4 Actively engage with Indigenous owners to develop land management agreements for biodiversity conservation.

T5 Provide ongoing financial support for joint and cooperative management agreements over existing national parks and reserves.

T6 Work with Indigenous representatives to determine how to better support Indigenous aspirations for conservation management.

Private land conservation

T7 Commission the Victorian Environmental Assessment Council to conduct a review of private land conservation, with a focus on:

- the potential contribution of private land conservation to achieve a comprehensive, adequate and representative national park and conservation system
- priorities for private land conservation and incentives needed to achieve these priorities
- barriers to private land conservation and how to overcome them
- the role of government in promoting private land conservation.

T8 Implement measures and incentives to support conservation on private land:

- exempt properties with Trust for Nature covenants from local government rates
- exempt sales of properties with Trust for Nature covenants from stamp duty
- pay for Trust for Nature covenants in priority areas through the BushTender program
- fund a base transaction fee for all new Trust for Nature covenants
- establish a land improvement fund to support landholders to maintain and improve the conservation values of covenanted properties.

T9 Provide support for non-government organisations that manage large areas for conservation (eg Trust for Nature and Bush Heritage Australia) through capacity building, collaboration with Parks Victoria and other measures.

T10 Ensure that conservation gains on private lands secured with public funds are monitored and maintained into the future, by mechanisms such as permanent conservation covenants.

Planning and management

T11 Develop a strategic plan to guide the future of Victoria's national park estate that also communicates its role and importance.

T12 Improve community education to build broad support for national parks.

T13 Promote conservation-compatible, broad community uses of national parks to encourage physical and mental well-being rather than high-end tourism uses.

T14 Strengthen protection of the national park and conservation system from activities incompatible with the primary purpose of nature conservation:

- Amend the National Parks Act to prohibit mineral exploration and fossicking in the national park estate.
- Maintain a ban on cattle grazing.
- Rule out commercial-scale ecological thinning or logging by stealth.
- Reverse the decision to allow private commercial developments and limit leases to existing structure in parks (no new buildings and structures for commercial purposes).
- Amend the Nature Conservation Trust Act to prohibit mining and mineral exploration in areas under a perpetual conservation covenant and in Trust for Nature reserves.

T15 Strengthen the focus on management planning for national parks and improve the policy development capacity within the parks agency.

T16 Improve the scientific skills base of staff employed by the parks agency, including for monitoring.

T17 Set up scientific advisory panels for specific national park management issues as they arise.

T18 Upgrade and expand invasive plant and animal control programs, and monitor their effectiveness.

T19 Conduct ecologically beneficial fire management with advice provided by an expert panel.

T20 Provide dedicated funding for management and monitoring of national parks, with a specific budget line to allow tracking of spending levels.

T21 Review existing state charges and levies, such as the parks and waterways levy, to identify funding options for improving management of the national park and conservation system.

T22 Build the resilience of the national park and conservation system to climate change by improving the knowledge base, protecting climate refugia, connecting the national park estate along environmental gradients and including a climate adaptation focus in national park management plans (other recommendations in chapter 5).

T23 Implement recommendations by the Victorian Environmental Assessment Council to facilitate stewardship agreements with organisations and individuals for small public land reserves, including voluntary and payment-based agreements. They should clarify appropriate public land uses, and provide training programs and additional resources if required for conservation outcomes.[326]

Native vegetation protection

Effective regulation

T24 Develop new vegetation laws, as part of the proposed Victorian Environment and Conservation Act (described in chapter 5) that include the establishment of an independent Native Vegetation Regulator to assess clearing applications, oversee monitoring, conduct enforcement, administer offset schemes and provide expert advice for policy-making.

T25 Strengthen the native vegetation management framework, including by the following measures:

- Revert to a clear state-wide objective of 'net gain'.

- Reinstate the three-step hierarchical approach of (1) avoid adverse impacts, (2) minimise impacts and (3) offset impacts.
- Assess the indirect impacts of agricultural activities (cropping, grazing) on vegetation and hydrology.
- Develop a knowledge base to predict the likely responses of different vegetation types to climate change.

T26 Implement a systematic approach to compliance monitoring and enforcement of vegetation rules at local and state levels:

- Establish a native vegetation monitoring program, with oversight by the Native Vegetation Regulator.
- Audit the performance of permit-holders, including at offset sites.
- Establish environmental monitors to ensure compliance with approval conditions, especially for large developments.
- Publish online all relevant information, including permits, plans, assessment and monitoring reports, enforcement notices and actions.
- Provide resources to local governments to perform their duties.
- Regularly audit and report on the effectiveness of the system, including estimates of illegal clearing.

T27 Improve the offsets framework to deliver genuine conservation gains:

- Commission an independent audit of offsets under the native vegetation management framework to assess the extent to which offset targets are being achieved, their degree of permanence, and improvements needed to deliver a state objective of 'net gain'.
- Require offsets for all approved actions that are likely to be detrimental to species on the state government's advisory lists of threatened plants and animals.
- Establish a long-term monitoring program for offsets.
- For low risk activities in low value areas, require offset payments according to a fixed rate and where the funds can be used to support existing protected areas.
- Support the accreditation of pooled services that can bank offset credits and source required offset outcomes.
- Ensure that any offsets to provide for improved management of existing protected areas will achieve genuine 'additionality'.

Biolinks and stewardship

T28 Develop a statewide biolinks plan to enhance landscape connectivity and manage and restore conservation values at the landscape level:

- Build on the flagships and biolinks identified in the 2009 Securing Our Natural Future: A White Paper for Land and Biodiversity at a Time of Climate Change.
- Incorporate focal landscapes and priority biodiversity zones identified in the Trust for Nature's Statewide Conservation Plan.
- Supports the community to undertake detailed landscape, regional and local biolink ecological assessments and planning.
- Include a framework for engaging the community, building land manager capacity and communication.

T29 Expand the use of ecomarkets, such as BushTender and offsets, within a framework of delivering genuine, permanent conservation gains (by perpetual covenants).

T30 Review the Land for Wildlife program to recommend how it can be expanded and its environmental outcomes improved.

T31 Commission research on how to increase the ecological and evolutionary resilience of native vegetation in the face of climate change, including consideration of changes in local provenance requirements and the role of connectivity.

Native forest protection

Timber harvesting and forest protection

T32 Transition Victoria's wood products industry from native forests to plantations. For woodchip, pulp and paper customers complete the transition within five years and for sawn timber customers within 10 years. Aim to be employment positive in five years and economically positive in 10 years. Provide security of supply to the restructured timber industry and support the use of leading-edge technology. Elements of this transition would include:

- an immediate moratorium on logging of high value conservation sites, such as Leadbeater's possum habitat in the Central Highlands
- industry assistance and a regional development package to support the transition to plantations and investment in new technology
- additions to the national park and conservation system after detailed regional investigations by an appropriately qualified independent body such as the Victorian Environmental Assessment Council.

T33 Immediately ban logging in western Victoria and cancel the regional forest agreement applying to south-west Victoria.

T34 Apply the federal Environment Protection and Biodiversity Conservation Act to all relevant forestry activities by removing the exemption for forestry conducted under regional forest agreements.

T35 Reform forestry policies and guidelines including the regional forest agreements, the code of timber production and timber contracts to require that all threatened species are protected, and climate change and invasive species threats are properly considered.

T36 Establish Victoria as a world-leader in protecting forest-based carbon stores that assist the state in meeting carbon pollution reduction targets.

T37 Incorporate informal forestry reserves such as 'special protection zones' into the national park and conservation system by protecting them under the National Parks Act.

Firewood collection

T38 Introduce a new approach to managing firewood in Victoria that ensures continued firewood supply and protection of native forests:

- Establish a regional development program to provide incentives to support private farm forestry growers to provide firewood.
- Phase out firewood collection from public land.
- In the interim, require all collection from public land to be licenced with stringent conditions to protect conservation values.

Bushfire management

Planning for public safety and biodiversity

T39 Assess the need for prescribed burning programs at a local level in the context of other potentially more useful public safety measures, such as building designs, public and private fire shelters, fire-wise planning provisions, building regulations, powerline maintenance and location and public education.

T40 Do cost-benefit assessments of a range of safety measures when planning fire management, acknowledging that strategies other than fuel reduction are likely to be more useful and cost-effective in some areas.

T41 Give priority in fuel reduction planning to prescribed burns that are (a) critical for public safety and (b) beneficial to both public safety and biodiversity.

T42 Replace any annual state-wide target (5% or otherwise) for prescribed burning by a risk-based approach, focussed on meeting local objectives in regional fire operation plans that reduce risks to life, property and biodiversity.

T43 Apply strong planning rules and building codes in bushfire prone areas to avoid placing homes and people at risk and to reduce the need to remove or modify native vegetation. Take climate change predictions for more frequent and more severe fire events into account.

Ecologically beneficial fire regimes

T44 Establish a suitable range of age classes for each ecological vegetation division (or ecological vegetation class as appropriate) and incorporate this into long-term fire operations planning, making provision for wildfire events as well as planned burns. In particular, this applies to the retention of adequate long-unburnt areas as they cannot be recovered for decades or, in some cases, centuries. Apply the precautionary principle to these decisions.

T45 Revise minimum and maximum tolerable fire intervals for each ecological vegetation division (and in critical cases, for each ecological vegetation class) allowing as far as possible for the full range of species likely to be affected. Develop clear guidelines for burn severity and patchiness for different ecological vegetation classes.

Prescribed burning practices and responses to wildfire

T46 Plan fuel reduction across all land tenures, including private land, and include slashing and other methods as well as burning.

T47 Include both planned burns and wildfire, and the effectiveness of burns, in assessing whether fuel reduction aims and biodiversity protection have been achieved.

T48 Take account of the condition of ecological vegetation classes (such as drought stress) at the time of proposed burning.

T49 In fire plans require protection of a sufficient number and range of hollow-bearing trees for the long-term protection of hollow-dependent fauna. Apply this requirement also to tree clearing that is conducted for safety reasons in advance of prescribed burns.

T50 Include fire-sensitive species and ecological communities (eg rainforest) as 'assets' warranting protection from both wildfire and planned burns.

Research, monitoring and adaptive management[327]

T51 Include adaptive management, in response to short term and long-term monitoring, as an essential component of fire management planning.

T52 Develop rapid monitoring methods (such as DNA sampling) for invertebrates, non-vascular plants, fungi and microbes, to assess short and long-term impacts of fires on biodiversity.

T53 Conduct research and/or monitoring to investigate:

- the effectiveness of fuel reduction burns in different ecological vegetation classes
- whether fire regimes are trending towards or away from long-term maintenance of an appropriate range of age classes, with particular reference to old age classes
- the effects of different fire regimes (frequency, severity, patterns and scales of patchiness) on different species and ecological vegetation classes
- changes in vegetation composition after repeated fires, including changes in flammability
- seasonal differences in post-fire recovery, and post-fire pest plant and animal invasion
- how long seeds and eggs remain viable in soil
- the effects of below-ground fire.

Education and communication

T54 Conduct ongoing public education on the following topics:

- the full range of options for increasing personal safety in the face of fire, especially local options for increasing safety
- the limitations of fuel reduction burn programs in relation to public safety, especially in severe fire weather
- an understanding of the impacts of different fire regimes on an area's natural values
- the need for adaptive management in the face of new knowledge.

Invasive species management

T55 Develop stand-alone biosecurity legislation to strengthen the approach to harmful invasive organisms (details in chapter 5):

T56 Establish regional weed committees involving local governments, other land managers and community representatives to develop strategies and allocate resources for weed eradication and control.

T57 Develop training and certification systems for weed control to be required for all workers and contractors involved with weed control on public lands, modelled on the DPI Weedstop certification.

T58 Expand programs facilitating community engagement in pest plant and animal management and ecological monitoring.

T59 Reclassify deer, a 'game' species currently protected under the Wildlife Act, as a pest species, map current populations and implement coordinated control programs, eradicating populations where feasible.

T60 Undertake a control program to rapidly reduce the population of feral horses in the alpine national parks and surrounding areas, primarily using aerial shooting under RSPCA-endorsed protocols.

T61 Develop guidelines for managing native species whose distribution is changing dramatically as a consequence of climate change or other anthropogenic drivers and which may have adverse impacts on biodiversity.

3.7 Sources

Endnotes

1 Bureau of Meteorology (2010)
2 Bureau of Meteorology (2014b)
3 Bureau of Meteorology (2010)
4 Australian Government (2012)
5 Mittermeier et al (1997)
6 Geoff Carr, Ecology Australia (personal communication)
7 Royal Botanic Gardens Melbourne (2011)
8 Chapman (2009); Department of Sustainability and Environment (2010a)
9 Gibson (2006)
10 For Victoria: Tom May, Museum Victoria (personal communication); for Australia: Chapman (2009)
11 Tom May, Museum Victoria (personal communication)
12 McCarthy (2014)
13 Museum Victoria (2009)
14 Museum Victoria (2009)
15 Auld & Keith (2009)
16 de Groot et al (2012)
17 For numbers of Australian species: mostly Chapman (2009). For mammals: Department of Sustainability and Environment (2010a); Menkhorst & Knight (2010). For birds: BirdLife Australia, with assistance from Euan Ritchie; Pizzey & Knight (1997). For reptiles: Department of Sustainability and Environment (2010a). For frogs: Gillespie & Kum (2011). For invertebrates: Department of Sustainability and Environment (2010a). For vascular plants: Walsh & Stajsic (2007). For bryophytes: Jolley (2006); Department of Sustainability and Environment (2010a). For lichens: McCarthy (2014). For threatened and extinct numbers: Department of Sustainability and Environment (2005); Department of Sustainability and Environment (2009d); Garnett et al (2011); Department of Sustainability and Environment (2013)
18 Parks Victoria (2007); Parks Victoria (2010); Commissioner for Environmental Sustainability (2013)
19 Parks Victoria (2007); Taylor et al (2011)
20 Parks Victoria (2013)
21 Crisp et al (2001)
22 Department of the Environment (nd-a)
23 Environment Australia (2001)
24 Dutson et al (2009)
25 Mifsud (2002); MonumentalTrees.com (nd)
26 Mifsud (2002)
27 Lindenmayer et al (2012)
28 Keith et al (2009)
29 Keith et al (2009)
30 Dutson et al (2009)
31 Gullan (nd-b)
32 Department of Sustainability and Environment (2010a)
33 Department of Sustainability and Environment (2005); Department of Sustainability and Environment (2009d); Department of Sustainability and Environment (2013)
34 Bilney et al (2010)
35 Eldridge & James (2009)
36 Gibbons & Lindenmayer (2002)
37 Amos et al (2012)
38 Victorian Auditor General (2009)
39 Victorian Catchment Management Council (2002); Dunlop et al (2004); Victorian Catchment Management Council (2007); Victorian Environmental Assessment Council (2010)
40 Matthews et al (2011)
41 For current advisory lists: Department of Sustainability and Environment (2005); Department of Sustainability and Environment (2009d); Department of Sustainability and Environment (2013). For advisory lists current in 2001: Traill & Porter (2001), based on advisory lists of 2000, 1999 and 1995
42 Commissioner for Environmental Sustainability (2013)
43 Lindenmayer et al (2011b)
44 Department of Sustainability and Environment (2007b)
45 Department of the Environment (nd-d)
46 Plants: Walsh & Stajsic (2007); mammals: Menkhorst & Knight (2010); birds: BirdLife Australia Working List 2013; slugs & snails: Collett et al (2007)
47 Cunnington (2003)
48 Department of Environment and Primary Industries (2014d)
49 Bureau of Rural Sciences (2009); Victorian Environmental Assessment Council (2010); Australian Bureau of Statistics (2013d); Trust for Nature (2013); Department of Environment and Primary Industries (2013)
50 Australian Bureau of Statistics (2013c)
51 Australian Bureau of Statistics (2013c); Australian Bureau of Statistics (2013d)
52 Australian Bureau of Statistics (2013a); Australian Bureau of Statistics (2013d)
53 Victorian Parliament Education and Training Committee (2012); Australian Bureau of Statistics (2013b)
54 Australian Bureau of Statistics (2013d)
55 Victorian Environmental Assessment Council (2010)
56 State of the Environment 2011 Committee (2011)
57 Victorian Environmental Assessment Council (2010)
58 Commissioner for Environmental Sustainability (2008)
59 Victorian Environmental Assessment Council (2010), Department of Sustainability and Environment (2010a)
60 Victorian Environmental Assessment Council (2010)
61 Threatened Species Scientific Committee (2008b)
62 Endersby (2010)
63 Victorian Environmental Assessment Council (2010)
64 Victorian Environmental Assessment Council (2010); Matthews et al (2011)
65 Victorian Environmental Assessment Council (2010)
66 Department of Sustainability Environment Water Population and Communities (2011)
67 Victorian Environmental Assessment Council (2010)
68 Threatened Species Scientific Committee (2008b)
69 Trust for Nature (2013)
70 Trust for Nature (2013), based on the JANIS criteria
71 Department of the Environment (nd-c)
72 Victorian Environmental Assessment Council (2011)
73 Department of Sustainability and Environment (2008b)
74 Matthews et al (2011)
75 Victorian Environmental Assessment Council (2011)
76 Victorian Environmental Assessment Council (2010)
77 Victorian Environmental Assessment Council (2010)
78 Victorian Environmental Assessment Council (2010)

79 Victorian Environmental Assessment Council (2011)

80 Fischer & Lindenmayer (2007)

81 Amos et al (2012)

82 Department of Sustainability and Environment (2008b); Victorian Environmental Assessment Council (2011)

83 Victorian Environmental Assessment Council (2010)

84 Commissioner for Environmental Sustainability (2013)

85 Cheal (2010)

86 Commissioner for Environmental Sustainability (2013)

87 National Institute of Economic and Industry Research (2010)

88 VicForests (2011); ABARES (2012)

89 ABARES (2012); VicForests (2013c); Department of Environment and Primary Industries (2013)

90 ABARES (2008)

91 Lindenmayer et al (2012); Lindenmayer et al (2013)

92 Poulton (2006). The Department of Sustainability and Environment (2008c) defines old-growth as forest which contains significant amounts of its oldest growth stage – usually senescent trees – in the upper stratum and where the where the effects of past disturbances are now negligible.

93 Poulton (2006)

94 Lindenmayer & Ough (2006); Department of Sustainability and Environment (2008c).

95 Lindenmayer et al (2012)

96 Department of Sustainability and Environment (2008c)

97 Department of Sustainability and Environment (2008c). Forest species listed in 2006 in the state's advisory lists numbered 145 animals and 278 plants.

98 Gibbons & Lindenmayer (2002)

99 Lindenmayer et al (2013)

100 Department of Sustainability and Environment (2008c)

101 Department of Sustainability and Environment (2008c), with advice from Richard Hughes, The Wilderness Society, October 2013.

102 Department of the Environment (nd-b); Department of Environment and Primary Industries (2013)

103 Trust for Nature (2013)

104 Trust for Nature (2013)

105 Trust for Nature (2013)

106 Department of Sustainability and Environment (2008b); Department of Sustainability and Environment (2011b); Personal communication, Peter Johnson, Statewide Coordinator, Land for Wildlife, April 2014.

107 Trust for Nature (2013)

108 Fitzsimons (2006)

109 Australian Bureau of Statistics (2013d)

110 Department of Environment and Primary Industries (2014b); Parks Victoria (2014)

111 Parks Victoria (2014)

112 Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee (JANIS) (1996)

113 Traill & Porter (2001)

114 EVC data: Department of Sustainability and Environment (2007b). JANIS targets: Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee (JANIS) (1996). NCR reserve targets: Traill & Porter (2001), with modifications

115 Taylor et al (2011)

116 Sharafi et al (2012)

117 Bennett et al (2009)

118 McGregor et al (2008); Traill (2009)

119 McGregor et al (2008); Bennett et al (2009)

120 Dunlop et al (2012)

121 Department of Sustainability and Environment (2012b)

122 Department of Sustainability and Environment (2012b); Bureau of Meteorology (2012); Bureau of Meteorology (2013b); Bureau of Meteorology (2013a); Bureau of Meteorology (2014c)

123 Bureau of Meteorology (2014a)

124 Department of Sustainability and Environment (2012b)

125 Commissioner for Environmental Sustainability (2012)

126 Commissioner for Environmental Sustainability (2012)

127 Commissioner for Environmental Sustainability (2012)

128 Bureau of Meteorology (2014a)

129 Matthews et al (2011)

130 Dunlop et al (2012)

131 Dunlop & Brown (2008)

132 Dunlop et al (2012)

133 Dunlop & Brown (2008)

134 Dunlop et al (2004); Victorian Environmental Assessment Council (2010); Department of Sustainability and Environment (2010a); Commissioner for Environmental Sustainability (2013)

135 Department of Sustainability and Environment (2010a)

136 Low (2011)

137 Dunlop & Brown (2008)

138 Victorian Environmental Assessment Council (2010)

139 Mac Nally et al (2009)

140 Gullan (nd-a)

141 Department of Sustainability and Environment (2009c); Matthews et al (2011)

142142 Commissioner for Environmental Sustainability (2008); Department of Sustainability and Environment (2009b). In 2006, in action statements prepared under the Flora and Fauna Guarantee Act, 11 vegetation communities and 111 plant species were considered directly threatened by weed invasions.

143 Hennessy et al (2007); Booth et al (2009)

144 Weiss (2007)

145 Threatened Species Scientific Committee (2010)

146 Traill & Porter (2001)

147 Department of Sustainability and Environment (1997); Department of Sustainability and Environment (2002)

148 Department of Environment and Primary Industries (2014e)

149 Bilney (2013)

150 Department of Sustainability and Environment (2008d)

151 Department of Environment and Primary Industries (2014c)

152 Cunnington (2007)

153 Berger et al (1998); Skerratt et al (2007)

154 Nash (2013)

155 Clarke et al (2007)

156 Department of Sustainability and Environment (2009a)

157 Cunnington (2007)

158 Maron & Kennedy (2007); Howes & Maron (2009); Maron et al (2011)

159 Low (2011)

160 Low (2011)

161 Victorian Environmental Assessment Council (2010)

162 Gibbons & Lindenmayer (2002)

163 Fischer & Lindenmayer (2007); Department of Sustainability and Environment (2008b); Victorian Environmental Assessment Council (2010). The quote is from the Department of Sustainability and Environment.

164 Threatened Species Scientific Committee (2008b)

[165] Woodgate & Black (1988)

[166] Department of Sustainability and Environment (2008b), estimated by comparing satellite images from 1989/1995 to 1998/2005.

[167] Department of Sustainability and Environment (2008b)

[168] Department of Sustainability and Environment (2008b)

[169] Commissioner for Environmental Sustainability (2013)

[170] Dunlop et al (2004); Commissioner for Environmental Sustainability (2008); Department of Sustainability and Environment (2010a)

[171] Victorian Environmental Assessment Council (2010)

[172] Victorian Environmental Assessment Council (2010)

[173] VicForests (2013a); VicForests annual sustainability reports

[174] ABARES (2012); Commissioner for Environmental Sustainability (2013)

[175] Lindenmayer & Ough (2006)

[176] Lindenmayer et al (2012)

[177] Lindenmayer et al (2012)

[178] Lindenmayer et al (2013)

[179] Lindenmayer et al (2011a)

[180] Mueck & Peacock (1992)

[181] Lindenmayer et al (2011a). Young regenerating mountain ash forest has more fine fuels– created by logging operations, the collapse of small stems and shedding of branches during self-thinning – and is drier than old-growth forest.

[182] Lindenmayer et al (2013)

[183] Mackay et al (2008)

[184] Forest Solutions (2013)

[185] VNPA (2010)

[186] Gilfedder et al (2010)

[187] Matthews et al (2011)

[188] Fischer et al (2010)

[189] Gibbons & Lindenmayer (2002); Lindenmayer et al (2012)

[190] Lindenmayer et al (2012)

[191] Lindenmayer et al (2011a)

[192] Lindenmayer et al (2012)

[193] Brown et al (2009)Brown et al 2010 review

[194] Department of Sustainability and Environment (2010b); York (2011)

[195] York (2011)

[196] York (2011)

[197] Brown et al (2009)

[198] Matthews et al (2011)

[199] Dunlop et al (2004)

[200] Victorian Environmental Assessment Council (2010)

[201] Maron & Fitzsimons (2007)

[202] Barr (2008); Barr (2009)

[203] Barr (2005); Barr (2009)

[204] Hennessy et al (2007)

[205] Hajkowicz & Moody (2010); Department of Primary Industries (2008)

[206] Matthews et al (2011)

[207] As recognised in the listing of two potential threatening processes relevant to fire regimes under the Flora and Fauna Guarantee Act.

[208] Cheal (2010)

[209] Cheal (2010)

[210] New et al (2010)

[211] McMullan-Fisher et al (2011)

[212] Woinarski & Legge (2012)

[213] Driscoll et al (2010); Kelly et al (2011)

[214] Cheal (2010)

[215] Di Stefano & York (2012)

[216] Matthews et al (2011)

[217] Clarke (2008)

[218] Department of Sustainability and Environment (2011a)

[219] Cheal (2010)

[220] Di Stefano & York (2012)

[221] Taylor et al (2012)

[222] Clarke (2008)

[223] Gill (2009)

[224] MacHunter et al (2009)

[225] MacHunter et al (2009)

[226] Hennessy et al (2007); Hennessy et al (2008)

[227] Department of Sustainability and Environment (2008a)

[228] Dunlop & Brown (2008)

[229] Department of Natural Resources and Environment (1997)

[230] Victorian Environmental Assessment Council (2011)

[231] Victorian Environmental Assessment Council (2011); Trust for Nature (2013)

[232] VNPA (2010)

[233] Victorian Environmental Assessment Council (2010)

[234] Trust for Nature (2013)

[235] Department of Primary Industries (2010)

[236] Members of the Yorta Yorta Community v The State of Victoria and Ors (1998) 3 AILR 401

[237] Dudley (2008)

[238] Buckley (2013)

[239] Buckley (2013)

[240] Miller et al (2007); Parks Victoria (2007); Victorian Auditor General (2010)

[241] Victorian Catchment Management Council (2007)

[242] Parks Victoria (2007)

[243] Parks Victoria (2012)

[244] Dunlop & Brown (2008)

[245] Dunlop & Brown (2008)

[246] Dunlop et al (2012)

[247] Dunlop & Brown (2008)

[248] Dunlop et al (2012)

[249] Dunlop et al (2012)

[250] Dunlop et al (2012)

[251] Victorian Environmental Assessment Council (2011); Victorian Catchment Management Council (2012); Commissioner for Environmental Sustainability (2013)

[252] Environment Defenders Office (Victoria) (2012)

[253] Environment Defenders Office (Victoria) (2012). The total number of permits issued is not known. In 2010–11, 1968 permit applications to clear native vegetation were referred to the Department of Sustainability and Environment but these are thought to represent about one third of all applications.

[254] A 'net gain' is a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation.

[255] Chee (2013)

[256] Commissioner for Environmental Sustainability (2013)

[257] Department of Environment and Primary Industries (2014a)

[258] Chee (2013)

[259] Victorian Auditor General (2012)

[260] Pickett et al (2013)

[261] Department of Sustainability and Environment (2012a)

[262] Victorian Environmental Assessment Council (2010)

[263] Department of Sustainability and Environment (2008b)

[264] Maron & Gordon (2013)
[265] Maron et al (2012)
[266] Maron & Gordon (2013)
[267] Maron et al (2012)
[268] Pickett et al (2013)
[269] Threatened Species Scientific Committee (2008a)
[270] Pickett et al (2013)
[271] Cunningham et al (2012)
[272] Victorian Environmental Assessment Council (2010); VNPA (2010)
[273] Victorian Environmental Assessment Council (2010)
[274] Freudenberger & Harvey (2003); Hobbs & Cramer (2008); Threatened Species Scientific Committee (2008b); Dunlop & Brown (2008)
[275] Freudenberger & Harvey (2003)
[276] Matthews et al (2011)
[277] Matthews et al (2011)
[278] Matthews et al (2011)
[279] Department of Sustainability and Environment (2009e)
[280] Geddes et al (2011)
[281] Department of Sustainability and Environment (2008b)
[282] Geddes et al (2011)
[283] Vesk & Dorrough (2006)
[284] Geddes et al (2011)
[285] Department of Sustainability and Environment (2008b)
[286] Department of Sustainability and Environment (2009e)
[287] Commissioner for Environmental Sustainability (2013)
[288] Lindenmayer et al (2013)
[289] The Victorian Forest Alliance (2006)
[290] New Economics Advisory Service (2013)
[291] National Institute of Economic and Industry Research (2010)
[292] VicForests (2013b)
[293] National Institute of Economic and Industry Research (2010)
[294] The Victorian Forest Alliance (2006); National Institute of Economic and Industry Research (2010)
[295] National Institute of Economic and Industry Research (2010)
[296] Feehely et al (2013)
[297] Hawke (2009)
[298] VicForests (2013a)
[299] Environment Defenders Office (Victoria) (2013); Caripis (2013)
[300] Environment Defenders Office (Victoria) (2013)
[301] Forest Solutions (2013)
[302] VNPA (2010)
[303] Wallace (2010)
[304] This is consistent with the underpinning JANIS document, which states: 'Modifications to reserve design will be required through time as new values are identified and programs monitoring the effectiveness of established reserves identify deficiencies in reserve design and management'.
[305] Lumsden et al (2013)
[306] Feehely et al (2013)
[307] Department of Sustainability and Environment (2007a)
[308] Department of Natural Resources and Environment (2002)
[309] Feehely et al (2013)
[310] Victorian Auditor General (2009); Feehely et al (2013).
[311] Lindenmayer et al (2013); Feehely et al (2013)
[312] MyEnvironment Inc v VicForests [2012] VSC 91
[313] Mackey et al (2008)
[314] Hasson et al (2009)
[315] Price & Bradstock (2012)
[316] Price & Bradstock (2012)
[317] Bradstock et al (2012)
[318] Comrie (3013)
[319] Gill (2012)
[320] Gibbons et al (2012)
[321] Gill et al (2012)
[322] Teague et al (2010)
[323] Clarke (2008); MacHunter et al (2009); New et al (2010)
[324] Bilney (2013)
[325] VNPA (2010)
[326] Recommendations 10 and 11, Victorian Environmental Assessment Council (2011)
[327] These recommendations mostly derive from the Symposium on Fire and Biodiversity in Victoria jointly held by the VNPA and the Royal Society of Victoria, 24-25 Oct 2011 (Gill et al 2012).

References

ABARES (2008) *Forests of Australia (2008).* Australian Government, Australian Bureau of Agricultural and Resource Economics Science

ABARES (2012) *Australia's Forests at a Glance 2012.* Australian Government Department of Agriculture, Fisheries and Forestry

Amos JN, Bennett AF, Nally RM, Newell G, Pavlova A, et al (2012) Predicting landscape-genetic consequences of habitat loss, fragmentation and mobility for multiple species of woodland birds. *PLoS ONE* 7: e30888

Auld TD, Keith DA (2009) Dealing with threats: integrating science and management. *Ecological Management & Restoration* 10: S79-S87

Australian Bureau of Statistics (2013a) *4618.0 - Water Use on Australian Farms, 2011-12.* Australian Government Australian Bureau of Statistics

Australian Bureau of Statistics (2013b) *5220.0 - Australian National Accounts: State Accounts, 2011-12.* Australian Government Australian Bureau of Statistics

Australian Bureau of Statistics (2013c) *7121.0 - Agricultural Commodities, Australia, 2011-12.* Australian Government Australian Bureau of Statistics

Australian Bureau of Statistics (2013d) *Land Management and Farming in Austraila, 2011-12.* Australian Government Australian Bureau of Statistics

Australian Government (2012) *Interim Biogeographic Regionalisation of Australia Version 7.* Department of Sustainability, Environment, Water, Population and Communities,

Barr N (2005) *The Changing Social Landscape of Rural Victoria.* Victorian Government Department of Primary Industries

Barr N (2008) The Social Landscapes of Rural Victoria. Landscape Analysis and Visualisation In *Lecture Notes in Geoinformation and Cartography*, pp. 305-32

Barr N (2009) *The House on the Hill: The Transformation of Australia's Farming Communities* Melbourne: Halstead Press.

Bennett AF, Haslem A, Cheal DC, Clarke MF, Jones RN, et al (2009) Ecological processes: a key element in strategies for nature conservation. *Ecological Management & Restoration* 10: 192–99

Berger L, Speare R, Daszak P, Green DE, Cunningham AA, et al (1998) Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Sciences* 95: 9031-36

Bilney RJ (2013) The protected pest: deer in Australia. *The Conversation* 12 February 2013

Bilney RJ, Cooke R, White JG (2010) Underestimated and severe: small mammal decline from the forests of south-eastern Australia since European settlement, as revealed by a top-order predator. *Biological Conservation* 143: 52-59

Booth C, Carr G, Low T (2009) *Weedy Pasture Plants for Salinity Control: Sowing the Seeds of Destruction.* Invasive Species Council

Bradstock RA, Cary GJ, Davies I, Lindenmayer DB, Price OF, Williams RJ (2012) Wildfires, fuel treatment and risk mitigation in Australian eucalypt forests: Insights from landscape-scale simulation. *Journal of Environmental Management* 113: 146-57

Brown G, Tolsma A, Murphy S, Miehs A, McNabb EG, York A (2009) *Ecological Impacts of Firewood Collection – A Literature Review to Inform Firewood Management on Public Land in Victoria.* Victorian Government Arthur Rylah Institute for Environmental Research; Department of Forest and Ecosystem Science, University of Melbourne

Buckley R (2013) Rights and wrongs in national park tourism. *Wildlife Australia* 50: 30-31

Bureau of Meteorology (2010) *Bureau of Meteorology Climate Zones.* http://www.bom.gov.au/iwk/climate_zones/map_2.shtml. Accessed January 2014

Bureau of Meteorology (2012) *Special Climate Statement 41: Extreme November Heat in Eastern Australia.* Australian Government Bureau of Meteorology

Bureau of Meteorology (2013a) *Australia's warmest 12-month period on record.* Australian Government Bureau of Meteology

Bureau of Meteorology (2013b) *Special Climate Statement 43: Extreme Heat in January 2013.* Australian Government Bureau of Meteorology

Bureau of Meteorology (2014a) *Australian Climate Variability & Change: Trend Maps.* http://www.bom.gov.au/climate/change/#tabs=Tracker&tracker=trend-maps. Accessed March 2014

Bureau of Meteorology (2014b) *Daily Extremes.* http://www.bom.gov.au/cgi-bin/climate/extremes/daily_extremes.cgi. Accessed March 2014

Bureau of Meteorology (2014c) *Special Climate Statement 48: One of Southeast Australia's Most Significant Heatwaves.* Australian Government Bureau of Meteorology

Bureau of Rural Sciences (2009) *Land Use Summary. Victoria – State Report.* Australian Collaborative Land Use and Management Practices. Australian Government Bureau of Rural Sciences,

Caripis L (2013) Victorian law change abandons native forests to loggers *The Conversation* 27 May 2013

Chapman A (2009) *Numbers of Living Species in Australia and the World.* Australian Biodiversity Information Services, Toowoomba

Cheal DC (2010) *Growth Stages and Tolerable Fire Intervals for Victoria's Native Vegetation Data Sets. Fire and Adaptive Management Report No. 84.* Victorian Government Department of Sustainability and Environment

Chee YE (2013) Hidden flaws in Victoria's new native vegetation clearing rules *The Conversation* 3 October 2013

Clarke MF (2008) Catering for the needs of fauna in fire management: science or just wishful thinking? *Wildlife Research* 35: 385-94

Clarke MF, Taylor R, Oldland J, Grey MJ, Dare A (2007) Challenges in managing miners. *The Victorian Naturalist* 124: 102-05

Collett N, Lefoe G, Yen AL (2007) Invasive terrestrial invertebrates in Victoria. *The Victorian Naturalist* 124: 86-102

Commissioner for Environmental Sustainability (2008) *State of the Environment Victoria 2008.* Commissioner for Environmental Sustainability, Melbourne, Victoria

Commissioner for Environmental Sustainability (2012) *Climate Change Victoria: The Science, Our People and Our State of Play.* Victorian Commissioner for Environmental Sustainability

Commissioner for Environmental Sustainability (2013) *State of the Environment Victoria 2013.* Commissioner for Environmental Sustainability Victoria

Comrie N (3013) *Bushfires Royal Commission Implementation Monitor – 2013 Annual Report.* Bushfires Royal Commission Implementation Monitor

Crisp MD, Laffan S, Linder HP, Monro A (2001) Endemism in the Australian flora. *Journal of Biogeography* 28: 183-98

Cunningham S, Duncan D, Driscoll D (2012) Land use intensification impacts on biodiversity in the mallee/wheat landscape of central NSW In *Land Use Intensification: Effects on Agriculture, Biodiversity and Ecological Processes*, ed. S Cunningham, D Lindenmayer, A Young: CSIRO Publishing

Cunnington J (2003) *Pathogenic Fungi on Introduced Plants in Victoria. A Host List and Literature Guide for their Identification.* Victorian Government Department of Primary Industries

Cunnington J (2007) Invasive plant pathogenic fungi in native Victorian ecosystems *The Victorian Naturalist* 124: 79-83 de Groot R, Branderb L, van der Ploega S, Costanza R, Bernard F, et al (2012) Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services* 1: 50-61

Department of Environment and Primary Industries (2013) Public Land Management (PLM25). ed. VGDoEaP Industries

Department of Environment and Primary Industries (2014a) *Biodiversity*. http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity. Accessed January 2014

Department of Environment and Primary Industries (2014b) *Indigenous Land Management*. http://www.depi.vic.gov.au/forestry-and-land-use/managing-land/indigenous-land-management. Accessed April 2014

Department of Environment and Primary Industries (2014c) *Myrtle Rust*. http://www.depi.vic.gov.au/agriculture-and-food/pests-diseases-and-weeds/plant-diseases/shrubs-and-trees/myrtle-rust. Accessed March 2014

Department of Environment and Primary Industries (2014d) *NaturePrint*. http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity/natureprint. Accessed January 2014

Department of Environment and Primary Industries (2014e) *Smooth Newt*. http://www.depi.vic.gov.au/agriculture-and-food/pests-diseases-and-weeds/pest-animals/a-z-of-pest-animals/smooth-newt. Accessed January 2014

Department of Natural Resources and Environment (1997) *Victoria Biodiversity: Directions in Management.* Victorian Government Department of Natural Resources and Environment

Department of Natural Resources and Environment (2002) *A Framework for Action: Native Vegetation Management in Victoria.* Victorian Government Department of Natural Resources and Environment

Department of Primary Industries (2008) *Future Farming.* Victorian Government Department of Primary Industries

Department of Primary Industries (2010) *Minerals Exploration and Mining in Victoria: Landholder Information Booklet.* Victorian Government Department of Primary Industries

Department of Sustainability and Environment (1997) *Predation of Native Wildlife by the Cat Felis catus. Action Statement, Flora and Fauna Guarantee Act 1988.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2002) *Predation of Native Wildlife by the Introduced Red Fox Vulpes vulpes. Action Statement, Flora and Fauna Guarantee Act 1988.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2005) Advisory List of Rare or Threatened Plants in Victoria - 2005. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2007a) *Code of Practice for Timber Production 2007.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2007b) *Native Vegetation Information: Overview of native vegetation spatial datasets.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2008a) *Climate Change in Victoria: 2008 Summary.* Victorian Government Department of Sustainability and Enviroment

Department of Sustainability and Environment (2008b) *Net Gain Accounting. First Approximation Report.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2008c) *Victoria's State of the Forests Report 2008.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2008d) *Victoria's Public Land Phytophthora cinnamomi Management Strategy.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009a) *Action Statement, Flora and Fauna Guarantee Act 1988. Cool Temperate Rainforest Dry Rainforest (Limestone); Warm Temperate Rainforest (Coastal East Gippsland); Warm Temperate Rainforest (Cool Temperate Overlap, Howe Range); Warm Temperate Rainforest (East Gippsland Alluvial Terraces); Warm Temperate Rainforest (Far East Gippsland); Human activity which results in artificially elevated or epidemic levels of Myrtle Wilt within Nothofagus dominated Cool Temperate Rainforest.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009b) *Advisory List of Environmental Weeds of Coastal Plains and Heathy Forests Bioregions of Victoria.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009c) *Advisory List of Environmental Weeds of the Inland Plains Bioregions of Victoria.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009d) Advisory List of Threatened Invertebrate Fauna in Victoria - 2009. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2009e) *Securing Our Natural Future: A White Paper for Land and Biodversity at a Time of Climate Change.* Victorian Department of Sustainability and Environment, Melbourne

Department of Sustainability and Environment (2010a) *Biodiversity is Everybody's Business: Victoria's Biodiversity Strategy 2010 – 2015, Consultation Draft.* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2010b) *Victoria's Firewood Strategy for Public Land.* Victorian Government Department of Sustainability and Enviroment

Department of Sustainability and Environment (2011a) *About Fire Ecology: An Overview.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2011b) *BushTender*. http://www.dse.vic.gov.au/conservation-and-environment/biodiversity/rural-landscapes/bushtender Accessed May 2011

Department of Sustainability and Environment (2012a) *Future Directions for Native Vegetation in Victoria: Review of Victoria's Native Vegetation Permitted Clearing Regulations.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2012b) *Report on Climate Change and Greenhouse Gas Emissions in Victoria.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2013) Advisory List of Threatened Vertebrate Fauna in Victoria 2013. Victorian Department of Sustainability and Environment

Department of Sustainability Environment Water Population and Communities (2011) *Nationally Threatened Ecological Communities of the Victorian Volcanic Plain: Natural Temperate Grassland & Grassy Eucalypt Woodland. A Guide to the Identification, Assessment and Management of Nationally Threatened Ecological Communities.* Australian Government Department of Sustainability Environment Water Population and Communities

Department of the Environment (nd-a) *Australia's 15 National Biodiversity Hotspots.* http://www.environment.gov.au/topics/biodiversity/biodiversity-conservation/biodiversity-hotspots/national-biodiversity-hotspots. Accessed December 2013

Department of the Environment (nd-b) *CAPAD 2012*. http://www.environment.gov.au/node/34737. Accessed November 2013

Department of the Environment (nd-c) *Species Profile and Threats Database.* http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

Department of the Environment (nd-d) *Threatened ecological communities in Victoria.* Australian Government Department of the Environment

Di Stefano J, York A (2012) *Relationships Between Disturbance Regimes and Biodiversity: Background, Issues and Approaches for Monitoring.* Victorian Government Department of Sustainability and Environment

Driscoll DA, Lindenmayer DB, Bennett AF, Bode M, Bradstock RA, et al (2010) Fire management for biodiversity conservation: key research questions and our capacity to answer them. *Biological Conservation* 143: 1928-39

Dudley N (2008) *Guidelines for Applying Protected Area Management Categories.* IUCN, Gland, Switzerland

Dunlop M, Brown PR (2008) *Implications of Climate Change for Australia's National Reserve System: A Preliminary Assessment. Report to the Department of Climate Change Rep.* Department of Climate Change, Canberra, Australia

Dunlop M, Hilbert DW, Ferrier S, House A, Liedloff A, et al (2012) *The Implications of Climate Change for Biodiversity Conservation and the National Reserve System: Final Synthesis.* CSIRO Climate Adaptation Flagship, Canberra

Dunlop M, Poldy F, Turner G (2004) *Environmental Sustainability Issues Analysis for Victoria.* CSIRO Sustainable Ecosystems, Canberra

Dutson G, Garnett S, Gole C (2009) *Australia's Important Bird Areas: Key Sites for Bird Conservation*. Birds Australia

Eldridge D, James A (2009) Soil-disturbance by native animals plays a critical role in maintaining healthy Australian landscapes. *Ecological Management & Restoration* 10: S27-S34

Endersby D (2010) *Terrestrial Biodiversity Review: Bioregional Vegetation Summaries.* Sinclair Knight Merz

Environment Australia (2001) *Directory of Important Wetlands in Australia* Environment Australia, Canberra

Environment Defenders Office (Victoria) (2012) *A Framework for Action? Implementation and Enforcement of Victoria's Native Vegetation Clearing Controls.* Environment Defenders Office (Victoria)

Environment Defenders Office (Victoria) (2013) *EDO Legal Briefing Note Changes to Victoria's Logging Laws The Sustainable Forests (Timber) Amendment Bill 2013.* Environment Defenders Office (Victoria)

Feehely J, Hammond-Deakin N, Millner F (2013) *One Stop Chop: How Regional Forest Agreements Streamline Environmental Destruction.* Lawyers for Forests, Melbourne

Fischer J, Lindenmayer DB (2007) Landscape modification and habitat fragmentation: a synthesis. *Global Ecology and Biogeography* 16: 265-80

Fischer J, Zerger A, Gibbons P, Stotta J, Law BS (2010) Tree decline and the future of Australian farmland biodiversity. *Proceedings of the National Academy of Science* 107: 19597–602

Fitzsimons J (2006) Private protected areas? Assessing the suitability for incorporating conservation agreements over private land into the National Reserve System: A case study of Victoria. *Environmental and Planning Law Journal* 23: 365-85

Forest Solutions (2013) *Review of Commercial Forestry Management in Western Victoria: Timber Resources, Harvest Levels, Silviculture, and Systems and Processes.* Victorian Government Department of Environment and Primary Industries

Freudenberger D, Harvey J (2003) *Assessing the Benefits of Vegetation Enhancement for Biodiversity: A Draft Framework.* Australian Government Environment Australia

Garnett S, Szabo J, Dutson G (2011) *The Action Plan for Australian Birds 2010* CSIRO Publishing

Geddes LS, Lunt ID, Smallbone LT, W.Morgan J (2011) Old field colonization by native trees and shrubs following land use change: Could this be Victoria's largest example of landscape recovery? *Ecological Management & Restoration* 12: 31-36

Gibbons P, Lindenmayer D (2002) *Tree Hollows and Wildlife Conservation in Australia.* Melbourne: CSIRO Publishing.

Gibbons P, van Bommel L, Gill A, Cary G, Driscoll D, others (2012) Land management practices associated with house loss in wildfires. *PLoS ONE* 7: e29212

Gibson M (2006) Introducing bryophytes. *The Victorian Naturalist* 123: 192-94

Gilfedder M, Zhang L, Theiveyanathan T, Marcar N, Roxburgh S, et al (2010) *Methods to Assess Water Allocation Impacts of Plantations.* CSIRO

Gill AM (2009) *Fire Management for Biodiversity Conservation in Reserves.* Victorian Government Department of Sustainability and Environment

Gill AM (2012) Fire regimes, biodiversity conservation and prescribed-burning programs. *Proceedings of the Royal Society of Victoria* 124: 1-6

Gill M, Cheal DC, Loyn R, Tolhurst K, Watson S, et al (2012) Proceedings from the Symposium on Fire and Biodiversity in Victoria jointly held by the VNPA and the Royal Society of Victoria, 24-25 Oct 2011. *Proceedings and Transactions of the Royal Society of Victoria* 124

Gillespie GR, Kum KC (2011) The bleating tree frog 'Litoria dentata' Keferstein (Anura: Hylidae): An addition to the frog fauna of Victoria. *Victorian Naturalist* 128: 256-59

Gullan P (nd-a) *Introduced Plants & Animals of Victoria*. http://www.viridans.com/INTRO/index.html. Accessed April 2013

Gullan P (nd-b) *Victorian Ecosystems*. http://www.viridans.com/ECOVEG/. Accessed July 2013

Hajkowicz S, Moody J (2010) *Our Future World: An Analysis of Global Trends, Shocks and Scenarios.* CSRIO

Hasson AEA, Mills GA, Timbal B, Walsh K (2009) Assessing the impact of climate change on extreme fire weather events over southeastern Australia. *Climate Research* 39: 159-72

Hawke A (2009) *The Australian Environment Act: Report of the Independent Review of the Environment Protection and Biodiversity Conservation Act 1999.* Australian Government Department of the Environment, Heritage and the Arts

Hennessy K, Fawcett R, Kironoa D, Mpelasoka F, Jones D, et al (2008) *An Assessment of the Impact of Climate Change on the Nature and Frequency of Exceptional Climatic Events.* Australian Government Bureau of Meteorology and CSIRO

Hennessy K, Fitzharris B, Bates BC, Harvey N, Howden SM, et al (2007) Australia and New Zealand. Climate Change 2007: Impacts, Adaptation and Vulnerability In *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. ML Parry, OF Canziani, JP Palutikof, PJvd Linden, CE Hanson, pp. 507-40. Cambridge, UK: Cambridge University Press

Hobbs RJ, Cramer V (2008) Interventionist approaches for restoring and maintaining ecosystem function in the face of rapid environmental change. *Annual Review of Environmental Resources* 33: 39-61

Howes A, Maron M (2009) Interspecific competition and conservation management of continuous subtropical woodlands. *Wildlife Research* 36: 617-26

Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee (JANIS) (1996) *Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia.* Australian Government

Jolley H (2006) Melbourne's marvellous mosses. *The Victorian Naturalist* 123: 215-21

Keith H, Mackey BG, Lindenmayer DB (2009) Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests. *Proceedings of the National Academy of Science* 106: 11635–40

Kelly LT, Nimmo1 DG, Spence-Bailey LM, Haslem A, Watson SJ, et al (2011) Influence of fire history on small mammal distributions: insights from a 100-year post-fire chronosequence. *Diversity and Distributions* 17: 462–73

Lindenmayer D, Blanchard W, McBurney L, Blair D, Banks S, et al (2012) Interacting factors driving a major loss of large trees with cavities in a forest ecosystem. *PLoS ONE* 7: 1-16

Lindenmayer D, Ough K (2006) Salvage Logging in the montane ash eucalypt forests of the Central Highlands of Victoria and its potential impacts on biodiversity. *Conservation Biology* 20: 1005-15

Lindenmayer DB, Blair D, McBurney L, Banks S (2013) *New Restoration Forest Management Prescriptions to Conserve Leadbeater's Possum and Rebuild the Cover of Ecologically Mature Forest in the Central Highlands of Victoria.* Fenner School of Environment and Society, The Australian National University, Canberra

Lindenmayer DB, Hobbs RJ, Likens GE, Krebsd CJ, Banksa SC (2011a) Newly discovered landscape traps produce regime shifts in wet forests. *Proceedings of the National Academy of Science* 108: 15887-91

Lindenmayer DB, Wood JT, McBurney L, MacGregor C, Youngentob K, Banks SC (2011b) How to make a common species rare: A case against conservation complacency. *Biological Conservation* 144: 1663–72

Low T (2011) *Climate Change and Queensland Biodiversity.* Queensland Government Department of Environment and Resource Management

Lumsden LF, Nelson JL, Todd CR, Scroggie MP, McNabb EG, et al (2013) *A New Strategic Approach to Biodiversity Management – Research Component.* Arthur Rylah Institute for Environmental Research, Victoria

Mac Nally R, Bennett AF, Thomson JR, Radford JQ, Unmack G, et al (2009) Collapse of an avifauna: climate change appears to exacerbate habitat loss and degradation. *Diversity and Distributions* 15: 720–30

MacHunter J, Menkhorst P, Loyn R (2009) *Towards a Process for Integrating Vertebrate Fauna into Fire Management Planning.* Victorian Government Department of Sustainability and Environment

Mackey BG, Keith H, Berry SL, Lindenmayer DB (2008) *Green Carbon : The Role of Natural Forests in Carbon Storage. Part 1, A Green Carbon Account of Australia's South-eastern Eucalypt Forest, and Policy Implications*. Canberra: ANU E Press.

Maron M, Fitzsimons J (2007) Agricultural intensification and loss of matrix habitat over 23 years in the West Wimmera, south-eastern Australia *Biological Conservation, 135 (4).* 135: 587-93

Maron M, Gordon A (2013) Biodiversity offsets could be locking in species decline. *The Conversation* 6 June 2013

Maron M, Hobbs RJ, Moilanen A, Matthews JW, Christie K, et al (2012) Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biological Conservation* 155: 141–48

Maron M, Kennedy S (2007) Roads, fire and aggressive competitors: determinants of bird distribution in subtropical forests. *Forest Ecology and Management* 240: 24-31

Maron M, Main A, Bowen M, Howes A, Kath J, et al (2011) Relative influence of habitat modification and interspecific competition on woodland bird assemblages in eastern Australia. *Emu* 111: 40-51

Matthews S, Carr G, McMahon A (2011) *VNPA Nature Conservation Review: Terrestrial Ecosystems.* Ecology Australia

McCarthy PM (2014) *Checklist of the Lichens of Australia and its Island Territories.* Australian Biological Resources Study, Department of the Environment

McGregor A, Coffey B, Deutsch C, Westcott G, Robinson J (2008) *Ecological Processes in Victoria: Policy Priorities for Sustaining Biodiversity. Discussion Paper Rep.*

McMullan-Fisher S, May T, Robinson R, Bell T, Lebel T, et al (2011) Fungi and fire in Australian ecosystems: a review of current knowledge, management implications and future directions. *Australian Journal of Botany* 59: 70-90

Menkhorst PW, Knight F (2010) *Field Guide to the Mammals of Australia.* Oxford University Press.

Mifsud BM (2002) Victoria's tallest trees. *Australian Forestry* 66: 197–205

Miller J, Nelson K, Steer R, Shepherd M (2007) *An Assessment of the Weed Management Program in Land Managed by Parks Victoria.* Biosis Research

Mittermeier R, Gil P, Mittermeier C (1997) *Megadiversity: Earth's Biologically Wealthiest Nations.* Conservation International, Cemex

MonumentalTrees.com (nd) *Tallest tree in the world: coast redwood* http://www.monumentaltrees.com/en/trees/coastredwood/coastredwood/.

Mueck S, Peacock R (1992) *Impacts of intensive timber harvesting on the forests of East Gippsland, Victoria.* Victorian Government Department of Conservation & Natural Resources

Museum Victoria (2009) Endemic Victorian Fauna. Unpublished

Nash M (2013) Alien invertebrates are invading the Australian Alps. *The Victorian Naturalist* 130: 127-36

National Institute of Economic and Industry Research (2010) *Opportunities, Issues and Implications for a Transition of the Victorian Wood Products Industry from Native Forests to Plantations.* National Institute of Economic and Industry Research, Clifton Hill, Victoria

New Economics Advisory Service (2013) *An Assessment of VicForests' Finances.* Australian Conservation Foundation New Economics Advisory Service

New T, Yen A, Sands D, Greenslade P, Neville P, et al (2010) Planned fires and invertebrate conservation in south east Australia. *Journal of Insect Conservation* 14: 567-74

Parks Victoria (2007) *State of the Parks 2007.* Victorian Government Parks Victoria

Parks Victoria (2010) *Plants and animals.* http://www.parkweb.vic.gov.au/1process_content.cfm?section=177&page=25. Accessed March 2011

Parks Victoria (2012) *Parks Victoria Annual Report 2011–2012.* Victorian Government Parks Victoria

Parks Victoria (2013) *Parks Victoria Annual Report 2012–2013.* Victorian Government Parks Victoria

Parks Victoria (2014) *Aboriginal joint management.* http://parkweb.vic.gov.au/park-management/aboriginal-joint-management. Accessed April 2014

Pickett EJ, Stockwell MP, Bower DS, Garnham JI, Pollard CJ, et al (2013) Achieving no net loss in habitat offset of a threatened frog required high offset ratio and intensive monitoring. *Biological Conservation* 157: 156–62

Pizzey G, Knight F (1997) *The Field Guide to the Birds of Australia.* Angus & Robertson.

Poulton T (2006) *Defining, Identifying and Protecting Old-growth Forest in Victoria.* Save Goolengook Inc.

Price OF, Bradstock RA (2012) The efficacy of fuel treatment in mitigating property loss during wildfires: Insights from analysis of the severity of the catastrophic fires in 2009 in Victoria, Australia. *Journal of Environmental Management* 113: 146-57

Royal Botanic Gardens Melbourne (2011) *Australian Orchids.* Royal Botanic Gardens Melbourne

Sharafi SM, Moilanen A, White M, Burgman M (2012) Integrating environmental gap analysis with spatial conservation prioritization: A case study from Victoria, Australia. *Journal of Environmental Management* 112: 240-51

Skerratt LF, Berger L, Speare R, Cashins S, McDonald KR, et al (2007) Spread of chytridiomycosis has caused the rapid global decline and extinction of frogs. *EcoHealth* 4: 125-34

State of the Environment 2011 Committee (2011) *Australia State of the Environment 2011.* Australian Government Department of Sustainability, Environment, Water, Population and Communities

Taylor M, Sattler P, Curnow C, Fitzsimons J, Beaver D, et al (2011) *Building Australia's Nature Net: The State of Protected Areas for Australia's Wildlife and Ecosystems.* WWF Australia, Sydney

Taylor RS, Watson SJ, Nimmo DG, Luke T. Kelly, Bennett AF, Clarke MF (2012) Landscape-scale effects of fire on bird assemblages: does pyrodiversity beget biodiversity? *Diversity and Distributions* 18: 519-29

Teague B, McLeod R, Pascoe S (2010) *2009 Victorian Bushfires Royal Commission Final Report.* Victorian Parliament

The Victorian Forest Alliance (2006) *Choosing a Future for Victoria's Forests.* The Wilderness Society

Threatened Species Scientific Committee (2008a) *Commonwealth Listing Advice on Grassy Eucalypt Woodland of the Victorian Volcanic Plain.* Australian Government Department of the Environment and Water Resources

Threatened Species Scientific Committee (2008b) *Commonwealth Listing Advice on Natural Temperate Grassland of the Victorian Volcanic Plain.* Australian Government Department of the Environment, Water, Heritage and the Arts

Threatened Species Scientific Committee (2010) *Loss and Degradation of Native Plant and Animal Habitat by Invasion of Escaped Garden Plants, Including Aquatic Plants.* Australian Government Department of Environment, Heritage and the Arts

Traill B, Porter C (2001) *Nature Conservation Review Victoria 2001* Victorian National Parks Association

Traill BJ (2009) Making ecological processes iconic: paying more attention to the natural machinery that connects us all. *Decision Point* 27: 4

Trust for Nature (2013) *The Statewide Conservation Plan for Private Land in Victoria.* Trust for Nature

Vesk P, Dorrough J (2006) Getting trees on farms the easy way? Lessons from a model of eucalypt regeneration on pastures. *Australian Journal of Botany* 54: 509-19

VicForests (2011) *Plantations – Complementing Victoria's Native Forest Timber.* Vicforests

VicForests (2013a) *Statement of Corporate Intent 2013-14 to 2015-16.* VicForests

VicForests (2013b) *VicForests Annual Report 2012-13.* VicForests

VicForests (2013c) *VicForests' 2013 Area Statement.* VicForests

Victorian Auditor General (2009) *Administration of the Flora and Fauna Guarantee Act 1988.* Victorian Auditor-General's Office

Victorian Auditor General (2010) *Control of Invasive Plants and Animals in Victoria's Parks.* Victorian Auditor-General's Office

Victorian Auditor General (2012) *Effectiveness of Compliance Activities: Departments of Primary Industries and Sustainability and Environment.* Victorian Auditor-General's Office

Victorian Catchment Management Council (2002) *The Health of our Catchments: A Victorian Report Card.* Victorian Catchment Management Council

Victorian Catchment Management Council (2007) *Catchment Condition Report 2007.* Victorian Catchment Management Council

Victorian Catchment Management Council (2012) *Catchment Condition and Management Report 2012.* Victorian Catchment Management Council

Victorian Environmental Assessment Council (2010) *Remnant Native Vegetation Investigation Discussion Paper.* Victorian Environmental Assessment Council

Victorian Environmental Assessment Council (2011) *Remnant Native Vegetation Investigation.* Victorian Environmental Assessment Council

Victorian Parliament Education and Training Committee (2012) *Inquiry into Agricultural Education and Training in Victoria.* Parliament of Victoria

VNPA (2010) *Better Protection for Special Places. Victorian National Parks Association Small Parks Project.* Victorian National Parks Association

Wallace L (2010) *Independent Review on Progress with Implementation of the Victorian Regional Forest Agreements (RFAs).* Victorian Government

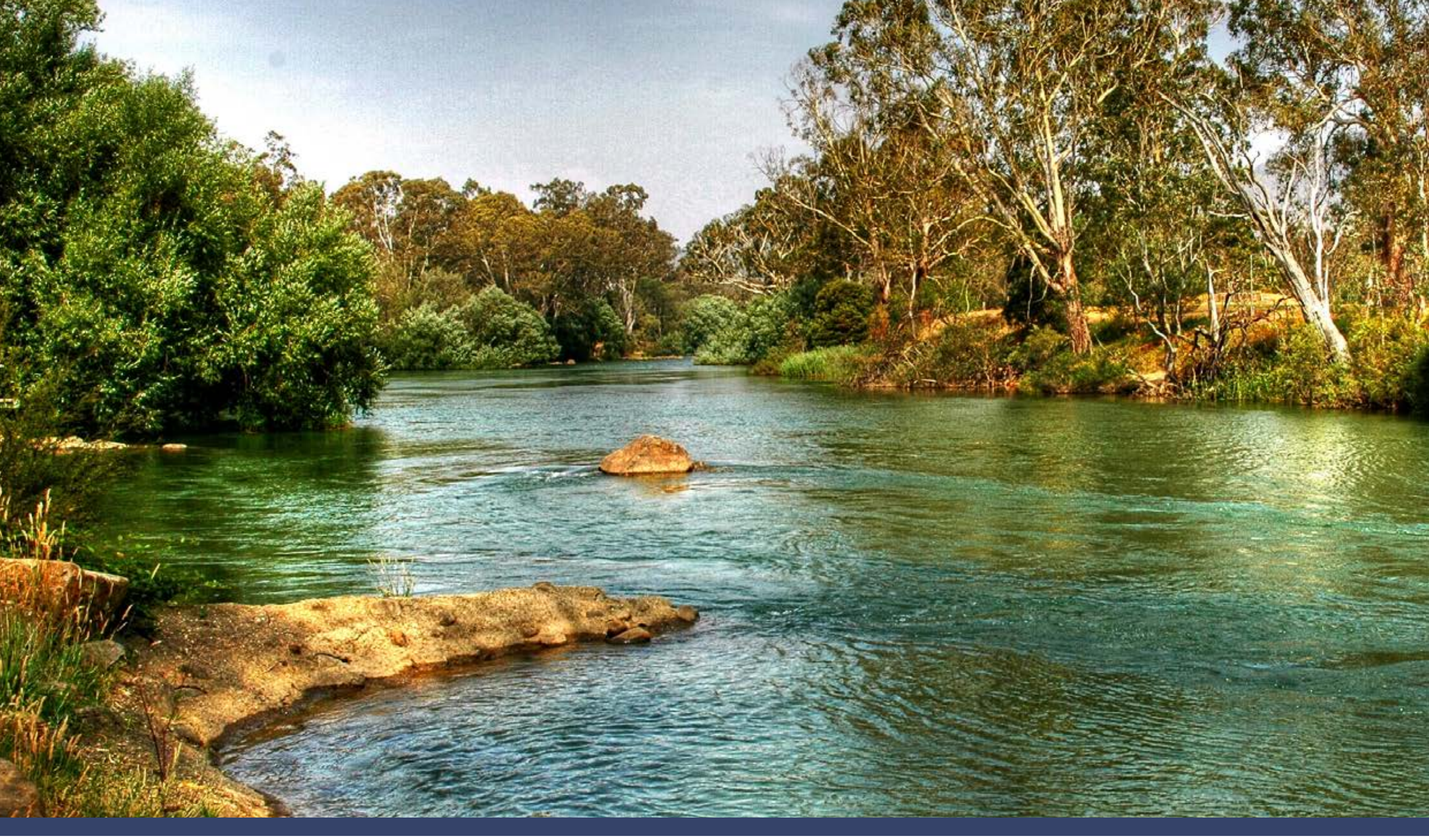
Walsh NG, Stajsic V (2007) *Census of the Vascular Plants of Victoria.* Royal Botanic Gardens Melbourne

Weiss J (2007) Contingency planning and prioritising pest plants. *The Victorian Naturalist* 124: 83-86

Woinarski J, Legge S (2012) The impacts of fire on birds in Australia's tropical savannas. *Emu* 113: 319-52

Woodgate P, Black P (1988) *Forest Cover Changes in Victoria 1869-1987.* Victorian Government Department of Conservation, Forests and Lands

York A (2011) Firewood and biodiversity - are we burning their homes to warm ours? *The Conversation* 12 September 2011



4. Freshwater Ecosystems

Guide to chapter 4

Chapter 4 focuses on freshwater habitats – rivers and streams, wetlands and aquifers – on ecosystems dependent on freshwater, in particular riparian (streamside) and floodplain habitats. Estuarine and coastal ecosystems such as mangroves, salt marshes and seagrass beds also rely on freshwater input, but are covered in chapter 2.

Section 4.1 describes the natural values of Victoria's freshwater ecosystems and the major habitat types and section 4.2 characterises important ecological processes, particularly natural flow regimes. Section 4.3 describes the current state of biodiversity and habitats in freshwater ecosystems. Section 4.4 outlines major threats, in particular disruptions to flow regimes and degradation of freshwater habitats. Finally, sections 4.5 and 4.6 identify gaps and priority reforms for policies and programs in six major areas: environmental flows, riparian habitats, freshwater protected areas, wetlands, groundwater and catchment management.

Topics covered

4.1 Values
- Biodiversity
- Important places
- Habitat types

4.2 Ecological characteristics and processes
- Flow regimes
- Ecotones and diversity
- Riparian vegetation and water quality

4.3 State of freshwater ecosystems
- Threatened biodiversity
- Rivers and streams
- Wetlands
- Riparian vegetation
- Floodplains
- Groundwater-dependent ecosystems

4.4 Major threats
- Changes to natural flow regimes
- Loss and degradation of habitats
- Dysfunction of biological interactions
- Climate change

4.5 Conservation gaps and priorities
- Environmental flows
- Riparian protection and restoration
- Freshwater protected areas
- Wetlands
- Groundwater
- Catchment management

4.6 Future directions

4.7 Sources

4.1 Values

For many of us, water simply flows from a faucet… We have lost a sense of respect for the wild river, for the complex workings of a wetland, for the intricate web of life that water supports. We have been quick to assume rights to use water but slow to recognise obligations to preserve and protect it… In short, we need a water ethical guide to right conduct in the face of complex decisions about natural systems we do not and cannot fully understand.

Sandra Postel, 1992[1]

Much of Victoria's landscape is densely woven with rivers and streams – the greatest concentration of waterways on Australia's mainland. They engender life-sustaining connections from mountain headwaters to coastal estuaries, laterally between waterways, riparian fringes and floodplains, and vertically between surface and subterranean habitats.

Variability along these three spatial dimensions and through the fourth dimension of time has generated great diversity and complexity in Victoria's freshwater ecosystems – from cold, rushing mountain streams to warm, slow-moving pools in the drylands, subterranean seepages through rock pores and fractures, and a multitude of wetland types – lakes, floodplain billabongs, shallow freshwater and saline swamps, and alpine peatlands.

Figure 4.1 Victoria's rivers and river basins

Map: VNPA

For the richness of life they sustain, the refugia they provide in dry times and their contributions to the health and productivity of other ecosystems, Victoria's freshwater ecosystems have immense ecological value. They also have immense utility for humans, which has generated short-sighted exploitation without care for the system as a whole.

4.1.1 Biodiversity

Globally, freshwater ecosystems cover less than 1% of the earth's surface but support 6% of described species.[2] They are often highly productive and provide great habitat diversity because of the ecotones (transition areas between different environments) they create at multiple scales.[3]

Victoria's freshwater habitats are known to support more than 100 waterbird species, 54 freshwater fish, 38 frogs, 40 crayfish and a large uncounted number of other invertebrate species.[4] More than 800 vascular plants are associated with Victoria's wetlands.[5] Some groups of freshwater organisms – crayfish, galaxiid fish and stygofauna (groundwater-inhabiting organisms) – have high levels of endemism in Victoria (Table 4.1, Box 4.1). Many are also increasingly rare, with close to half or more of the state's frogs, freshwater fish and freshwater crayfish threatened.

Aquifer ecosystems, lacking light and low in energy and oxygen, are inhabited by specialised organisms known as stygofauna, which are mostly crustaceans but also include worms, mites, beetles, snails, and millipedes. Compared to surface water environments, groundwater ecosystems are relatively stable and persistent through geological time, and some may be 'living museums', with species from Gondwanan and earlier times.[6] Most Victorian groundwater ecosystems have not been surveyed, so little is known about the stygofauna, but they are likely to have exceptionally high endemicity, with most species confined to one aquifer.[7]

Table 4.1 Status of some freshwater groups[8]

Groups	Indigenous to Victoria	% of Australian species	Endemic to Victoria	Threatened or extinct [(1)]
Fish	54	20%	8 (15%)	31 (57%)
Frogs	38	16%	1 (3%)	15 (39%)
Turtles	3	12%	0	2 (67%)
Crayfish	38	25%	23 (60%)	25 (66%)

[(1)] Based on the Victorian government's advisory lists.

Box 4.1 Crustaceans and fish

South-eastern Australia is a hotspot for endemic crayfish. In Victoria, 40 species have been recorded (38 described) – mostly burrowing and spiny crayfish but also swamp and land crayfish and yabbies. At least 23, possibly 25, are unique to Victoria.[9] Some freshwater habitats have multiple species with tiny ranges. Because of their limited dispersal capacity, small ranges, low rates of reproduction and slow maturation, crayfish are vulnerable to decline. Twenty-six species have been assessed as threatened (in the government's 2009 advisory list), and 12 are listed as threatened under the Flora and Fauna Guarantee Act.

Another 25 shrimps, amphipods and other crustaceans are known to be endemic to Victoria.[10] Six new endemic isopods were recently identified in groundwater-dependent streams, springs and seeps in The Grampians National Park. There are undoubtedly many more endemic crustaceans in groundwater ecosystems, for they dominate stygofaunal communities, and most are unique to single aquifers.

Of Victoria's 54 known freshwater fish species, eight galaxiids are endemic, with many still to be formally described after research showing that what was called the mountain galaxias (*Galaxias olidus*) is really a complex of 15 species.[11] More than half of Victoria's freshwater fish species, including the galaxiid endemics, are considered threatened.[12] Before trout were introduced into Victorian waters, galaxiids were the top fish predators.

4.1.2 Important places

Heritage river areas

Victoria has 18 heritage river areas, which are segments or corridors on public land declared under the Heritage Act for significant recreation, conservation, scenic or cultural heritage values. They total 2000 kilometres, 3% of the length of Victoria's named streams (Figure 4.2).

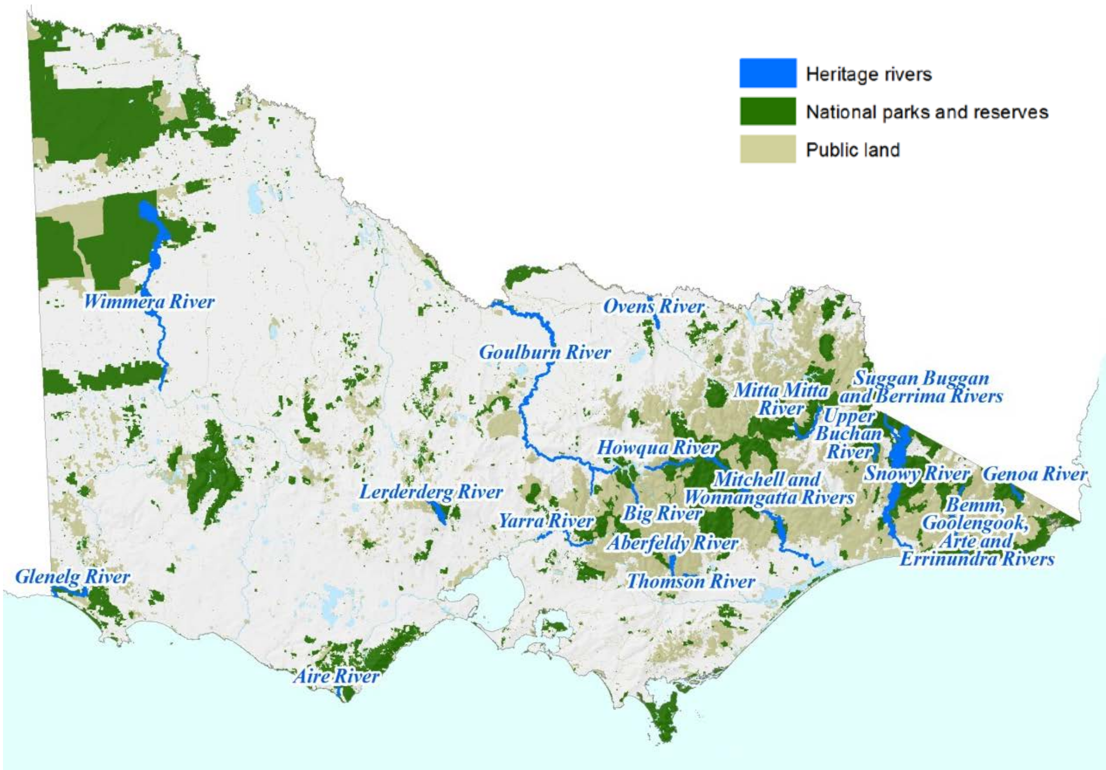
High-value wetlands

Nine freshwater wetland complexes have been recognised as internationally significant, and are listed under the Ramsar Convention (another two Ramsar wetlands are marine-only sites) (Figure 4.3). As the Victorian government recognises, many other wetlands have values likely to also qualify them for Ramsar listing.[13] More than 1300 freshwater wetlands in 29 sites are listed as nationally significant in Australia's Directory of Important Wetlands.[14] Many other wetlands also have very high values not recognised in the directory.

Important bird and biodiversity areas

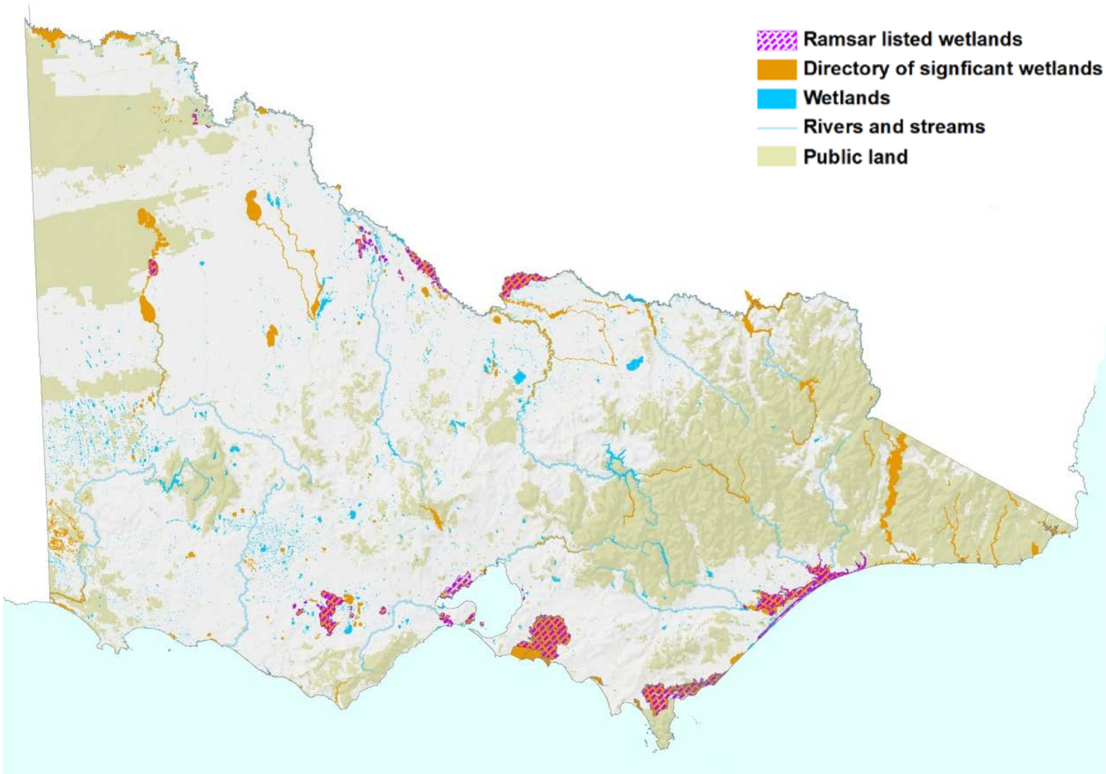
For waterbirds resident in Victoria, the following freshwater or partially freshwater sites have been identified as particularly significant and were designated in 2009 as 'important bird areas' by Birds Australia: Barmah-Millewa, Bellarine wetlands, Carrum wetlands, Devilbend reservoir, Gippsland Lakes, Lake Corangamite complex, Lower Brodribb River, Natimuk-Douglas wetlands, north Victorian wetlands, Port Fairy to Warrnambool, Werribee and Avalon, Western Port, Yambuk (more details in chapters 2 and 3).[15] Some of these wetlands grade from salt water to freshwater, and Lake Corangamite, Natimuk–Douglas and north Victorian wetlands consist of a mix of saline and fresh water lakes. To be designated as important bird areas, wetlands must regularly support threshold numbers of birds when conditions, such as water levels, are suitable.

Figure 4.2 Victoria's heritage rivers



Map: VNPA. Data source: Department of Environment and Primary Industries

Figure 4.3 Wetlands, including of international (Ramsar-listed) and national significance



Map: VNPA. Data source: Department of Environment and Primary Industries

4.1.3 Habitat types

Surface water-dependent ecosystems are those that rely on flowing waters (rivers, streams and springs) or still surface waters (pools, lakes, ponds and swamps).

Rivers and streams

Victoria has 3820 named watercourses extending 56,000 kilometres, as well as many un-named tributaries and distributaries (streams that flow away from a main branch) that bring total stream-length to about 85,000 kilometres.[16] Flows are naturally highly variable from year to year but are now regulated in the majority of rivers by storage, diversion and extraction of water for human uses. Victoria's 70 major water storages are capable of holding more than 12 million megalitres. Annual flows over the eight years from 2003-04 to 2010-2011 averaged 26 million megalitres but ranged from 7 million to 45 million (27 to 175% of the eight year average).[17]

Wetlands

Victoria has an estimated 23,739 natural wetlands, which are 'areas of permanent, periodic or intermittent inundation that hold still or very slow moving water'.[18] They cover about 600,000 hectares (2.6% of Victoria's surface area). There are also some 11,060 artificial wetlands (eg farm dams, reservoirs and sewage treatment ponds) covering 171,000 hectares. As well as providing habitat, wetlands help maintain water quality, by filtering nutrients and sediments, and reduce the impacts of floods, by slowing and holding floodwaters. Because of their high productivity and the incorporation of carbon into sediments, many freshwater wetlands are likely to be significant carbon sinks.[19]

Riparian habitats

As the interface between land and water channel, riparian areas are highly productive and ecologically important links between terrestrial and aquatic ecosystems. Although only a very small proportion of total catchment area, they have a large influence on the healthy functioning of river ecosystems by providing habitat, shading the water, and contributing carbon and nutrients. In largely cleared landscapes, they often contain the only native vegetation. They buffer rivers and streams to some extent from land use impacts – by filtering out sediment, nutrients and pesticides.[20] They are also often sites of high biodiversity – for example, supporting more birds and more species of birds than non-riparian sites.[21] Riparian habitats are valuable as resting, roosting, nesting and hawking sites for insect and fish-eating birds and mammals, as basking and hunting sites for reptiles, as calling and feeding sites for frogs, as shelter sites for insects.[22] They are important as refugia for land animals in dry times and as dispersal corridors. Their productivity means they are also likely to be significant carbon sinks. Victoria is fortunate in having 30,000 kilometres of riparian land in public ownership (crown water frontages, mostly on larger waterways), although state ownership has often not been exercised in the public interest.

Floodplains

The lowlands that border waterways, and which are flooded when water overflows river banks, are also highly productive and ecologically important transition zones (covered mostly in chapter 3).

Groundwater-dependent ecosystems

Ecosystems that depend partially or completely on water from beneath the earth's surface which has undergone physical and chemical changes due to interactions with the aquifer environment are of three types:[23]

- subterranean aquifer and cave ecosystems, often inhabited by specialised invertebrates known as stygofauna
- ecosystems dependent on groundwater coming to the surface, for example perennially flowing rivers and streams, and permanent wetlands in a floodplain
- ecosystems dependent on subsurface groundwater accessible through the roots of trees, for example river red gum forests along the lower River Murray and paperbark swamp forests.

4.2 Ecological characteristics and processes

4.2.1 Flow regimes

'The natural flow regime is of profound importance in the structuring and functioning of riverine ecosystems and shaping the life history strategies of freshwater-dependent biota.'

Yung En Chee, 2010[24]

Flow regimes – the patterns of water flow resulting from interactions of climate, geology, topography and vegetation – are 'the maestro' of riverine ecosystems, orchestrating ecological processes, maintenance of biodiversity and evolutionary change (Figure 4.4).[25] The life history strategies of aquatic species have evolved primarily in response to natural flow regimes.[26]

Influential aspects of flow regimes include the magnitude and seasonal patterns of river flows; the timing of extreme flows; the frequency and duration of floods, droughts and intermittent flows; daily, seasonal and annual flow variability; rates of change in flow events; and interactions between surface water and groundwater.[27]

Flow regimes are influential in the following ecological processes:[28]

- regulation of the hydrological cycle and biogeochemical cycles – storage, transport and transformation of water, minerals and organic matter
- primary production and secondary production – the capture, transformation and flow of energy through food webs
- formation and maintenance of biophysical habitats – flows affect substrates (sand, salt, rock) and structural features (boulders, logs)
- movement – flows are necessary to transport the various life-history stages of many microorganisms, plants and animals, and to recolonise re-wetted habitats
- biological interactions – flows facilitate processes such as seed dispersal, and influence competition, herbivory and predation
- natural disturbance regimes – eg floods and droughts alter ecosystems by creating spaces for colonisation, releasing and distributing resources, and altering the mortality rates of species.

Flow variability – habitat diversity and disturbance

Each component of a natural flow regime – from no flows to floods – facilitates different riverine functions and processes. For example, 'freshes', which substantially increase river height for a short while, improve water quality by flushing stagnant water, create new habitat patches and turn pools to runs, enabling the movement of sediments and organisms. 'Bankfull flows', which completely fill a channel without breaking the banks, maintain channel shape, while 'overbank flows' are vital for floodplain productivity and for organic inputs to rivers.[29]

The variability between seasons and years, ranging from drought to floods, often creates essential ecological disturbance, without which these systems become more uniform, sustaining less variety of life.[30] River headwaters and segments that flow through arid landscapes often dry out or contract to isolated pools. They are tough times for many aquatic species, with high levels of predation, competition and physiological stress, but this variability maintains species diversity by limiting domination by any particular groups of organisms. Organisms in dryland river systems adapted to persist in harsh conditions and prevent displacement by dominant but less tolerant species. In the short-term they suffer localised extinctions, with natural recovery occurring as species recolonise from local refuges or from elsewhere. Conserving habitat diversity requires maintaining the natural variability of interactions of water flow with features such as pools, runs, bars, benches, overhanging banks and anabranches and structural elements such as sediment, pebbles, boulders, tree roots, coarse woody debris and aquatic plants. These interactions produce fine-scale flow patterns such as slackwaters, eddies, transverse flows and velocity gradients.[31] The slackwater habitats created provide refuge from currents, and hatching, rearing and feeding environments for zooplankton and the young of shrimp and fish.

Connections and movements

Maintaining linkages is essentially about making sure that a river is part of the total landscape, that it is not just regarded as a channel running though the land. Maintaining each of the linkages [along a river, between a river and its banks and floodplains and between a river and groundwater sources] is essential to maintaining the ecological health of a river.

Victorian government, 2002[32]

Ecosystem function depends on flows to transport nutrients, organic materials, and organisms into and out of habitat patches. Flows are needed to disperse animals for breeding or to complete a life history stage, access resources or recolonise areas where local extinction has occurred. Waterbirds need particular flood durations and temperatures before breeding, many plant seeds require flooding prior to germination, and some fish need specific flows to migrate or breed. Murray cod, for example, migrate upstream with early spring flows, female tupong migrate downstream to spawning grounds during high flows in late autumn and winter, and broad-finned galaxias need a rise in water level for spawning along stream edges, then another high flow to cover the exposed eggs before hatching.[33]

Waterways facilitate connections at multiple scales – at the landscape scale, enabling seasonal movement of species, and at the local scale, facilitating daily movements and dispersal. Streamside vegetation is also essential for connectivity, for aquatic and terrestrial plants and animals.

Floodplains and flooding[34]

'Pulsed flooding is the major factor influencing biota in these river-floodplain systems…'

James Fitzsimmons and others, 2011

Overbank flooding of rivers is crucial for many vegetation communities and species on floodplains and for maintaining ecological connectivity along and across floodplains, and between rivers and floodplains. It is necessary for much more than meeting the water requirements of plants and animals in flood plains. Overbank flooding is integral to biological processes such as regeneration, dispersal and growth, and to geomorphological processes such as the deposition of silts and the regulation of ground water depth and chemistry.

A recent assessment of flooding requirements for floodplains of the Murray, Goulburn, Ovens and King Rivers in northern Victoria, the first such assessment in Victoria, found at least 110 ecological vegetation classes across 224,000 hectares and 124 rare or threatened plant taxa and 62 threatened vertebrate fauna taxa (excluding fish) depend on flooding.[35] Some examples of different flooding requirements are shown in Table 4.2. For about 30 ecological vegetation classes, the critical interval to maintain healthy ecosystems is one flood event about every two years.

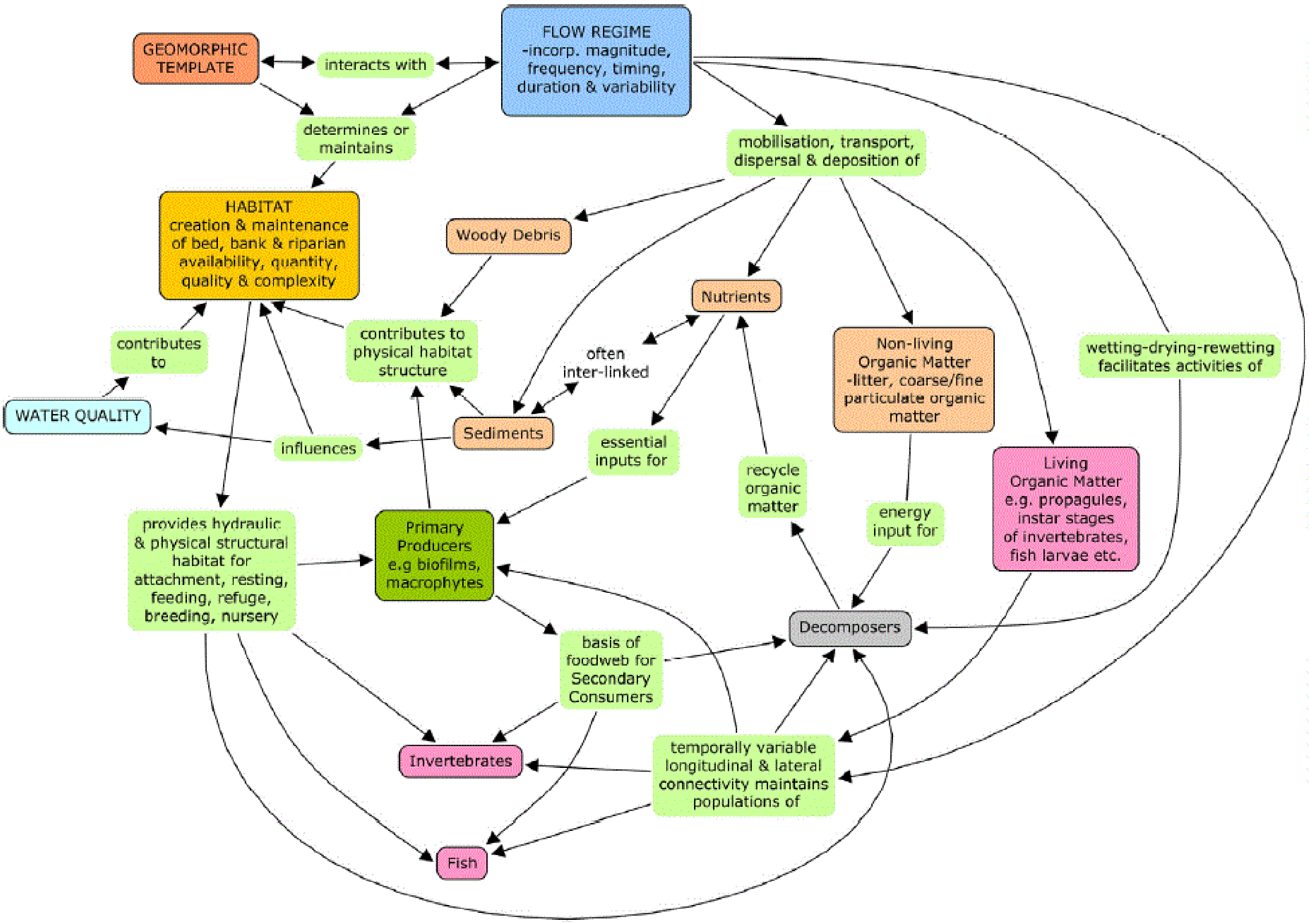
Table 4.2 Examples of flooding requirements for some flood-dependent ecological vegetation classes (EVCs) in the Murray River floodplain[36]

Ecological vegetation class	Critical interval (years)	Minimum duration (months)
Alluvial plains semi-arid grassland	25	1.5-6
Aquatic herbland	2	6-12
Billabong wetland aggregate	(variable) 2	>6
Floodplain riparian woodland	7	<1
Grassy riverine forest	4	1-4
Red gum swamp	3	4-9
Riverine chenopod woodland	30-50	<1-3

Biogeochemical cycles and energy transfers

The interaction of the flow regime with river and stream structures is integral to biogeochemical cycling and energy transfers through riverine systems.[37] For example, during low or no flow times, organic matter from riparian areas accumulates and dries on bars, benches and other features protruding from the water. Flow fluctuation subjects them to cycles of wetting and drying, which facilitates physical breakdown and microbial decomposition. Flows distribute this fresh pool of nutrients and carbon throughout the river system for use by microbes, zooplankton, algae, plants and animals. Microbes below streambeds and in stream banks where groundwater and surface water mix (in the 'hyporheic' zone) are also important recyclers, transforming nutrients and carbon washed into streams into food for aquatic invertebrates, in turn consumed by other organisms.[38] It is by such processes that water quality is maintained. After prolonged periods of no overbank flows (eg due to river regulation or drought), flooding can lead to 'blackwater' events and death of fish, crustaceans and other organisms. They occur when large accumulations of organic material are washed into streams and consumed by bacteria, leading to a sudden depletion of dissolved oxygen and increased acidity.[39]

Figure 4.4 A simplified conceptual model of the main hydrological, geomorphical and ecological interactions and processes in riverine ecosystems[40]



Source: Chee (2010)

4.2.2 Groundwater and surface water connectivity

As receptors, storages, and transmitters of water, groundwater systems (aquifers) regulate parts of the hydrological cycle, absorbing runoff and stream flows through river channels as well as the floodplain.[41] This process buffers changes to rates of flow during flooding. When floods recede, aquifers release water back to the stream, sustaining flow rates and again buffering rates of flow and river level changes. This process has implications for riverine life because changes in rates of flow and water levels affect water velocity, shear stress and intensity of scouring disturbance with impacts such as uprooting of seedling and adult plants. Rapid recession of flood flows may strand organisms in floodplain environments that are not suitable for longer-term survival. The mitigation of flood magnitude and rapid flow rate changes constitutes an ecosystem service called 'flood attenuation'.

Groundwater and surface water systems are intimately linked, with groundwater reserves relying on surface recharge and many surface ecosystems relying on groundwater sustenance.[42] A study in the Murray-Darling basin showed that water stress in river red gums was lower between flood events in areas underlain by shallow aquifers, implying groundwater dependency.[43] Because only small changes in the depth to groundwater can substantially reduce water available to vegetation, groundwater-dependent systems are likely to be vulnerable to changes in groundwater flow.

Underground systems are buffered from many environmental changes taking place at the surface and have much higher levels of endemic and relict species (from ancient lineages) than surface environments.[44] But stygofauna are potentially highly vulnerable to changes in groundwater regimes. They are often specialised with long life cycles and low fecundity, some with limited capacity to survive environmental change. Underground groundwater ecosystems are dark with low energy and oxygen availability and low productivity. They have very simple food webs, dominated by detritivores (organisms that feed off dead plants and animals), with microbes rather than plants at the base. To detect population declines requires close monitoring but response times to change can be decades.'[45]

4.2.3 Ecotones and diversity

'Acting in concert, bioclimatic, hydrologic and geomorphic processes create complex mosaics of habitat patches at multiple spatiotemporal scales. In natural settings, the quantity, quality, physical properties and spatial arrangement of habitat types will determine the type and abundance of the biotic community as well as the rates of ecological processes.'

Yung En Chee, 2010[46]

Riverine ecosystems have high ecological value in part because of the diversity of ecotones (transitional habitats) they create – zones of exchange of materials and energy and pathways for movement of organisms (as well as of pollution).[47] At large scales, they provide a range of wet to moist habitats, with gradients extending outward to riparian and floodplain areas and below ground. At smaller scales, ecotones occur where fluctuating flows interact with elevated features such as bars and benches, and at interfaces with groundwater.

One important ecotone known as the hyporheic zone is in the sediments of stream beds and banks where surface water and groundwater mix and water chemistry is altered by microbes. Where the water emerges, it promotes growth of periphyton (bottom organisms attached to plants and other objects), creating hotspots of productivity that sustain microorganisms and invertebrates.[48] Variations in the stream bed, changes in flow direction and features such as riffles, sand and gravel bars generate a mosaic of patches of surface-groundwater exchanges.[49] The hyporheic zone often extends for several kilometres along rivers and also laterally (landward).[50] (Groundwater is also connected to coastal and marine ecosystems.)

4.2.4 Riparian vegetation and water quality

Intact riparian vegetation alongside rivers provides a multitude of benefits – it provides connectivity in the landscape, is highly biodiverse, provides habitat for and protects rare and threatened species, improves water quality (by filtration and shading to keep the water cool), stabilises banks and provides in-stream habitat for fish and invertebrates.

Riverside Rescue, 2011[51]

The typical sign of a degraded stream or river is a narrow strip of fringing vegetation or none at all. A healthy riparian zone is essential to maintain water quality.[52] By stabilising the soil and stream banks and reducing the velocity of overland flow, riparian vegetation limits water and wind erosion. It filters and retains incoming sediments and processes nutrients, limiting their input into streams. Healthy riparian soils are important for microbial conversion of nutrients into forms available for use by plants and animals. When riparian vegetation is lost or degraded, high sediment and nutrient loads lead to turbid water, toxic algal blooms and reduced aquatic biodiversity.

4.2.5 Freshwater refugia

Many freshwater ecosystems are important refugia – places in which organisms can persist when regional environments change – and will become increasingly so as the climate changes. Australian freshwater organisms have evolved in conditions of high natural variability and their life history strategies are frequently oriented around refugia. The richness of refugial strategies in Australian riverine ecosystems is unusually high by global standards because of Australia's long-term climate variability.[53] In dry times and places, sites of permanent wetness – wetlands, springs, groundwater-fed rivers for example – are vital for the persistence of many species. Some surface aquatic animals prevent desiccation (drying out) by migrating into moist areas such as the hyporheic zones of rivers. Water-filled crayfish burrows are refugia for some stream insects.[54] Aquifers have been refugia from increasing surface aridity in Australia over millenia.[55]

4.3 State of freshwater ecosystems

4.3.1 Threatened biodiversity

World-wide, freshwater habitats have the highest proportion of threatened plants and animals, and Victoria seems no different. Close to half or more of the state's frogs, freshwater fish and freshwater crayfish are threatened (Table 4.4). Six wetland communities have been listed as threatened, although this does not reflect the real status of wetland communities, which have not been comprehensively mapped and assessed.

The poor status of native fish in Victoria is a telling indication of the pervasive deterioration of freshwater habitats. In the Murray-Darling system (as a whole), native fish populations are estimated to be at 10% of their pre-European colonisation levels, and most of the fish biomass, 80-90% in some rivers, consists of introduced species.[56] More than half of Victoria's freshwater fish are threatened, including species endemic to the state (Table 4.4). At least three are extinct (although they survive elsewhere) and it is possible that others (particularly galaxiids) have gone extinct before being discovered, due to introduced predatory trout.[57] A similarly high proportion of other freshwater groups are also threatened – about two-thirds of crayfish and turtles and more than a third of frogs. Formal listings of threatened species under the Flora and Fauna Guarantee Act do not reflect the conservation status of freshwater groups, with only about half the species considered threatened (on the Victorian government's advisory lists) formally listed (Table 4.4). Several wetland ecological communities have been listed as threatened under state or national laws (Table 4.3) and more than 85% of the 145 wetland ecological vegetation classes mapped in Victoria are threatened in at least one bioregion.[58]

Table 4.3 Wetland ecological communities listed under state and national laws

Wetland communities listed under the Flora and Fauna Guarantee Act
Alpine bog community
Fen (bog pool) community
Granite foothills spring wetland (north-east Victoria) community
Herb-rich plains grassy wetland (west Gippsland) community
Lowland riverine fish community of the southern Murray-Darling Basin
Montane swamp complex community
Red gum swamp community no. 1
Sedge rich *Eucalyptus camphora* swamp community
Wetland communities listed under the Environment Protection & Biodiversity Conservation Act
Alpine sphagnum bogs and associated fens ecological community (endangered)
River Murray and associated wetlands, floodplains and groundwater systems, from the junction of the Darling River to the sea (critically endangered) (11 kilometres is in Victoria)
Seasonal herbaceous wetlands (freshwater) of the temperate lowland plains (critically endangered)

Table 4.4 Extinct and threatened species in some freshwater groups (government advisory lists and Flora and Fauna Guarantee Act)[59]

Freshwater group	Extinct (regionally)	Critically endangered	Endangered	Vulnerable	Extinct or threatened (Advisory)	% extinct or threatened (Advisory)	Extinct or threatened (FFG Act)[1]
Fish	3	11	6	11	31	57%	19
Frogs	0	8	4	3	15	39%	11
Turtles	0	0	1	1	2	67%	1
Crayfish	0	3	14	8	25	66%	12

Sources: Department of Sustainability and Environment and others listed for Table 4.1. (1) FFG Act is the Flora and Fauna Guarantee Act.

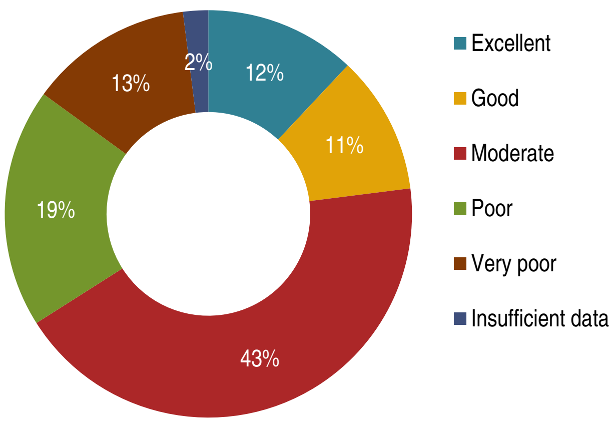
4.3.2 Rivers and streams

The latest Victorian survey of the condition of 29,000 kilometres of rivers and streams (the 2010 index of stream condition, Box 4.2) found that less than one-quarter (23%) of river length was in good or excellent condition and close to one-third (32%) was in poor or very poor condition, with the remainder (43%) in moderate condition (Figure 4.5).[60] The results are similar to those obtained in the 2004 Index, so the 2010 results, obtained at the end of the millennium drought (1997-2009), suggest that rivers and streams in good condition have resilience to severe droughts.[61]

Fourteen of Victoria's 29 basins had less than 10% of their river length in good or excellent condition (Figure 4.6). Most are in the state's mid-west and have been extensively cleared for agriculture. Only three basins, largely within national parks, had at least 70% of their river length in good or excellent condition and another three had at least 50% in this condition.

The major problem for Victoria's rivers and streams is of over-extraction of water and the imposition of water regimes suited to human consumption and opposed to ecological needs. This is at its worst during dry times when consumptive uses are given even greater priority over environmental health. For example, in 2007–08, the environment received less than 7% of its already inadequate entitlement while irrigators received 30–35% of their much larger entitlements. The volume of environmental entitlements was just 6% of total entitlements but only 1% was delivered for the environment that year.[62]

Figure 4.5 Victorian river condition, 2010[63]



Data source: Department of Environment and Primary Industries

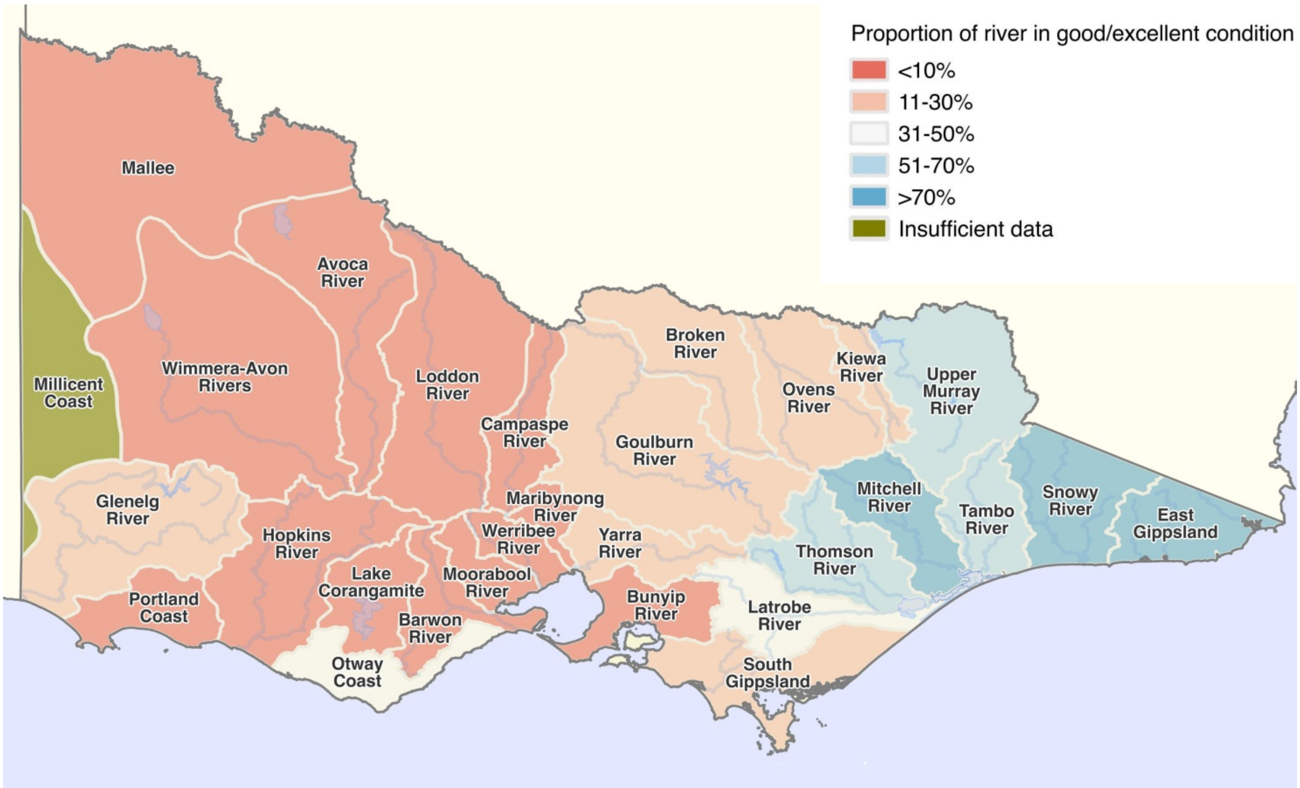
Box 4.2 About the index of stream condition[64]

The index of stream condition is the first statewide measure of river health in Australia. It combines information on 23 indices of five aspects of river health: hydrology, water quality, streamside vegetation, physical form (bed and bank condition and instream habitat) and aquatic life. The point of reference for most of these assessments is 'generally accepted to be what a river would have looked like in its undisturbed or unmodified form'. The condition is evaluated for sections of river 10-30 kilometres in length known as 'reaches'.

Three statewide assessments of river and stream condition have been published to date (in 1999, 2004 and 2013). The latest assessment used remote sensing – LiDAR, which records a three dimensional image, and aerial photography – to assess the streamside zone and physical form. This allows a continuous coverage instead of sampling at random locations.[65] One limitation of LiDAR is that it cannot be used to assess understorey diversity or identify plant species.

There are some concerns about the method used for calculating the Index.[66] When data on particular attributes is lacking, as it is for many reaches, a 'pro rata' score is applied but there is no justification presented for this and it undermines the credibility of the scores. The scores for each attribute are added together, which means that a high score in one indice can mask a low score in another.

Figure 4.6 The proportion of rivers in good to excellent condition in Victoria's river basins, as assessed by the Index of Stream Condition in 2010



Map: VNPA. Data source: Department of Environment and Primary Industries

4.3.3 Wetlands

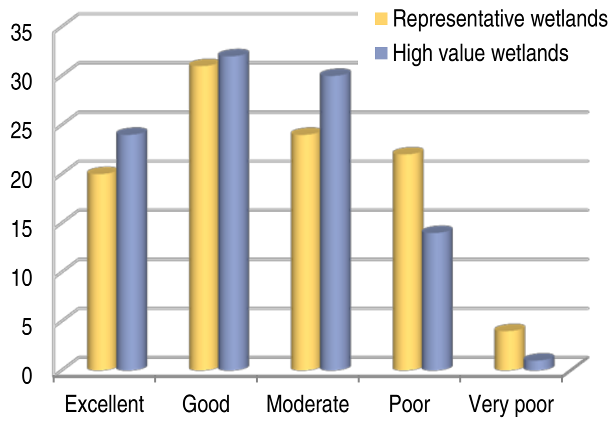
In 1994 it was estimated that about a quarter of Victoria's original wetlands (4000 in number, covering 200,000 hectares) had been destroyed, mainly through drainage (Table 4.7). Many more have been extensively modified and damaged, and their overall extent and condition is thought to be declining. However, there is no more recent information about the overall extent of loss. A 2013 update to the wetland inventory recorded a total of 23,739 natural wetlands covering 604,322 hectares.[67] The increase since 1994 is due to more accurate mapping.

A 2012 index of wetland condition assessment of 587 high-value wetlands (6% of Victoria's non-alpine wetlands) from 2009-10 found that just over half were in good or excellent condition, about a third were in moderate condition and 15% were in poor or very poor condition (Box 4.3).[68] The aspects of wetland health of greatest concern are wetland catchment (42% in poor condition), hydrology (33% in poor condition) and vegetation (47% in poor condition). The poor condition of catchments and wetland vegetation are due to land clearing, changes in flow regimes, grazing, cropping, and weed invasion, exacerbated by the recent drought.

A 2010-11 assessment of an additional 240 wetlands (2% of non-alpine wetlands), selected as representative of Victoria's wetland types, also found that about half were in good or excellent condition but about one quarter were in poor or very poor condition. The aspects of wetland health of greatest concern are similar to those for high-value wetlands: wetland catchment (63% in poor condition), hydrology (25% in poor condition) and vegetation (48% in poor condition).

For both high-value and representative wetlands, condition was generally worse on private land than on public land (Table 4.8). The majority of wetlands (69%) are on private land.[69] But the total area of wetlands is greatest on public land, for they average 54 hectares compared to 13 hectares for wetlands on private land. Only 13% of wetlands, but 55% by area, are in some form of protected area, although not all these are in the national park and conservation system (the tenures recognised by VNPA as securely protected, section 1.4.1).

Figure 4.7 The percentage of representative wetlands (2010-11) and high-value wetlands (2009-10) in good, moderate or poor condition[70]



Source: Index of Wetland Condition

Close to 200,000 hectares of 'significant wetlands and associated buffers' occur on private land (Table 4.6). This includes part of 10 Ramsar wetlands and 93% of the extent of the nationally listed, critically endangered seasonal herbaceous wetland community.[71]

Table 4.5 Significant wetlands on private land[72]

Significant wetland category	Area on private land (hectares)
Ramsar wetlands (with a 250 metre buffer)	48,349
Nationally important wetlands	53,984
Bioregionally significant wetlands	48,652
Important bird areas (with a 250 metre buffer)	47,259
Seasonal herbaceous wetlands (nationally threatened community)	17,078
Total, excluding overlaps between categories	188,126

Source: Trust for Nature

Box 4.3 Index of wetland condition[73]

This assessment combines information on five aspects of wetland health – catchment, physical form, hydrology, soils, water properties and vegetation. All assessments involved an on-site visit to score wetland condition using a standardised method.[74] The first assessment was conducted from 2009-11 and the next one is planned for 2017-18.

Table 4.6 Broad wetland types and losses since European colonisation (1994 data)[75]

Wetland type	Wetlands (number)	Wetlands lost (number)	Wetlands lost (%)	Current area (hectares)	Wetland area lost (hectares)	Wetland area lost (%)
Shallow freshwater	9,140	3,532	28	168,077	95,443	31
Deep freshwater	2,303	349	12	141,126	91,055	37
Saline	1,373	44	3	221,210	14,676	7
Total	12,816	3,925	23	530,413	201,175	26

Source: Department of Sustainability and Environment

Table 4.7 The condition of different aspects of high-value and representative wetlands[76]

Feature	High-value wetlands (%)			Representative wetlands		
	Poor-very poor	Moderate	Good-excellent	Poor-very poor	Moderate	Good-excellent
Catchment	42	9	49	63	9	28
Physical form	2	4	94	5	7	88
Hydrology	33	13	53	25	7	68
Water properties	3	12	85	5	23	72
Soils	10	9	81	20	18	62
Vegetation	47	23	30	48	18	35
Total	14	30	56	26	24	51

Source: Index of wetland condition

4.3.4 Riparian and floodplain habitats

About 500,000 hectares of Victoria is riparian (defined nominally as the area within 60 metres of a named and mapped waterway).[77] As the interface between terrestrial and aquatic ecosystems, riparian zones suffer the impacts of both river regulation and damaging land uses, particularly land clearing and grazing. As a result, most riparian areas in Victoria are degraded.[78] The worst are in the west, including in the Corangamite, Hopkins, Barwon and Moorabool basins, and the best are in the forests of the Otways, the North East and East Gippsland. Despite their often poor condition, riparian areas are highly valuable in rural areas because they often represent a substantial proportion of remnant vegetation.[79] This is due to state ownership of about 60% of the frontage on named waterways and 'the sporadic practice of leaving vegetation along watercourses to protect stream morphology'.[80] However, about 30% of vegetation within a 60 metre zone has been cleared (Table 4.10) and much of it is fragmented and weed-infested.

A 1999 survey found that less than 10% of riparian land was in good to excellent condition, and over 50% was in poor to very poor condition.[81] A 2001 national assessment of river condition found that about half (53%) of the assessed river length in Victoria had substantially or severely modified riparian vegetation.[82]

A 2010 assessment of stream condition, using different methods, found that about one-fifth of streamside vegetation was in excellent condition and about the same proportion was in poor condition (Table 4.9). Major causes of degradation include land clearing, altered flow regimes, stock access and invasive species.[83]

Table 4.8 The proportion of riparian vegetation in excellent or poor condition in 10 regions, 2010[84]

Region	Excellent condition (%)	Poor condition (%)	Reaches assessed (number)
Mallee	1	6	73
North Central	4	13	111
Glenelg Hopkins	8	47	123
Wimmera	10	15	84
Goulburn Broken	14	3	117
Port Phillip	21	31	131
Corangamite	26	30	138
West Gippsland	28	15	114
North East	31	12	139
East Gippsland	47	9	138
Average/total	**21**	**19**	**1168**

Source: Index of stream condition. The other reaches were in moderate condition.

Riparian areas on private lands have been much more damaged than those on public lands. Close to half of riparian land on named waterways (46% based on a 60 metre buffer from the waterway) is on private land and only 44% has native vegetation (Table 4.10).[85] Less than 1% of private riparian land has formal protection, in the form of a conservation covenant, and most of the riparian vegetation on private land (93%) is of ecological vegetation classes not sufficiently represented in protected areas. In contrast, 92% of public riparian land is vegetated and 31% is in some form of protected area (Table 4.10).

Victorian floodplains have suffered widespread and increasing decline due to regulation of river flows preventing pulse flooding. Currently, large overbank flows occur only when water storages are full, and for most of the Murray River floodplain the frequency of small and moderate floods has declined by two-thirds or more compared to the natural flood frequency.[86] As a consequence, growing numbers of river red gums and black boxes are dying or dead, river red gum growth rates have declined and acid sulphate soils have developed due to the drying of once-permanent wetlands.[87] In 2010, an estimated 79% of the area of river red gum, black box and other box communities in 'the living Murray icon sites' was in a stressed condition (moderate to severely degraded condition).[88]

Table 4.9. Riparian land in Victoria – tenure, native vegetation, protected[89]

Category of riparian land	Area (hectares)	% riparian area
Total riparian area(1)	509,063	100
Private land	233,519	46
Public land	275,475	54
With native vegetation	356,435	70
Private with native vegetation	102,490	20
Public with native vegetation	253,945	50
Private with under-represented EVCs(2)	83,978	16
Public with under-represented EVCs	94,857	19
Private protected by covenant(3)	845	0.02
Managed by Parks Victoria	86,003	17

Source: Trust for Nature. Notes: (1) Riparian is defined as a 60 m wide area each side of named waterways. (2) Ecological vegetation class. (3) Protected by a perpetual Trust for Nature covenant.

4.3.5 Groundwater-dependent ecosystems

[There are] critical gaps in our understanding of the condition and prospects for Victoria's groundwater resources.

Victorian Catchment Management Council, 2012[90]

The extent and condition of subterranean groundwater ecosystems are unknown. There has been recent mapping using remote sensing data to identify potential groundwater-dependent ecosystems (as a first-cut prediction) and work is underway to determine the sensitivity of these ecosystems to changes in groundwater quality and quantity.[91] Groundwater resources are increasingly under pressure from extraction and a changing climate, and there is insufficient monitoring to determine whether extraction rates are sustainable.[92] Groundwater comprises about 15% of Victoria's total water use and extraction is increasing.[93] Increased extraction and reduced recharge led to drops in the level of several aquifers from the late 1990s to 2010 but they have risen since wetter conditions in 2011. Long-term declines have continued in Gippsland associated with dewatering of Latrobe Valley coal mines and off-shore oil and gas extraction.[94]

4.4 Major threats

[H]uman settlements have transformed inland waters into a complex and extensive system for harvesting, transporting and controlling the movement of water, with the highest levels of per capita storage in the world.

State of the Environment Victoria 2008[95]

Freshwater ecosystems are the most threatened on earth,[96] a status that probably also applies in Victoria. Most Victorian wetlands have been lost or substantially degraded, and most Victorian rivers have been transformed to service agriculture and human settlements, resulting in the highest per person levels of water storage in the world.[97] About a third of the 41 potentially threatening processes listed under Victoria's Flora and Fauna Guarantee Act affect freshwater ecosystems. The biggest threats are alterations to natural flow regimes, various invasive species, loss and degradation of riparian vegetation and, increasingly, climate change.

4.4.1 Changes to natural flow regimes

Dams, weirs and water extractions have imposed vastly different flow regimes on Victoria's rivers and are the greatest threat to freshwater ecosystems. There are 70 major dams in Victoria, hundreds of smaller dams and weirs on waterways, and thousands of farm dams on drainage lines or off-stream.[98] The proportion of total flow leaving Victoria's river basins was 56% in 2009-10 and 74% in 2010–11. The flow was less than 10% of natural levels in six basins in 2009-10.[99] Flow patterns have also been disrupted by physical changes to rivers due to dredging, straightening and levee banks, and changes to catchments.

Regulation has reversed normal flow patterns for many Victorian rivers. Under natural conditions, there are typically high winter and spring river flows and low summer and autumn flows. But water is used all year for industrial and domestic purposes, and agricultural users use more during summer, leading to large releases in summer. Changes to flow regimes include loss of flow variability, longer periods of zero or low flow, reduced flood frequencies and magnitudes, reversal of flow seasonality, and loss of no-flow periods.[100] In more than half of Victoria's 29 river basins, fewer than 20% of rivers have healthy flow regimes. In some years, more than three-quarters of the total flow is harvested from a quarter of Victoria's river basins.[101] In such heavily regulated systems, extensive overbank flooding essential for floodplain health occurs only in rare extreme flood events.[102]

The impacts are profound and multi-faceted, resulting in loss or degradation of aquatic, riparian, floodplain, estuarine and groundwater habitats. Almost half (46%) of Victoria's high-value wetlands and a third (32%) of other wetlands recently assessed are threatened by compromised flows, most due to changed flow regimes in their source rivers.[103] Impoundments and loss of natural disturbance due to flow variability have changed the composition of riparian vegetation, and much floodplain vegetation is stressed or dying due to loss of natural flooding regimes. Large areas of mature river red gums in Hattah-Kulkyne National Park downstream from Lake Mournpall have died in recent years due to lack of water. These problems are likely to be exacerbated by climate change, with reduced rainfall and higher evapo-transpiration rates leading to reduced runoff.

The movement of freshwater organisms is greatly impeded by weirs, dams and other constructions. A 1999 inventory identified close to 2500 potential barriers to fish movement – about 40% were farm dams and weirs and 30% were weirs and dams with stream gauges.[104] Large numbers of culverts and road crossings that also impede movement were not counted.

Migration is an essential part of the life cycle of at least 18 native fish species. Golden perch, for example, spawn in the flooded reaches of lowland rivers, use floodplains as nurseries, and then disperse, sometimes for than 2000 kilometres.[105] All aquatic fauna is likely to be affected in various ways – due to reduced availability of accessible habitat, ecosystem changes resulting from exclusion of migratory species, the loss of recolonisation opportunities, fish kills, increased predation and fishing pressure and reduced genetic diversity. A few barriers have a benefit in preventing movement of harmful introduced fish, protecting threatened galaxiids from predatory trout.[106]

Thermal pollution is another consequence of regulated flows, occurring when water discharged from the bottom layer of a dam is substantially colder than the river or stream into which it is released. There are 49 publicly managed dams and an unknown number of privately managed dams in Victoria that are more than five metres deep and discharge water from the bottom layers but the extent to which they cause cold water pollution is unknown due to a lack of temperature monitoring.[107] Most native fish require warm temperatures for spawning, so cold water releases can prevent or slow reproduction. They can reduce growth rates of young animals, reduce overall biological production, and displace temperature-sensitive species.

Box 4.4 Regent parrots need floodplain flooding[108]

The nationally vulnerable eastern subspecies of the regent parrot feeds in mallee vegetation and breeds in hollows in old floodplain eucalypts. Most of them are along the Murray River and highly dependent on riverine flooding. But relatively few breeding sites are amongst the highest priority areas for environmental watering. Only about half of the breeding sites are likely to be inundated by a large flood which, because of river regulation, may occur only once every several decades, far less often than is needed to maintain the trees. Without flooding, the parrot's breeding trees will deteriorate or die, and not be replaced.

Changes to groundwater flows

Because groundwater and surface river flows are interconnected, extraction of groundwater linked to a river system will impact on that river. This is a simple but fundamental fact which water management agencies around the world still struggle with...

Jon Nevill and others, 2010

Exploitation of groundwater has been increasing, often in the absence of a sound understanding of sustainability and needs of groundwater-dependent ecosystems. The physical and functional connections between surface water and groundwater mean that flow changes affecting one are also likely to affect the other.[109]

Loss of groundwater volume reduces habitat for stygofauna and diminishes contributions to river baseflows and wetlands.[110] Most wetlands depend on groundwater to some degree and are vulnerable to changes in groundwater level, because only small drops can substantially reduce the water available to vegetation.[111] A recent wetland assessment found that a quarter of wetlands fed by groundwater had an altered flow regime.[112]

The converse – excessive recharge due to irrigation and replacement of deep-rooted native vegetation with shallow-rooted crops and pasture – is also a problem, leading to dryland salinity. Rising water levels intercept salt and transport it upwards, resulting in stream and land salinisation. Saline groundwater can threaten the biodiversity of surface wetlands and rivers and drive shifts to more salt-tolerant plants and animals.[113]

Groundwater quality is compromised by changes to the natural flow regime and changes in land use (eg removal of native vegetation cover in the catchment, grazing, overuse of fertilisers, erosion of riparian zone) that result in increased sediments, nitrates, phosphates and toxic substances. Fine sediments can clog the top layer of channel sediments, reducing the permeability of the stream bed, hindering exchanges between surface water and groundwater, and reducing the diversity and productivity of this hyporheic zone.[114]

4.4.2 Loss and degradation of habitat

Compromised flow regimes are the major cause of loss and degradation of freshwater habitats, as discussed above. Others are grazing, land clearing and intensive land uses, and removal of woody debris from streams.

Livestock grazing

Grazing severely threatens riparian and floodplain habitats and wetlands, driving vegetation loss, land degradation and poor water quality.[115] In the recent index of wetland condition assessment, it was the most prevalent threat for high-value wetlands, occurring at more than half those surveyed.[116] No catchments in predominantly agricultural regions are in good condition.[117] In the Goulburn Broken catchment, a review of all licensed frontages found that only 10% were in near-natural condition, and more than half were substantially modified.

Cattle trampling and grazing destabilise the banks of wetlands and waterways and promote erosion. Cattle spread weeds, and damage and prevent regeneration of native vegetation. Their preference for particular plants changes the composition, structure and function of riparian and wetland vegetation.[118] Cattle dung and urine are a source of nutrients and, in combination with increased turbidity, they degrade water quality and promote the growth of algae and pathogens, which are a problem for human health as well as biodiversity (Box 4.5).[119] High turbidity can kill fish, reduce growth rates and increase disease.[120] Grazing has led to loss of sensitive habitats, such as sedge rich and herbaceous communities of lowland drainage lines, and changes in abundance and diversity of fish and other animals.[121] A comparison of stream frontages along the Broken-Boosey system in northern Victoria found that grazed frontages had less groundcover, less regeneration, fewer shrubs, more regionally listed weed species and more bare ground than ungrazed frontages.[122]

Box 4.5 Riparian grazing and human health[123]

'Prevention of contamination provides greater surety than removal of contaminants by treatment, so the most effective barrier is protection of source waters to the maximum degree practical.'

Australian Drinking Water Guidelines[124]

The 'Australian drinking water guidelines' state that pathogens are the greatest risk to consumers of drinking water and that preventing contamination is the most effective way to ensure safe drinking water. Yet, Victoria's crown water frontage licences allow landholders to graze and water cattle in waterways, increasing the costs of water treatment and exposing people to disease risks.

Cattle faeces contain pathogens such as *Cryptosporidium*, *Giardia*, *Escherichia coli*, *Salmonella*, *Campylobacter* and *Leptospira* that can be transmitted to humans through water that is ingested or used to grow fruit and vegetables. There are risks with recreation in water downstream of cattle access points. Many pathogens can survive in water or faeces for weeks or months. The cost of water treatment increases as the quality of water decreases, and there are some gaps in the extent or sufficiency of treatment or testing across Victoria. Nutrient inputs from cattle also increase the potential for toxic algal blooms.

Land clearing and intensive land uses

Clearing alters natural patterns of water flow into wetlands, rivers and recharge areas for groundwater. It leads to salinisation and erosion, and increases sediment and nutrient runoff. A study in the granitic Strathbogie Ranges of northeastern Victoria found that 150 years of clearing and agriculture had seriously eroded gullies, streambeds and banks, generating massive 'sand slugs' that blanket pools for kilometres downstream, altering water flows and destroying habitat.[125] Clearing and degradation of vegetation fringing streams and wetlands destroys wildlife habitat and compromises the filtration of sediment and nutrients. Nitrates leached from agricultural fertilisers and from urban and industrial areas pollute groundwater and contribute to eutrophication, stimulating algal blooms and aquatic weeds.[126] Other agricultural or industrial pollutants are heavy metals (mercury, nickel, lead for example) and toxic biocides. There have been numerous cases of contamination killing aquatic species in the short-term, and chronic contamination, which is poorly studied, can compromise reproduction and alter behaviour and metabolism of wildlife.[127]

Physical damage

Damage caused by excavation (dredging, draining), infilling, vehicles and recreation (as well as grazing and land clearing) threaten wetland and riparian areas. More than a third of high-value wetlands assessed in 2009-2011 had had vehicles driving on them, and more than a quarter of high-value wetlands and almost half of the 'representative' wetlands assessed had been excavated.[128]

4.4.3 Dysfunction of biological interactions

Of particular interest is the example of waters in the upper Murray where post c1920 catches of small [trout cod] became rare. … Although changes to habitat were undoubtedly occurring, the upper Murray did not experience the perturbations to flow or temperature regimes generally associated with impairment of the reproduction and recruitment of cod until the 1950s. Some form of negative interaction with introduced fish species, possibly predation, appears the most plausible explanation.

Will Trueman, 2007[129]

Invasive species

Many introduced animals, plants and pathogens threaten freshwater biodiversity, and the extensive modification of freshwater habitats by altered flow regimes, clearing and grazing aids their spread.[130] Climate change is expected to further exacerbate their impacts (see chapter 3).

Introduced fish

Eight exotic fish species have established in Victorian waterways, another is maintained by stocking and two are supplemented by large-scale stocking (Table 4.11).[131] All were introduced for fishing, except gambusia, which was introduced for biological control of mosquitoes (for which it is of little value). Some native fish have been spread beyond their natural range, with unknown impacts. Australia-wide, introduced species (mostly fish) are considered detrimental to more than three-quarters of threatened native fish species.[132] The impacts of invasive fish include domination of habitat and exclusion of native fish, predation of native fish and frogs, damage to aquatic habitats and spread of disease.[133] Carp have become the dominant freshwater fish in many Victorian waterways, displacing native fish, increasing water turbidity and damaging plants. In many sites, they contribute more than 90% of fish biomass (Box 4.6).

Predatory salmonids – brown trout and rainbow trout – impose substantial predation pressure on native fish and frog larvae, and have been implicated in the decline of small native fish, especially galaxiids.[134] Recent work has shown that there are many more galaxiid species in Victoria than previously thought, many endemic with tiny ranges, most threatened by trout. Brown and rainbow trout could have already caused extinctions of 'undiscovered unique lineages, worthy of recognition as species, in small and remote catchments'.[135] Brown trout are also suspected of contributing to declines of trout cod and Macquarie perch.[136]

Table 4.10 Introduced freshwater fish species[137]

Exotic fish species established in inland waterways
Brown trout (*Salmo trutta)*
Rainbow trout (*Oncorhynchus mykiss*)
European carp (*Cyprinus carpio*)
Goldfish (*Carassius auratus*)
Tench (*Tinca tinca*)
Roach (*Rutilus rutilus*)
Redfin perch (*Perca fluviatilis*)
Gambusia (*Gambusia holbrooki*)
Exotic fish species released for stocking
Brown trout (*Salmo trutta*)
Rainbow trout (*Oncorhynchus mykiss*)
Chinook salmon (*Oncorhynchus tschawytscha*)
Native fish introduced beyond their natural range
Freshwater Catfish (*Tandanus tandanus*)
Murray cod (*Maccullochella peelii peelii*)
Trout Cod (*Maccullochella macquariensi*)
Macquarie perch (*Macquaria australasica*)
Golden Perch (*Macquaria ambigua*)
Silver Perch (*Bidyanus bidyanus*)
Australian Bass (*Macquaria novemaculeata*)

Box 4.6 Ecosystem-transforming impacts of carp[138]

Carp are the largest exotic fish in Victoria and superabundant in the Murray-Darling basin. They can achieve densities up to 1000 fish per hectare (three tonnes a hectare). The highly regulated rivers of Victoria provide lots of still water habitats that suit them. Adult carp have no natural predators, and potential native predators of juvenile carp have suffered massive declines.

Carp are ecosystem engineers, changing the characteristics of invaded habitats.[139] Because of the way they feed – sieving the bottom sediment for snails, crustaceans, insect larvae and seeds – they stir up silt, increasing water turbidity. The detrital carbon they eat 'may become "locked" away from the trophic chain for their lifetime (up to 50 years), rather than passing up through a food chain of macroinvertebrates and smaller fish'. Their feeding also destroys aquatic plants, reducing photosynthetic production and changing the composition of invertebrate communities. They outcompete and displace native fish species.

Feral animals

Feral deer, pigs and horses can severely damage wetlands and riparian areas, many of their impacts similar to those of cattle –vegetation damage, decline of particular plant species, erosion and addition of nutrients and pathogens to water.

Weeds

A 2008 government advisory list records 29 invasive plants in aquatic habitats in Victoria, 17 rated as high or very high risk.[140] Just four are listed under the Catchment and Land Protection Act, and therefore have any restrictions over sale or use, or requirements for control. The weed ranked as the highest risk, arrowhead (*Sagittaria graminea*) ,has recently been recognised as a 'weed of national significance' (but is not declared in Victoria). This vigorous weed chokes streams and rivers, restricting water flow, compromising stream health and threatening native plants and animals. Ramsar wetlands at 'immediate risk' include Barmah National Park, Kerang Wetlands and Gunbower Forest.[141] Control is difficult because it can reproduce by seeds and tubers, survives a long time in seed banks and is tolerant to herbicides and mechanical removal. There are no effective herbicides registered for use.

More than 250 environmental weeds are invading riparian vegetation in Victoria.[142] Invasion is facilitated by periodic flooding, grazing, nutrient enrichment, and spread of weeds from agricultural land and via roads.[143] A 2004 survey found that only about one-quarter (27%) of river reaches had a healthy riparian ground layer, most having been invaded by weeds such as Phalaris, Rye Grass and thistles. Although 80-90% of reaches had a healthy shrub and tree layer, woody weeds such as willows and blackberries dominated many sites.[144]

Diseases

The frog-killing chytrid fungus (*Batrachochytrium dendrobatidis*) has probably been a major factor in the rapid decline of several of Victoria's threatened frogs, including the alpine tree frog, growling grass frog, stuttering frog and the endemic baw baw frog.[145] The disease is spread by infected frogs and tadpoles and via water and soil.[146] Introduced plant diseases (myrtle rust and *Phytophthora*) are a threat to riparian and floodplain habitats (see chapter 3).

Fish stocking

Negative impacts of alien salmonids on native aquatic fauna … have been noted for over 140 years. … Despite these impacts, salmonid management is focused largely on providing improved recreational angling opportunities, whereas management of their impacts is almost non-existent.

Jean Jackson and others, 2004[147]

Predatory introduced trout 'have been liberated into almost all waters [of the Murray-Darling Basin] thought to be suitable for them'.[148] And every year, for the benefit of recreational fishers, the Victorian government releases millions of hatchery-bred fish into the environment, including the predatory introduced rainbow trout and brown trout. In 2012, more than 600,000 exotic salmonids were released into 70 lakes or reservoirs, including about 300,000 each of rainbow trout and brown trout and 11,000 chinook salmon.[149] About 2 million native fish of six species were also released in 2011-2012, mostly golden perch and Murray cod.[150]

A 2013 audit of the stocking program by Victoria's auditor general found that the primary industries department was 'not paying sufficient attention to the protection and conservation of ecological processes, habitats and supporting ecosystems in these fisheries'.[151] Environmental risks have not been adequately assessed and the program is focused too narrowly on recreational fishing outcomes (Box 4.7).

Stocking no longer occurs in some streams and dams where threatened species are known to occur.[152] But generally there is a lack of research of the impacts of stocking of both exotic and native fish and a lack of monitoring. There are four main ways by which stocking may affect the ecology of a system (either negatively or positively):[153]

- competition with or predation of native species
- altered genetic composition of wild populations – including erosion of genetic diversity, homogenisation of the gene pool and loss of population structure and locally adapted populations
- unintentional introduction of pathogens or other organisms (the nature of aquaculture practices makes aquaculture facilities prone to the proliferation of disease)
- ecosystem level effects, such as exceeding the carrying capacity of the system and trophic cascades.

The protozoan *Chilodonella cyprinid*, which can infect many native fish species, has spread within Victoria through the stocking of infected trout.[154]

Box 4.7 Fish stocking in the Loddon River basin[155]

In a case study in the Loddon River Basin, Victoria's auditor general noted the high conservation values of the basin, including 20 Ramsar-listed sites and several threatened species. The Loddon is also the site of a river restoration project. Stocking occurs of the following species:

- golden perch and Murray cod in 13 rivers and lakes
- introduced trout in 18 rivers and lakes
- various native species into seven rivers

Despite recreational fishing being popular in the area, with 33 formalised fishing access sites, there is no fishery management plan. Fishing of Murray cod (threatened) and Murray spiny crayfish from all waters and silver perch from lakes and impoundments, and fishing in Ramsar-listed Gunbower Creek are permitted. The audit noted that 'Without a complete and robust assessment of all risk and threats, or an integrated long-term management plan for the basin, fishing activities, stocking programs and public access may result in irreversible impacts to the sustainability of these sites and species.'

4.4.4 Climate change

'As Victoria's growing population is heavily dependent on surface water (and increasingly groundwater) sources, reduced water availability is likely to intensify competition for water resources and exacerbate alteration of natural flow regimes.'

Yung En Chee, 2010

Many predicted aspects of climate change – higher temperatures, lower rainfall, higher evaporation, and reduced soil moisture levels, runoff, streamflow and groundwater recharge – will exacerbate existing pressures on freshwater ecosystems. By 2030, runoff into most waterways is projected to decrease by 5 to 45%, and by 2070, river and stream flow may be reduced by half across much of the state.[156] The extent and frequency of droughts in Victoria may more than double by 2050.[157] During the recent millennium drought, stream flow volumes declined to less than a third of the long-term average, and flow reductions since the mid-1990s have already exceeded climate change projections for 2030.[158]

Warmer waters are detrimental to many aquatic species – temperatures above 22 ˚C are lethal for mayfly larvae, for example, and warming may reduce the growth, reproduction and capacity to tolerate toxins of some fish species.[159] Higher temperatures alter oxygen concentration, respiration, production and decomposition.[160] The heating and expansion of surface layers increases the risk of thermal stratification in stationary water (eg dams, weir pools, billabongs) or very slow flowing river reaches and the frequency of algal blooms. Increased fire risk is likely to also reduce runoff – post-fire regrowth uses more water than mature forests – and reduce water quality.[161] Greater frequency of drought will exacerbate demand on water resources and intensify competition between consumptive and non-consumptive uses of groundwater.

4.5 Conservation gaps and priorities

4.5.1 Environmental flows

The rivers have been worked too hard, and in many places we are just as excessively mining the groundwaters that feed them.

Richard Kingsford, 2007[162]

Although socially and economically challenging, restoring environmental flows is essential if Victoria is to arrest degradation and biodiversity decline in freshwater systems. Because of the extent of over-allocation of water and distortion of flow regimes in Victoria, this will require a much stronger commitment to buy back water entitlements on over-allocated rivers, remove impediments to environmental flows, and return to rivers a greater degree of natural flow variability.

Victoria has established an environmental water reserve but it is highly inadequate for many rivers and aquifers and has low security compared to agricultural and industrial uses (Box 4.8). During the millennium drought (1997–2010), many Victorian catchments experienced very low stream flow, among the lowest on record, but environmental allocations were sacrificed in several areas to augment supplies for agricultural and urban uses.[163] In 2007–08, for example, the environment received less than 7% of its entitlement while irrigators received 30–35%.[164]

Although Victoria's wetlands have suffered grievously from being deprived of natural flows, there has been very limited use of environmental water reserves for wetlands, and only for wetlands on public land.[165]

Victoria's 2013 waterway management strategy proposes to better integrate management of rivers and wetlands, and has a policy to identify priority wetlands in regional waterway strategies 'where environmental water management plans and environmental watering is required to maintain or improve wetland values at risk from altered water regimes'.[166] This is important but the strategy overall fails to specify objectives and actions to drive reforms essential to protect and restore wetland health.

Because it lacks clear objectives and targets, the waterway management strategy is likely to perpetuate current patterns of over-extraction at the expense of the health of freshwater ecosystems. A much greater commitment is needed to restore more-natural flow regimes. Targets for environmental flows should be based on a range of ecological criteria (such as specified in Table 4.12) and achieved by a mix of regulatory measures, market-based instruments and infrastructure improvements. The most cost-effective and efficient way to return water to the environment is by purchasing water from willing sellers.[167]

Box 4.8 Victoria's environmental water reserve

The environmental water reserve was established in 2005 under the Water Act as a share of water set aside to 'preserve the environmental values and health of water ecosystems, including their biodiversity, ecological function and quality of water, and the other uses that depend on environmental condition.'[168] It is managed by the Victorian environmental water holder, an independent statutory body. Environmental water can be in the form of entitlements held in storage and released to a river, rules based water (conditional on other entitlements) or above cap (what's left over after consumptive demand is satisfied).

Implementation of the environmental water reserve has been flawed as it lacks sufficient reliable water to protect environmental values and has been repeatedly qualified by the minister responsible for water giving priority to general consumptive demands during dry times. The Water Act requires the following amendments to enable achievement of the purpose of the environmental water reserve:[169]

- Improve the objective of the environmental water reserve to give surface and groundwater systems enforceable statutory protection. The current objective does not require environmental values and the health of ecosystems to be protected.

- Protect the environmental water reserve from qualification of rights. Critical human water needs and ecological needs should be prioritised over general consumptive rights. Qualification of rights for any elements of the environmental water reserve should require financial compensation or water payback.
- Introduce a legislated cap on the amount of water that can be extracted from Victorian water resources to protect environmental values (Sustainable Diversion Limits in the Murray-Darling Basin go some way to meeting this recommendation).
- Bring forward the first water resource assessment and statutory review to 2014.

Restoring floods for floodplains

[An] efficient and effective watering regime to sustain flood-dependent natural values is achievable.

Paul Peake and others, 2011[170]

Restoration of flooding regimes is essential to the health of floodplain biota, including 110 flood-dependent ecological vegetation classes and almost 200 rare and threatened plants and animals on the Murray River floodplain in northern Victoria.[171] Many rivers are so heavily regulated that only rare extreme flood events result in extensive overbank flows.[172] Recent environmental watering programs have focussed only on the largest floodplain blocks ('icon' sites) and a small set of values such as colonial nesting waterbirds, and the reason for their selection over other sites is often unclear or based on the potential to use small-scale engineering works as an alternative to buying water licences.[173] This latter politically expedient approach is based on the flawed notion that the same, limited water supply can be divided further for multiple uses, and is being used to justify reduced allocation of water to wetlands in the Murray-Darling Basin.[174]

Victoria needs 'a comprehensive, systematic, spatially explicit and publicly transparent inventory of flood dependent natural values' as a basis for allocating water and determining priorities for infrastructure investment to protect floodplains.[175] An assessment of the flood requirements of ecological vegetation classes and threatened taxa has recently been done for the Victorian floodplains of the Murray, Goulburn, Ovens and King Rivers.[176] Identifying all flood-dependent natural values and estimating their water requirements should be a high priority for all Victoria's river basins with flood-dependent biota.

Floodplain watering strategies should be based on the flooding requirements of the entire range of terrestrial and aquatic species, and be focused on maintaining natural values including for the following:[177]

- sites likely to assist the recovery of threatened species
- sites of high species richness
- sites for colonial breeding species
- sites that may be in poor condition at present but would recover with watering and be likely to support significant natural values
- corridors important for movement – from flight paths for the daily movements of Superb Parrots between breeding and feeding areas to corridors for longer-term movements such as in response to changing climate over the course of decades.

To achieve sustainable flooding regimes will require much better information about the flooding needs of floodplain biota.[178] The quantification of benefits of improving flooding regimes should go beyond site-specific values to the broader benefits of ecological connectivity. A conceptual framework is needed by which to compare different values and risks and to aid transparent decision-making on water allocations. Although yet to be fully implemented, the Murray-Darling Basin Authority has made progress by developing a hydrological model to set environmental targets for flooding frequencies.[179]

4.5.2 Riparian protection and restoration

Actions to maintain, improve and augment native vegetation on stream frontages are among the most likely to be highly beneficial for improving ecological connectivity and conserving biodiversity.

Victorian Environmental Assessment Council, 2011[180]

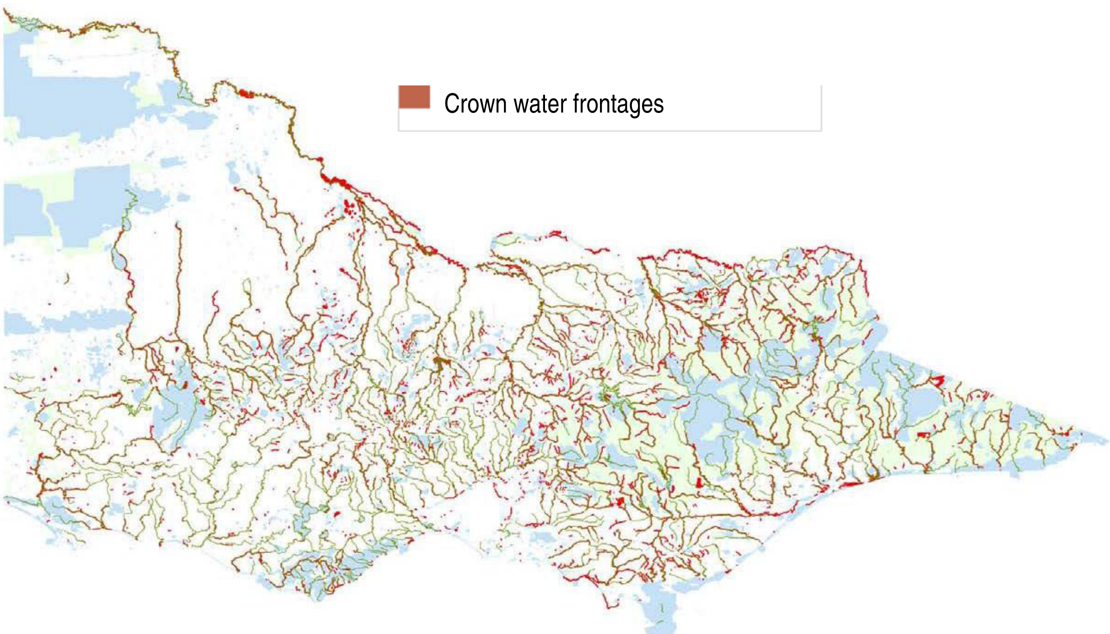
With more than half its riparian area along named waterways in public ownership, Victoria has a great opportunity to address many significant water quality, health and conservation problems by reforming management of the 30,000 kilometres of crown water frontages (Figure 4.7).

Riparian restoration typically requires excluding stock by fencing (and providing off-stream watering), controlling weeds and reintroducing native plants. There is high potential to restore at least some ecological functions of riparian areas, including carbon sequestration, and many benefits are likely to accrue (Box 4.9).[181] The extent of benefits will depend on the attributes of particular riparian areas and the health of the catchment – adjacent land-uses may continue to cause damage or limit recovery – but 'some is better than none'.[182]

To manage crown water frontages in the public interest, for both environmental and public health benefits, stock access needs to be restricted and high-value areas managed for conservation.[183] This requires classifying areas according to conservation criteria, providing incentives for licence holders to fence riparian areas and manage them for conservation, enforcing licence conditions and funding a restoration program.[184]

Similar stewardship measures need to be applied to riparian areas on private land, which account for 46% of riparian area (within 60 metres of a named waterway) and 29% of the extent of riparian areas with native vegetation.[185] The vegetation on privately owned riparian land is mostly of high conservation significance, with more than 90% of it mapped as ecological vegetation classes that are poorly represented in the conservation system. There needs to be more focus on permanently protecting high-value privately owned riparian land by covenants or acquisition for the national park and conservation system.

Figure 4.8 Victoria's crown water frontages



Victoria is unique in still having significant areas of riparian land in public ownership as crown water frontages. They are mostly on larger streams where the riparian land forms a boundary between properties. Most are licensed for agricultural activities by an adjoining landholder but more recently they have also been licensed for conservation purposes. There are currently about 10,000 licenses, issued for five years. Licensees are responsible for managing weeds, pests and fire and for maintaining public access for recreation. Many are being used by landholders without a license for purposes that require licensing. On smaller streams in agricultural landscapes, riparian land is usually in private ownership.

Box 4.9 Benefits of restoring riparian zones[186]

Better ***water quality*** due to:

- more stable soil and stream banks, reducing erosion
- filtering of nutrients and sediments from adjacent areas
- less nutrient input and increased capacity for nutrient processing, therefore reduced input into streams

Improved ***in-stream biodiversity*** due to:

- reduced nutrient and sediment loads in streams
- greater stream shading, which moderates water temperature (10% increase in riparian cover reduces water temperature by about 1 ºC)
- more litter, woody debris and other organic matter in streams, providing more habitat and food sources for aquatic communities (canopy cover of at least 50% is required to provide a reliable supply of leaf litter to support the aquatic food web)

Enhanced ***terrestrial biodiversity*** due to:

- restoration of plant communities unique to riparian areas
- improved condition of vegetation (eg exclusion of stock facilitates natural regeneration)
- increased landscape productivity (riparian areas tend to have larger trees, more regular flowering and reliable plant growth)
- increased foraging, breeding and refugial options for species
- improved habitat for threatened species

Increased ***resilience of ecological communities*** due to:

- re-establishment of dispersal corridors and habitat for species persistence
- restoration of drought refuges
- amelioration of threatening processes

Mitigation of climate change due to:

- a high capacity for carbon storage in riparian vegetation

Box 4.10 Riparian land management, public health and potential legal liabilities

Cattle faeces and urine contain pathogens that can be transmitted to humans, and uncontrolled access of cattle to rivers and streams in Victoria has the potential to introduce these pathogens into untreated or insufficiently treated water sources used by humans. In addition to the overwhelming environmental reasons to restrict stock access, there are strong human health and associated legal reasons to do so.

The Environment Defenders Office (Victoria) has warned that the 'statutory regime around the use of crown water frontages and human health create legal risks for the state government, which are likely to increase as time goes on.'[187] Legal risks include the following:

- The Water Act creates a civil liability for a person who pollutes water, whether authorised or not, and who by that act causes injury to another person.
- The Health Act creates a breach where a person causes a nuisance or knowingly allows a nuisance to exist or emanate from any land owned or occupied by or in the charge or that person.
- The Wrongs Act gives rise to a right to damages where the act or omission of a public authority breaches its duty of care, for example, where it fails to comply with general procedures and applicable standards.
- Injury to a person or their property arising from uncontrolled stock access on riparian land could give rise to an action in common law or statutory negligence or to a claim in public nuisance.

4.5.3 Freshwater protected areas

The need to establish comprehensive and representative freshwater protected areas is urgent … This should be accompanied by effective land and water management that pays more than lip service to the environmental requirements of aquatic ecosystems.

Richard Kingsford and Jon Nevill, 2005[188]

There is just as much need for comprehensive, adequate and representative protection of freshwater ecosystems as there is of terrestrial and marine ecosystems but Australia-wide, only about 2% of named rivers are protected within national parks.[189] Even internationally significant (Ramsar) wetlands are not fully protected – only about half their area in Victoria is in land tenures designated for conservation, and activities like duck hunting are permitted in several sites. Heritage rivers are only protected from the construction of major on-stream dams and not from other alterations to flow regimes.

'Failure to jointly assess freshwater and terrestrial biodiversity results in bias towards terrestrial ecosystems and in effect undervalues the linkages between them.'

Yung En Chee, 2010[190]

The bias is also evident in the lesser protection for many freshwater organisms in protected areas, with fishing permitted in national parks. It is also evident in the configuration of many protected areas (typically square or rectangular) being unrelated to natural drainage characteristics.[191] The bias to terrestrial ecosystems undervalues the linkages between freshwater and terrestrial systems, and the partial protection of wetlands or watercourses means they are highly vulnerable to degrading processes outside park boundaries.[192] The condition of surrounding areas is the primary determinant of wetland condition. While this is acknowledged in the waterway management strategy, it provides no imperative for reform.

There is also a strong bias in the types of wetlands protected, mostly due to the historical conversion of prime agriculture areas to freehold title, leaving little of many freshwater types in public ownership. In the Wimmera – the only bioregion for which there is published information on the extent to which freshwater ecosystems are protected within reserves – the once abundant shallow, less permanent wetlands are poorly represented, probably because their intermittent inundation meant they were more easily converted to agriculture than permanent wetlands.[193]

Nonetheless there are parts of Victoria with large areas of native vegetation and freshwater environments managed as part of 'largely intact ecosystems in extensive parks, reserves or forests'.[194] The protection of highly value, largely intact freshwater ecosystems should be optimised by creating freshwater reference areas under the Reference Areas Act. They provide a unique opportunity to serve as baseline reference areas and should be strictly protected from threats such as fish stocking and recreational fishing.

An essential basis for identifying priority freshwater communities for protection is their systemic classification and description – as has been done for terrestrial vegetation communities. Victoria has broad classifications of types of freshwater environments but these take no account of biological characteristics.[195] There needs to be a state-wide process for classifying freshwater communities and identifying priority areas for conservation investment or action.[196]

Selection of priority sites for freshwater protected areas needs to accommodate the 'unique aspects of freshwater biodiversity, ecology, and system function' – including freshwater-specific biodiversity elements and their strong connectivity.[197] The bioregional classification used for terrestrial ecosystems is 'not effective in representing aquatic ecosystem patterns across Victoria'.[198]

More detailed mapping is needed.[199] Victoria's rivers and streams have been mapped only at a coarse scale, with small streams and tributaries omitted. There is even less information on subsurface ecosystems and linkages with surface ecosystems. Wetlands greater than 1 hectare have been comprehensively mapped and classified into seven categories based on water regimes and salinity. They have also been mapped based on ecological vegetation classes but this mapping is far from comprehensive, with more than two-thirds of wetlands identified by hydrological factors (in four bioregions assessed) not identified in the ecological vegetation class mapping, and only 21% of the area of wetlands covered.[200] The lack of coverage is a serious impediment for wetland conservation planning and the establishment of a comprehensive, adequate and representative reserve system, and conveys a misleading impression of their condition and conservation status. The vegetation classification system has the potential to be a sound basis for planning because it combines hydrology and floristics but it needs to be comprehensive.

The selection of priority areas for protection of freshwater ecosystems should be systematic and based on identified biodiversity and conservation values, such as outlined in Table 4.12.

Table 4.11 Criteria that can be used to assign value in the identification of priority areas for conservation[201]

Criteria	Description of purpose or rationale
Biodiversity Values	
Taxa/community richness	The number of taxa or communities (whichever is relevant) within a planning unit. The greater the richness, the greater the value of the planning unit.
Taxa/community/habitat diversity	The full variety of taxa/communities/habitats (whichever is relevant) within a planning unit. The greater the diversity, the greater the value of the planning unit.
Species aggregations	Site/planning unit regularly hosts and/or supports large numbers of species (particularly migratory species).
Significant population numbers	Site/planning unit supports a significant proportion of the individuals of a native species.
Conservation Values	
Conservation status	The presence-absence or number of taxa, populations, communities or habitat types that are threatened or endangered. The greater the number of such biological entities in the planning unit, the greater the value of planning unit
Rarity, uniqueness, irreplaceability	The rarity, uniqueness, irreplaceability of taxa, populations, communities or habitat types within the focal region. The rarer the biological entities in the planning unit, or the more rare entities within the planning unit, the greater the value of the planning unit
Naturalness/intactness	These terms imply freedom from anthropogenic degradation and disturbances such as urbanisation, clearing, intensive agriculture, grazing, timber harvesting. The greater the degree of naturalness/intactness, the more valuable the planning unit.
Spatial attributes & landscape context	Spatial attributes refers to characteristics such as the size, shape, orientation, spatial configuration and juxtaposition of planning units, which have a bearing on population processes, susceptibility to degradation or disturbance and species persistence. Landscape context is a function of a planning unit's landscape position, and whether it plays a role in providing or supporting ecological processes, particularly for maintaining species populations. Connectivity – does the planning unit provide linkage/movement corridors between refuges (during periods of environmental stress or natural disturbances) or areas important for fulfilling for species life-history requirements (e.g. mating, spawning and nursery grounds)? Buffering – the planning unit may not be important in and of itself, but effectively buffers important areas from adverse influences. Component within a network of areas – the planning unit may not be important in and of itself, but it may have value for being a component in a network with a role in processes such as facilitating recolonisation following local extinction
Representation	Number of examples of the focal biodiversity feature (ie. taxa, communities, habitat type, ecological process) within a single planning unit or network of units. The more under-represented the biodiversity feature, the more valuable the planning unit
Practical considerations	
Physical environment	Lack of contamination: pollution , nutrients
Vulnerability to threatening processes	Risk of future degradation or conversion to production lands, urban development, or for any other purpose that would be detrimental biodiversity within the relevant time frame.

Comprehensive, adequate and representative inclusion of freshwater sites in national parks needs to be complemented by flow regimes that maintain or restore their conservation values. Damaging uses of freshwater areas – such as fishing of declining species – should be prohibited.

It is more than two decades since the last state review of the role of protected areas in freshwater conservation (by the Land Conservation Council in 1991)[202] and much has changed since then to warrant a new investigation of priority areas, and law and policy reforms. The legislation that resulted from the Land Conservation Council investigation, the Heritage Rivers Act, was a major advance at the time (until recently Victoria was the only Australian state with a law specifically for river protection) but it has been poorly implemented and needs revamping.[203] Management plans for heritage rivers have languished and there is insufficient focus on whole-of-catchment managment to protect their values.

In 1991 the Land Conservation Council also recommended the designation of 16 rivers as 'representative rivers' – in recognition of the great variety of Victoria's rivers, exemplified by the contrast between the cold, fast-flowing waters of the deep v-shaped Kiewa River and the warm, slow-moving pools of the lower Wimmera.[204] Rivers designated as representative need not be totally intact or contain outstanding values, but would be the least disturbed of each type (Table 4.13). They would serve as benchmarks for understanding how particular types of rivers function and the restoration potential for others of that type. Designation was intended to permit current uses to continue, require flow regimes to be maintained and motivate selective restoration. This 20 year old recommendation has great merit. The 2002 Victorian River Health Strategy noted the merit of the concept and a new preliminary classification of rivers had been developed but the concept seems to have lapsed.

An emerging priority under climate change is to protect freshwater refugia to facilitate survival of organisms under increasingly adverse conditions.[205] This should include 'evolutionary' refugia – sites that have been protected from dramatic climatic extremes over millennia, such as cave groundwater ecosystems for stygofauna – and 'displaced' refugia – sites such as mountain ranges, deep valleys and areas with steep climatic and environmental gradients, where species might find suitable habitats after displacement from original habitats. High priority should be given to identifying and protecting freshwater refugia.

Table 4.12 Land Conservation Council schedule of representative rivers[206]

Geomorphic unit	Representative rivers (gauge location)
East Victorian dissected uplands	Upper Big River (Glen Valley) Snowy Creek (Granite Flat) Dargo River (Dargo) Buchan River (Mellick Munjie Creek) Nicholson River (Deptford)
East Victorian uplands, dissected plateau	Macalister River (Glencairn)
East Victorian dissected uplands, riverine plains	Thurra River (Point Hicks) Cornella Creek (Colbinabbin)
West Victorian dissected uplands	Avoca River (Avoca)
West Victorian dissected uplands, volcanic plains	Lerderderg River (O'Briens Crossing) McCallum Creek (Carisbrook)
Otway Ranges, dissected plains	Gellibrand River (Carlisle River)
South Gippsland Ranges, riverine plains	Tarra River (Yarram)
Volcanic plains, dissected coastal plains	Kennedy Creek (Kennedy Creek)
Volcanic plains, coastal plains	No representative recommended.
Volcanic plains, west Victorian dissected uplands	Moorabool River (Morrisons)

Note: Representative rivers lie upstream of the nominated stream gauge. No recommendation was made for one category because all streams considered had been substantially modified.

4.5.4 Wetlands

[In] terms of the legal protection they receive, Victorian wetlands are still stuck in the past. Falling between a patchwork of partially applicable state and federal measures, wetlands are the forgotten piece of Victoria's environmental puzzle, covered by a plethora of rules and regulators but not effectively protected by any of them.

Environment Defenders Office (Victoria), 2012[207]

More than 95% of Victoria's wetland losses have occurred on private lands and 80% of remaining wetlands are on private lands, yet protection for these wetlands under Victoria's planning framework is inconsistent, usually non-specific, and often non-existent.[208] Wetlands on private land include part of 10 Ramsar-listed wetlands and 3600 nationally important wetlands.[209] Protection relies on particular shires or councils applying appropriate zones and overlays in their planning schemes and rigorously assessing development or land use proposals. There are wide-ranging exemptions, and decision-makers have broad discretion. Even when permits are required, decision-makers tend to impose conditions rather than refuse applications.[210] Overall, councils have been reluctant to use the few environmental protection measures in Victoria's planning laws to protect wetlands.[211]

There is need to amend planning schemes to ensure that high-value wetlands are identified – for example, by requiring that high-value wetlands identified by catchment management authorities are identified as such in planning schemes – and given much stronger protection. This could be achieved by a new 'wetlands overlay' for planning schemes that prohibits development that would destroy or degrade high-value wetlands. High-value wetlands to be strictly protected would include all Ramsar sites.

Another legislative gap is in the definition of waterway in the Water Act, which may not encompass several types of wetlands on private land.[212] This should be fixed.

The Flora and Fauna Guarantee Act could provide protection to wetlands that are habitat for threatened species. The Secretary of the Department of Environment and Primary Industries has the power to make 'critical habitat determinations' and the environment minister can issue 'interim conservation orders' to conserve critical habitat that takes precedence over permits, licences, or planning schemes but only one critical habitat determination has ever been made and not a single interim conservation order has been issued.[213]

Victoria needs an overarching strategy to set out goals, targets and measures for wetland protection. (Victoria is the only Australian state without a dedicated wetlands policy or strategy.) The Victorian waterway management strategy has a chapter on wetlands but will not drive comprehensive reform. There are many bodies with some responsibility for wetland management in Victoria – catchment management authorities (six of which have a wetlands strategy), the Victorian Catchment Management Council, various state government agencies, and shires and councils. But none has a clear mandate. A state-wide strategy for wetlands would help coordinate these agencies and assign clear responsibilities.

Wetland conservation is also dependent on restoring more-natural flow regimes, addressed above, and addressing major threats such as damage by cattle and vehicles, pollution and invasion by weeds, fish and feral animals.

4.5.5 Groundwater

'The Department of Sustainability and Environment and water corporations do not know whether groundwater use is sustainable.'

Victorian auditor general, 2010[214]

There is growing pressure on groundwater reserves in Victoria. Entitlements and use have been rising, particularly when the availability of surface water declined during the millennium drought. In 2010, Victoria's auditor general found that there were insufficient groundwater data and monitoring to ascertain the extent of groundwater reserves and whether extraction rates were sustainable.[215] In 2012, Victoria's Catchment Management Committee concluded there was insufficient information to establish a state-wide verdict on groundwater levels, with 'critical gaps in our understanding of the condition and prospects for Victoria's groundwater resources.'[216]

About 43% of Victoria's 62 groundwater management units have inadequate or limited coverage by observation bores, and about 55% of management units have key bores at risk of failure.[217] There is also insufficient licencing, metering and compliance monitoring to be clear about who is extracting groundwater and how much. Many groundwater users do not have meters to measure extraction, and some extract water without licences. The auditor general highlighted particular concern about lack of metering of domestic and stock use, with the estimated use for these users increasing from 44,000 megalitres (9% of total extractions) in 2006–07 to 51,000 megalitres (11%) one year later. There is also no state-wide information on trends in groundwater salinity.[218]

There is need for research to ascertain the extent of reserves and sustainable extraction limits and ensure that these limits are applied. These limits need to take into account the dependence of many riverine, wetland and floodplain ecosystems on groundwater input. A recent mapping exercise by the government has identified the extent of potential linkages (as a first cut prediction)[219] but there is need for more information about the groundwater needs of surface and subterranean ecosystems and the ecology of stygofauna as the essential basis for sustainable management. There has been no research on the water requirements of stygofauna.[220]

The Water Act requires that environmental water requirements be considered in determining the sustainable yields of groundwater systems but there is no accepted definition of groundwater-dependent ecosystems and no consistent method for assessing their requirements, which means there are no specific provisions for their protection or maintenance.[221] However, some policy progress is evident in the 2011 'western region sustainable water strategy', which requires consideration of groundwater-dependent ecosystems.[222]

4.5.6 Catchment management

The processes that can be used to assess the condition of the state's land and water resources and the effectiveness of land protection measures are either absent or insufficient.

Victorian Catchment Management Council, 2012[223]

Effective management of freshwater ecosystems requires effective catchment management. All land use activities can potentially impact freshwater habitats and 'therefore matter'.[224] Catchment damage in Victoria has been most widespread and intense in areas used for agricultural production, natural resource extraction and urban development, on private land. With about two-thirds of the state in private tenure, from which about 80% of native vegetation has been cleared, whole-of-catchment management requires effective partnerships between private landholders and local, regional and state institutions, backed up by effective laws, institutional arrangements and incentives programs.

Essential to these partnerships and for achievement of catchment goals is for government agencies themselves to exemplify best practice land management and to comply with catchment management strategies and strive to meet condition targets. Many activities carried out on crown land by government agencies can either foster or mitigate land degradation – logging in state forests, weed and pest management and fire management for example. State laws and policies should be improved where necessary to achieve catchment condition targets – to prevent damaging grazing along rivers, unsustainable firewood collection and the establishment of new weeds. Under the Catchment and Land Protection Act, catchment management authorities have catchment-wide responsibilities across all land tenures, yet have no influence on how some of the most important biodiversity assets – many forests, rivers and wetlands – are managed to meet catchment targets. To be effective, catchment management strategies have to guide all activities in Victoria whether by private or public land managers.

The latest five-yearly report on catchment condition by the Victorian Catchment Management Council criticises the lack of evaluation and monitoring of the condition and management of land and water resources.[225] There is a lack of clarity about the objectives of management, about what is required to achieve healthy catchments and the priorities for investment. Although the Catchment and Land Protection Act has an objective to maintain and enhance long-term land productivity, explicit biophysical targets are lacking. The waterway management strategy also lacks clearly defined ecologically based objectives and targets for waterway health and clear actions to achieve them. Catchment management strategies need to be based on a more sophisticated ecosystem-based model that accounts for ecological processes, with clear targets and indicators and informed by long-term monitoring programs. As the Catchment Management Council stresses, there should be standard approaches to monitoring, evaluation and review, and a system of sharing information across sectors, organisations and communities involved in land and water management.

4.6 Future directions

More than any other issue, freshwater management in Victoria exposes the short-sightedness of exploitation without care for the health of the system. Dead and dying river red gums, desiccating wetlands, rivers dominated by exotic fish and regular toxic algal blooms are some of the more lamentable symptoms of chronically overworking Victoria's rivers.

The density and diversity of Victoria's waterways and wetlands and the multiple ecotones (transition zones) they create support a rich biodiversity, including many endemic crayfish and fish and ecological communities. Victoria's groundwater systems are likely to harbour a wealth of endemic stygofauna yet to be comprehensively surveyed. Hundreds of wetlands are recognised as internationally or nationally significant, and many support internationally significant numbers of birds.

But a great many rivers, wetlands, riparian zones and floodplains are suffering the effects of flow regulation that reverses natural seasonal patterns, suppresses floods essential for floodplain health, leaves too little water for essential ecological functions and imposes barriers to natural migrations and dispersals. Close to half or more of Victoria's native fish, frog and crayfish species are threatened. A quarter of wetlands have been destroyed and many others have been degraded. Freshwater ecosystems are also damaged by catchment activities such as land clearing, grazing in riparian zones, introduction of invasive species and nutrient enrichment. Victoria's highly stressed freshwater systems lack resilience to cope with the drier future and reduced water availability predicted by climate science

More than any other issue, freshwater highlights the need for whole-of-system planning and management, for freshwater systems are hyper-connected – from headwaters to estuaries, rivers to floodplains and surface waterbodies to below-ground aquifers. Restoring river and wetland health should be at the top of the state's priorities – not only for ecological reasons. This is needed also for economic and human health and for ecosystem services such as water purification. To achieve it will require improving natural flow regimes and connectivity, freshwater protected areas, restoration and management of degraded habitats, and whole-of-catchment management.[226]

The national park and conservation system has been mostly focused around terrestrial values, with freshwater features often incidentally and partially encompassed. Just as for terrestrial areas, a comprehensive, adequate and representative system of freshwater protected areas should be a core conservation strategy.

In recognition of the essential ecological and health services provided by riparian zones, Victoria should seize the opportunity provided by its 30,000 kilometres publicly owned network of crown water frontages to improve water quality and restore riparian habitats. The poor and declining status of many wetlands points to an urgent need to bolster laws and planning processes, particularly for the 80% of Victoria's wetlands on private land.

Sympathetic ecosystem-based management at the catchment scale is an essential complement to protection and restoration of freshwater ecosystems. Reducing pressures in riparian and floodplain areas – by managing invasive species, reducing grazing impacts, preventing clearing and supporting low impact agriculture – will facilitate natural recovery.

Following is a summary of reforms recommended as high priorities over the next decade to make substantial progress on the protection and restoration of Victoria's freshwater ecosystems.

Environmental flows

F1 Establish sustainable environmental flow targets based on ecological criteria for surface water and groundwater systems.[227]

F2 Purchase water entitlements in a staged program aiming to reliably achieve sustainable environmental flow targets.

F3 In over-allocated rivers, accord high security and reliability to environmental water and use it to improve natural flow variability, including natural flood frequencies and high and low flows.

F4 Remove legal and other barriers to environmental watering of wetlands on private land.

F5 Establish a program to strategically remove barriers, such as artificial structures, that prevent environmental water from reaching high conservation value floodplains and downstream areas.

F6 Undertake a systematic assessment of the condition of Victorian aquifers, including identification of linkages between groundwater and surface water, and establish base-level data for ongoing monitoring and to inform management.

F7 Develop watering strategies to protect and recover flood-dependent natural values on floodplains, with priority sites including those with threatened taxa, high species richness, colonial breeding sites or corridors important for movement of biota, and sites in poor condition with the potential to recover significant natural values.

Riparian protection

More details are in the VNPA *Riverside Rescue* report.[228]

F8 Establish a 'special offer' assistance program to crown water frontage licence holders to fence boundaries, set up off-river watering and improve management for environmental outcomes.

F9 Establish a 'waterway guardians' program to offer incentives to landholders with significant conservation assets on private land adjacent to crown water frontages or with privately owned frontages with high conservation values to manage these areas for conservation.

F10 Strategically add riparian areas that meet conservation criteria (for biodiversity values, connectivity and management integrity) to the national park and conservation system and manage them accordingly.

F11 For areas in moderate to good condition, but not suitable for addition to the national park and conservation system, issue a conservation licence that specifies minimum management actions, such as fencing, stock removal or grazing regimes and weed control.

F12 Enforce Victoria's laws to prevent unauthorised activities on riparian public land. Cancel licences where there is evidence of no improvement or action to improve conditions.

F13 Cancel riparian grazing licences where there is evidence of significant damage or no improvement or lack of action to improve conditions.

F14 Provide funding of $20 million per year for four years to accelerate the implementation of good management and assist landholders to take positive steps to repair, restore and protect riparian lands.

Freshwater protected areas

F15 Develop a state-wide process for classifying freshwater communities (akin to terrestrial vegetation communities) and systematically identify high priority areas for protection by applying criteria for assigning biodiversity and conservation value (such as in Table 4.12).

F16 Systematically identify freshwater refugia likely to facilitate survival of organisms under threat from climate change and provide them with a high level of protection.

F17 Create freshwater reference areas under the Reference Areas Act to optimise protection of freshwater ecosystems which are highly intact and have high biodiversity.

F18 Review and revamp the Heritage Rivers Act, including by extending it to wetlands, improving its capacity to prevent damaging land use changes, and requiring monitoring.

F19 Protect the 16 ‘representative rivers’ recommended by the Land Conservation Council in 1991 by amending the Heritage Rivers Act or by protecting them in the national park and conservation system.

Wetlands

F20 Develop a Victorian wetlands strategy that sets policy goals, targets and reporting regimes.

F21 Require land use planning schemes to contain wetland overlays to prohibit destruction or modification of high-value wetlands, as identified by catchment management authorities and including all Ramsar sites.

F22 Use the Flora and Fauna Guarantee Act to protect high-value wetlands that provide habitat for threatened species by declaring them as critical habitat and, where they are under imminent threat, by issuing ‘interim conservation orders’.

F23 Protect all Ramsar wetland sites on public land within the national park estate.

F24 Amend the Water Act to include all wetlands on private land in the definition of ‘waterway’.

Catchment management

Chapter 3 provides considerably more detail on land use recommendations.

F25 Strengthen catchment management strategies, including by adopting an ecosystem-based approach, identifying clear targets and indicators, developing a long-term monitoring program and clearly linking catchment management to the health of marine and coastal environments and the Murray River.

F26 Strengthen links between catchment management strategies and land-use planning.

F27 Revise and strengthen the Victorian waterway management strategy to define clear indicators and targets for regional river health and restoration.

F28 Recognise the important role played by streams and their environs in landscape connectivity and as carbon sinks by incorporating them into broader connectivity, restoration and carbon sequestration programs.

F29 Minimise land use impacts on rivers and streams by removing grazing from sensitive areas, promoting low impact agriculture and controlling weeds and feral animals. Complement these measures with education to promote improved management practices.

F30 Ensure that public land managers lead the way in complying with regional catchment strategies and their catchment condition targets developed by catchment management authorities.

4.7 Sources

Endnotes

[1] Postel (1992)
[2] Dudgeon et al (2006); Strayer & Dudgeon (2010)
[3] Chee (2010)
[4] Commissioner for Environmental Sustainability (2008)
[5] Environment Australia (2001)
[6] Humphreys (2009)
[7] Tomlinson & Boulton (2008); Dresel et al (2010)
[8] O'Brien (2007); Chapman (2009); Museum Victoria (2009); Department of Sustainability and Environment (2009a); Department of Sustainability and Environment (2010); Gillespie & Kum (2011); Cogger (2013); Department of Sustainability and Environment (2013); Australian Aquatic Biological (2014). Museum Victoria (2009) notes an additional 2 undescribed freshwater crayfish species likely to be endemic to Victoria.
[9] O'Brien (2007); Museum Victoria (2009). Two undescribed species are thought to be endemic.
[10] Museum Victoria (2009)
[11] Museum Victoria (2009); Raadik (2011)
[12] Department of Sustainability and Environment (2013)
[13] Department of Environment and Primary Industries (2013a)
[14] Environment Australia (2001);Papas & Moloney (2012)
[15] Dutson et al (2009)
[16] Chee (2010)
[17] Department of Sustainability and Environment (2012b)
[18] Department of Environment and Primary Industries (2013a)
[19] Bernal & Mitsch (2012)
[20] Department of Sustainability and Environment (2003a)
[21] Palmer & Bennett (2006)
[22] Department of Sustainability and Environment (2003a)
[23] Eamus et al (2006); Tomlinson & Boulton (2008); Chee (2010)
[24] Chee (2010)
[25] Walker et al (1995); Bunn & Arthington (2002); Poff & Zimmerman (2010). The quoted words are from Walker et al. 1995.
[26] Bunn & Arthington (2002)
[27] Kennard et al (2010); Chee (2010)
[28] Ricklefs et al (1984); McGregor et al (2008); Bennett et al (2009)
[29] Chee (2010)
[30] Ricklefs et al (1984)
[31] Crowder & Diplas (2006)
[32] Department of Natural Resources and Environment (2002)
[33] Department of Sustainability and Environment (2003a)
[34] Fitzsimons et al (2011)
[35] Peake et al (2011)
[36] Peake et al (2011)
[37] Chee (2010)
[38] Tomlinson & Boulton (2008)
[39] Department of Sustainability Environment Water Population and Communities (2012)
[40] Chee (2010)
[41] Chee (2010)
[42] Dresel et al (2010)
[43] Bacon et al (1993)
[44] Tomlinson & Boulton (2008); Guzik et al (2010)
[45] Tomlinson & Boulton (2008)
[46] Chee (2010)
[47] Chee (2010)
[48] Boulton (2007)
[49] Chee (2010)
[50] Ward & Palmer (1994)
[51] VNPA (2011)
[52] Williams et al (2010)
[53] Lake (1995)
[54] Tomlinson 2008 - Boulton and Lake in press
[55] Tomlinson & Boulton (2008)
[56] Lintermans (2007)
[57] Raadik (2011)
[58] Department of Environment and Primary Industries (2013a)
[59] Department of Sustainability and Environment (2009a); Department of Sustainability and Environment (2013)
[60] Department of Environment and Primary Industries (2013b)
[61] Department of Environment and Primary Industries (2013b)
[62] Department of Sustainability and Environment (2009b)
[63] Department of Environment and Primary Industries (2013b)
[64] Department of Environment and Primary Industries (2013b)
[65] Victorian Catchment Management Council (2012)
[66] Chee (2010)
[67] Department of Environment and Primary Industries (2013a)
[68] Papas & Moloney (2012). They assessed 39% of 'high value' wetlands (Ramsar listed, Directory of Important Wetlands in Australia, and Edenhope wetlands).
[69] Department of Environment and Primary Industries (2013a)
[70] Papas & Moloney (2012)
[71] Trust for Nature (2013)
[72] Trust for Nature (2013)
[73] Papas & Moloney (2012)
[74] Papas et al (2008)
[75] Papas & Moloney (2012), citing data from Department of Sustainability and Environment
[76] Papas & Moloney (2012)
[77] Trust for Nature (2013)
[78] Williams et al (2010)
[79] VNPA (2011)
[80] Department of Sustainability and Environment (2003b)
[81] Department of Sustainability and Environment (2005)
[82] Norris et al (2001)
[83] VNPA (2011)
[84] Department of Environment and Primary Industries (2013b)
[85] Trust for Nature (2013)
[86] Peake et al (2011)
[87] McCarthy et al (2006); Murray-Darling Basin Authority (2009) ; Peake et al (2011). Hazards of acid sulphate soils include acidification, loss of oxygen from water and mobilisation of metals.
[88] Cunningham et al (2011)
[89] Trust for Nature (2013)
[90] Victorian Catchment Management Council (2012)
[91] Dresel et al (2010); Victorian Catchment Management Council (2012)
[92] Victorian Auditor General (2010); Victorian Catchment Management Council (2012)
[93] Victorian Auditor General (2010); Department of Environment and Primary Industries (2014)

[94] Victorian Catchment Management Council (2012)
[95] Commissioner for Environmental Sustainability (2008)
[96] Dudgeon et al (2006); Vörösmarty et al (2010)
[97] Commissioner for Environmental Sustainability (2008)
[98] Department of Sustainability and Environment (2003a)
[99] Department of Sustainability and Environment (2012b).
[100] Chee (2010)
[101] Commissioner for Environmental Sustainability (2008)
[102] Peake et al (2011)
[103] Papas & Moloney (2012)
[104] Department of Sustainability and Environment (2003d)
[105] Reynolds (1983)
[106] Department of Sustainability and Environment (2003d)
[107] Ryan et al (2001)
[108] Peake et al (2011)
[109] Tomlinson & Boulton (2008)
[110] Tomlinson & Boulton (2008)
[111] Dresel et al (2010)
[112] Papas & Moloney (2012)
[113] Halse et al (2003)
[114] Boulton et al (2003); Tomlinson & Boulton (2008)
[115] Commissioner for Environmental Sustainability (2008); VNPA (2011)
[116] Papas & Moloney (2012)
[117] Victorian Catchment Management Council (2012)
[118] Department of Sustainability and Environment (2003b)
[119] VNPA (2011)
[120] Department of Sustainability and Environment (2003b)
[121] Frood & Calder (1987); Department of Sustainability and Environment (2003b)
[122] Robinson & Mann (1996)
[123] Holland (2009)
[124] National Health and Medical Research Council & Natural Resource Management Ministerial Council (2004)
[125] Davis & Finlayson (2000)
[126] Western Coastal Board (2002); Tomlinson & Boulton (2008); Matthews et al (2011); Environment Protection Authority Victoria (2013)
[127] Scientific Advisory Committee (1993). Input of toxic substances into rivers and streams is listed as a potentially threatening process.
[128] Papas & Moloney (2012)
[129] Trueman (2007)
[130] Bunn & Arthington (2002); Commissioner for Environmental Sustainability (2008)
[131] Department of Sustainability and Environment (2003c)
[132] Koehn (2004)
[133] Department of Sustainability and Environment (2003c)
[134] Lintermans (2007)
[135] Raadik (2011)
[136] Lintermans (2007); Trueman (2007)
[137] Department of Sustainability and Environment (2003c)
[138] Koehn (2004)
[139] Crooks (2002)
[140] Department of Sustainability and Environment (2008)
[141] Australian Weeds Committee (2012)
[142] Carr (1993)
[143] Carr (1993)
[144] Commissioner for Environmental Sustainability (2008), citing unpublished data on the Index of Stream Condition
[145] Department of the Environment and Heritage (2006); Hunter et al (2009); Hollis (2011); Howard et al (2011)
[146] Hunter et al (2009)
[147] Jackson et al (2004)
[148] Cadwallader (1978)
[149] Department of Primary Industries (2013)
[150] Fisheries Victoria (2012)
[151] Victorian Auditor General (2013)
[152] Lintermans (2007)
[153] Gillanders et al (2006)
[154] Gillanders et al (2006)
[155] Victorian Auditor General (2013)
[156] Commissioner for Environmental Sustainability (2008)
[157] Department of Sustainability and Environment (2012a)
[158] Victorian Catchment Management Council (2012), citing Sinclair Knight Merz (2009)
[159] Pusey & Arthington (2003); Davies et al (2004)
[160] Caissie (2006)
[161] Commissioner for Environmental Sustainability (2008)
[162] Kingsford (2007)
[163] Commissioner for Environmental Sustainability (2008)
[164] Commissioner for Environmental Sustainability (2008)
[165] Environment Defenders Office (Victoria) (2012a)
[166] Department of Environment and Primary Industries (2013a), Policy 12.7
[167] Productivity Commission (2010). Infrastructure projects financed under the Living Murray Initiative recovered water at a cost almost 40% greater than the cost of market-based measures.
[168] *Water Act 1989*, Environmental Water Reserve Objective (section 4B)
[169] The reforms are detailed in Environment Victoria & VNPA (2010)
[170] Peake et al (2011)
[171] Fitzsimons et al (2011)
[172] Peake et al (2011)
[173] Peake et al (2011); Pittock et al (2013)
[174] Pittock et al (2013)
[175] Peake et al (2011)
[176] Fitzsimons et al (2011)
[177] Fitzsimons et al (2011)
[178] Fitzsimons et al (2011)
[179] Murray-Darling Basin Authority (2012)
[180] Victorian Environmental Assessment Council (2011)
[181] Williams et al (2010)
[182] Williams et al (2010)
[183] Williams et al (2010)
[184] See Environment Victoria & VNPA (2010) for details.
[185] Trust for Nature (2013)
[186] Williams et al (2010)
[187] Environment Defenders Office (Victoria) (2009)
[188] Kingsford & Nevill (2005)
[189] Nevill (2007). In Victoria, the entire catchments of two small coastal rivers, the Benedore and Red Rivers in East Gippsland, lie within the Croajingalong National Park, and Wilson's Promontory National Park protects Darby River.
[190] Chee (2010)
[191] Robertson & Fitzsimons (2005)
[192] Fitzsimons & Robertson (2005); Chee (2010)
[193] Fitzsimons & Robertson (2005)

[194] Department of Environment and Primary Industries (2013a)
[195] Chee (2010)
[196] Chee (2010)
[197] Kingsford & Nevill (2005)
[198] Wells & Newall (1997)
[199] Chee (2010)
[200] Robertson & Fitzsimons (2004)
[201] A synthesis by Chee (2010)
[202] Land Conservation Council (1991)
[203] Nevill (2007)
[204] Land Conservation Council (1991)
[205] Chee (2010)
[206] Land Conservation Council (1991)
[207] Environment Defenders Office (Victoria) (2012a)
[208] Environment Defenders Office (Victoria) (2012a)
[209] Trust for Nature (2013)
[210] Bates (2010)
[211] Environment Defenders Office (Victoria) (2012a)
[212] Environment Defenders Office (Victoria) (2012a)
[213] Environment Defenders Office (Victoria) (2012b)
[214] Victorian Auditor General (2010)
[215] Victorian Auditor General (2010)
[216] Victorian Catchment Management Council (2012)
[217] Victorian Auditor General (2010)
[218] Victorian Catchment Management Council (2012)
[219] Dresel et al (2010)
[220] Tomlinson & Boulton (2008)
[221] Chee (2010)
[222] Department of Sustainability and Environment (2011)
[223] Victorian Catchment Management Council (2012)
[224] Chee (2010)
[225] Victorian Catchment Management Council (2012)
[226] Chee (2010)
[227] See Table 4.12 for criteria to consider.
[228] VNPA (2011)

References

Australian Aquatic Biological (2014) *Crayfish List – Freshwater Crayfish of Australia (January 2014)*March 2014

Australian Weeds Committee (2012) *Weeds of National Significance, Draft Sagittaria (Sagittaria platyphylla) Strategic Plan.* Australian Weeds Committee, Canberra

Bacon PE, Stone C, Binns DL, Leslie DJ, Edwards DW (1993) Relationships between water availability and Eucalyptus camaldulensis growth in a riparian forest. *Journal of Hydrology* 150: 541-61

Bates G (2010) *Environmental Law in Australia*. LexisNexisButterworths.

Bennett AF, Haslem A, Cheal DC, Clarke MF, Jones RN, et al (2009) Ecological processes: a key element in strategies for nature conservation. *Ecological Management & Restoration* 10: 192–99

Bernal B, Mitsch WJ (2012) Comparing carbon sequestration in temperate freshwater wetland communities. *Global Change Biology* 18: 1636–47

Boulton AJ (2007) Hyporheic rehabilitation in rivers: restoring vertical connectivity. *Freshwater Biology* 52: 632-50

Boulton AJ, Humphreys WF, Eberhard SM (2003) Imperilled subsurface waters in Australia: biodiversity, threatening processes and conservation. *Aquatic Ecosystem Health and Management* 6: 41-54

Bunn SE, Arthington AH (2002) Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* 30: 492-507

Cadwallader PL (1978) Some causes of the decline in range and abundance of native fishes in the Murray-Darling River system. *Proceedings ofihe Royal Society of Victoria* 90: 211-24

Caissie D (2006) The thermal regime of rivers: a review. *Freshwater Biology*: 1389–406

Carr GW (1993) *Exotic Flora of Victoria and its Impact on Indigenous Biota*. Melbourne: Inkata Press.

Chapman A (2009) *Numbers of Living Species in Australia and the World.* Australian Biodiversity Information Services, Toowoomba

Chee YE (2010) *Nature Conservation Review: Freshwater-dependent Ecosystems.* Melbourne University

Cogger H (2013) *Reptiles and Amphibians of Australia*. Collingwood: CSIRO Publishing.

Commissioner for Environmental Sustainability (2008) *State of the Environment Victoria 2008.* Commissioner for Environmental Sustainability, Melbourne, Victoria

Crooks J (2002) Characterising ecosystem-level consequences of biological invasions: the role of ecosystem engineers. *Oikos* 97: 153-66

Crowder DW, Diplas P (2006) Applying spatial hydraulic principles to quantify stream habitat. *River Research and Applications* 22: 79-89

Cunningham S, Griffioen P, White M, Mac Nally R (2011) *Mapping the Condition of River Red Gum (Eucalyptus camaldulensis Dehnh.) and Black Box (Eucalyptus largiflorens F.Muell.) Stands in The Living Murray Icon Sites. Stand Condition Report 2010.* Murray-Darling Basin Authority, Canberra

Davies PM, Cook B, Rutherford K, Walshe T (2004) *Managing High In-stream Temperatures Using Riparian Vegetation*. River Management Technical Guideline 5. Land and Water Australia, Canberra

Davis J, Finlayson B (2000) *Sand Slugs and Stream Degradation: The Case of Granite Creeks, North-East Victoria* Cooperative Research Centre for Freshwater Ecology, Canberra

Department of Environment and Primary Industries (2013a) *Improving Our Waterways: Victorian Waterway Management Strategy.* Victorian Department of Environment and Primary Industries

Department of Environment and Primary Industries (2013b) *Index of Stream Condition: The Third Benchmark of Victorian River Condition.* Victorian Department of Environment and Primary Industries

Department of Environment and Primary Industries (2014) *Groundwater*. http://www.depi.vic.gov.au/water/groundwater. Accessed February 2014

Department of Natural Resources and Environment (2002) *Healthy Rivers, Healthy Communities and Regional Growth: Victorian River Health Strategy.* Victorian Government Department of Natural Resources and Environment

Department of Primary Industries (2013) *Salmonid Fish Releases 2012.* http://www.dpi.vic.gov.au/fisheries/about-fisheries/fish-stocking-reporting/salmonid-fish-releases-2012. Accessed November 2013

Department of Sustainability and Environment (2003a) *Alteration to the Natural Flow Regimes of Rivers and Streams. Action Statement, Flora and Fauna Guarantee Act 1988.* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2003b) *Degradation of Native Riparian Vegetation along Victorian Rivers and Streams. Action Statement, Flora and Fauna Guarantee Act 1988.* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2003c) *Introduction of Live Fish into Waters within Victorian River Catchments. Action Statement, Flora and Fauna Guarantee Act 1988.* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2003d) *Prevention of Passage of Aquatic Biota by Instream Structures. Action Statement, Flora and Fauna Guarantee Act 1988*. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2005) *Index of Stream Condition: The Second Benchmark of Victorian River Condition* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2008) *Advisory List of Environmental Weeds of Aquatic Habitats of Victoria.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009a) Advisory List of Threatened Invertebrate Fauna in Victoria - 2009. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2009b) *Victorian Water Accounts 2007-2008: A Statement of Victorian Water Resources.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2010) *Biodiversity is Everybody's Business: Victoria's Biodiversity Strategy 2010 – 2015, Consultation Draft.* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2011) *Western Region Sustainable Water Strategy.* Victorian Government Department of Sustainability and Enviroment

Department of Sustainability and Environment (2012a) *Report on Climate Change and Greenhouse Gas Emissions in Victoria.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2012b) *Victorian Water Accounts 2010–2011: A Statement of Victorian Water Resources.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2013) Advisory List of Threatened Vertebrate Fauna in Victoria 2013. Victorian Department of Sustainability and Environment

Department of Sustainability Environment Water Population and Communities (2012) *Black Water Events and Water Quality.* Australian Government Department of Sustainability, Environment, Water, Population and Communities,

Department of the Environment and Heritage (2006) *Infection of Amphibians with Chytrid Fungus Resulting in Chytridiomycosis. Background Document for the Threat Abatement Plan.* Australian Government Department of the Environment and Heritage

Dresel PE, Clark R, Cheng X, Reid M, Fawcett J, Cochraine D (2010) *Mapping Terrestrial Groundwater Dependent Ecosystems: Method Development and Example Output.* Victoria Department of Primary Industries, Melbourne

Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, et al (2006) Freshwater biodiversity: importance, threats, status, and conservation challenges. *Biological Reviews* 81: 163-82

Dutson G, Garnett S, Gole C (2009) *Australia's Important Bird Areas: Key Sites for Bird Conservation.* Birds Australia

Eamus D, Froend R, Loomes R, Hose G, Murray B (2006) A functional methodology for determining the groundwater regime needed to maintain the health of groundwater-dependent vegetation. *Australian Journal of Botany* 54: 97-114

Environment Australia (2001) *Directory of Important Wetlands in Australia* Environment Australia, Canberra

Environment Defenders Office (Victoria) (2009) *Crown Frontage Grazing Licences, Water Quality and Human Health – An Analysis of Legal Obligations and Risks.* Environment Defenders Office (Victoria)

Environment Defenders Office (Victoria) (2012a) *Protecting Victorian Wetlands.* Environment Defenders Office (Victoria)

Environment Defenders Office (Victoria) (2012b) *Where's the Guarantee? Implementation and Enforcement of the Flor aand Fauna Guarantee Act 1988 & Wildlife Act 1975.* Environment Defenders Office (Victoria)

Environment Protection Authority Victoria (2013) *Gippsland Lakes Condition Report 1990-2011.* Environment Protection Authority Victoria

Environment Victoria, VNPA (2010) *A Victorian River Rescue Package. 2010 State Election Policy Priorities.* Environment Victoria and Victorian National Parks Association

Fisheries Victoria (2012) *Native Fish Releases 2012.* http://www.dpi.vic.gov.au/fisheries/about-fisheries/fish-stocking-reporting/native-fish-releases-2012. Accessed November 2013

Fitzsimons J, Robertson H (2005) Freshwater reserves in Australia: directions and challenges for the development of a comprehensive, adequate and representative system of protected areas. *Hydrobiologia* 552: 87–97

Fitzsimons JA, Peake P, Frood D, Mitchell M, Withers N, et al (2011) Flooding requirements for biodiversity values along the Victorian floodplain of the Murray Valley. *The Victorian Naturalist* 128: 48–85

Frood D, Calder M (1987) *Nature Conservation in Victoria: A Study Report.* Victorian National Parks Association

Gillanders BM, Elsdon TS, Munro AR (2006) *Impacts of native fish stocking on fish within the Murray-Darling Basin.* Murray-Darling Basin Commission

Gillespie GR, Kum KC (2011) The bleating tree frog 'Litoria dentata' Keferstein (Anura: Hylidae): An addition to the frog fauna of Victoria. *Victorian Naturalist* 128: 256-59

Guzik MT, Austin AD, Cooper SJB, Harvey MS, Humphreys WF, et al (2010) Is the Australian subterranean fauna uniquely diverse? . *Invertebrate Systematics* 24: 407–18

Halse SA, Ruprecht JK, Pinder AM (2003) Salinisation and prospects for biodiviersity in rivers and wetlands of south-west Western Australia. *Australian Journal of Botany* 51: 673-88

Holland D (2009) *Human Health Risk From Crown Water Frontage Licences.* Monash University Water Studies Centre

Hollis G (2011) *National Recovery Plan for the Baw Baw Frog Philoria frosti.* Victorian Government Department of Sustainability and Environment

Howard K, Antrobus J, Clemann N (2011) A tale of two mountains: fire, fungus and Alpine Tree Frogs. *The Victorian Naturalist* 128: 260-65

Humphreys WF (2009) Hydrogeology and groundwater ecology: does each inform the other? *Hydrogeology Journal* 17: 5-21

Hunter D, Pietsch R, Clemann N, Scroggie M, Hollis G, Marantelli G (2009) *Prevalence of the Amphibian Chytrid Fungus (Batrachochytrium dendrobatidis) in the Australian Alps.* Victorian Government Department of Sustainability and Environment

Jackson J, Raadik T, Lintermans M, Hammer M (2004) Alien salmonids in Australia: impediments to effective impact management, and future directions. *New Zealand Journal of Marine and Freshwater Research* 38: 447-55

Kennard MJ, Pusey BJ, Olden JD, Mackay SJ, Stein JL, Marsh N (2010) Classification of natural flow regimes in Australia to support environmental flow management. *Freshwater Biology* 55: 171-93

Kingsford R (2007) *Australian Heritage Rivers: A Major New Policy Proposal.* Connected Waters Initiate, University of NSW

Kingsford R, Nevill J (2005) Scientists urge expansion of freshwater protected areas. *Ecological Management & Restoration* 6: 161-62

Koehn JD (2004) Carp (*Cyprinus carpio*) as a powerful invader in Australian waterways. *Freshwater Biology* 49: 882–94

Lake PS (1995) Of floods and droughts: river and stream ecosystems in Australia In *Ecosystems of the World, River and Stream Ecosystems*, ed. CE Cushing, KW Cummins, GW Minshall, pp. 659-94. Amsterdam: Elsevier

Land Conservation Council (1991) *Rivers and Streams Special Investigation Final Recommendations.* Land Conservation Council, Melbourne

Lintermans M (2007) *Fishes of the Murray-Darling Basin: An Introductory Guide.* Murray-Darling Basin Authority

Matthews S, Carr G, McMahon A (2011) *VNPA Nature Conservation Review: Terrestrial Ecosystems.* Ecology Australia

McCarthy B, Conallin A, D'Santos P, Baldwin D (2006) Acidification, salinization and fish kills at an inland wetland in south-eastern Australia following partial drying. *Ecological Management and Restoration* 7: 221–23

McGregor A, Coffey B, Deutsch C, Westcott G, Robinson J (2008) *Ecological Processes in Victoria: Policy Priorities for Sustaining Biodiversity. Discussion Paper Rep.*

Murray-Darling Basin Authority (2009) *Acid Sulfate Soils in the Murray Darling Basin.* Murray-Darling Basin Authority

Murray-Darling Basin Authority (2012) *Hydrologic Modelling to Inform the Proposed Basin Plan: Methods and Results.* Murray-Darling Basin Authority, Canberra

Museum Victoria (2009) Endemic Victorian Fauna. Unpublished

National Health and Medical Research Council, Natural Resource Management Ministerial Council (2004) *Australian Drinking Water Guidelines 6.* Australian Government

Nevill J (2007) *Counting Australia's protected rivers*. http://www.onlyoneplanet.com/FWPA_protectedRivers.htm. Accessed December 2013

Norris RH, Prosser IP, Young B, Liston P, Bauer N, et al (2001) *The Assessment of River Conditions: An Audit of the Ecological Condition of Australian Rivers.* CSIRO, National Land and Water Resources Audit Office, Canberra

O'Brien M (2007) Freshwater and terrestrial crayfish (Decapoda, Parastacidae) of Victoria: status, conservation, threatening processes and bibliography. *The Victorian Naturalist* 124: 210-29

Palmer GC, Bennett AF (2006) Riparian zones provide for distinct bird assemblages in forest mosaics of south-east Australia. *Biological Conservation* 130: 447-57

Papas P, Lyon S, Jin C, Holmes J (2008) *Development of a Wetland Catchment Disturbance Index.* Victorian Department of Sustainability and Environment

Papas P, Moloney P (2012) *Victoria's Wetlands 2009–2011: Statewide Assessments and Condition Modelling.* Victorian Department of Sustainability and Environment

Peake P, Fitzsimons J, Frood D, Mitchell M, Withers N, et al (2011) A new approach to determining environmental flow requirements: Sustaining the natural values of floodplains of the southern Murray-Darling Basin. *Ecological Management & Restoration* 12: 128-37

Pittock J, Finlayson CM, Howitt J (2013) Beguiling and risky: 'environmental works and measures' for wetland conservation under a changing climate. *Hydrobiologia* 708: 111–31

Postel S (1992) *Last Oasis: Facing Water Scarcity*. New York: W.W. Norton.

Productivity Commission (2010) *Market Mechanisms for Recovering Water in the Murray-Darling Basin.* Australian Government

Pusey BJ, Arthington AH (2003) Importance of the riparian zone to the conservation and management of freshwater fish: a review. *Marine and Freshwater Research*: 1-16

Raadik T. 2011. *Systematic Revision of the Mountain Galaxias, Galaxias olidus Günther, 1866 Species Complex (Teleostei: Galaxiidae) in Eastern Australia*. University of Canberra

Reynolds LF (1983) Migration patterns of five fish species in the Murray-Darling river system. *Australian Journal of Marine and Freshwater Research* 34: 857-71

Ricklefs RE, Naveh Z, Turner RE (1984) Conservation of ecological processes. *The Environmentalist* 4: 6-16

Robertson H, Fitzsimons J (2004) Hydrology or floristics? Mapping and classification of wetlands in Victoria, Australia, and implications for conservation planning. *Environmental Management* 34: 499-507

Robertson H, Fitzsimons J (2005) Wetland reservation on Victoria's northern plains and riverine forests. *Proceedings of the Royal Society of Victoria* 117: 139-48

Robinson D, Mann S (1996) *Natural Values of the Public Lands Along the Broken, Boosey and Nine Mile Creeks of Northeastern Victoria.* Goulburn Valley Environment Group, Shepparton

Ryan T, Webb A, Lennie R, Lyon J (2001) *Status of Cold Water Releases from Victorian Dams.* Victorian Department of Natural Resources and Environment

Scientific Advisory Committee (1993) *Input of Toxic Substances into Victorian Rivers and Streams Due to Human Activities. Final Recommendation on a Nomination for Listing* Flora and Fauna Guarantee - Scientific Advisory Committee

Strayer DL, Dudgeon D (2010) Freshwater biodiversity conservation: Recent progress and future challenges. *Journal of the North American Benthological Society* 29: 344-58

Tomlinson M, Boulton A (2008) *Subsurface Groundwater Dependent Ecosystems: a Review of their Biodiversity, Ecological Processes and Ecosystem Services. Waterlines Occasional Paper Rep. No. 8.* National Water Commission, Canberra, ACT

Trueman W (2007) *Some Recollections of Native Fish in the Murray-Darling System with Special Reference to the Trout Cod Maccullochella macquariensis.* Native Fish Australia (Victoria) Incorporated

Trust for Nature (2013) *The Statewide Conservation Plan for Private Land in Victoria.* Trust for Nature

Victorian Auditor General (2010) *Sustainable Management of Victoria's Groundwater Resources.* Victorian Auditor General's Office, Melbourne

Victorian Auditor General (2013) *Management of Freshwater Fisheries.* Victorian Auditor-General's Office

Victorian Catchment Management Council (2012) *Catchment Condition and Management Report 2012.* Victorian Catchment Management Council

Victorian Environmental Assessment Council (2011) *Remnant Native Vegetation Investigation.* Victorian Environmental Assessment Council

VNPA (2011) *Riverside Rescue – Solutions for Riparian Land in Victoria.* Victorian National Parks Association, Melbourne

Vörösmarty CJ, McIntyre P, Gessner M, Dudgeon D, Prusevich A, et al (2010) Global threats to human water security and river biodiversity. *Nature* 467: 555-61

Walker KF, Sheldon F, Puckridge JT (1995) A perspective on dryland river ecosystems. *Regulated Rivers: Research & Management* 11

Ward J, Palmer M (1994) Distribution patterns of interstitial fresh-water meiofauna over a range of spatial scales, with emphasis on alluvial river aquifer systems. *Hydrobiologia* 28: 147-56

Wells F, Newall P (1997) *An Examination of an Aquatic Ecoregion Protocol for Australia.* Australian and New Zealand Environment and Conservation Council Canberra

Western Coastal Board (2002) *Skenes Creek to Marengo coastal action plan.* Western Coastal Board, Geelong

Williams L, Hale1 R, Reich P, Lake S (2010) *Ecological Benefits of Riparian Restoration – With Particular Application to Victoria.* Riverside Rescue. Victorian National Parks Association, Melbourne

5. Environmental Governance

A GUIDE TO CHAPTER 5

The focus here is environmental governance issues that underpin problems faced across all environments. Environmental governance is the system of laws, implementation mechanisms, accountability regimes, and institutional arrangements necessary for environmental protection and conservation of biodiversity. Governance is not the same as government – it also encompasses actors such as communities, businesses, and NGOs – but the focus here is primarily the Victorian government, for it is the primary administrator of the laws, policies and programs that influence people's actions in the Victorian environment.

There is a particular focus on modernising and integrating environmental laws and developing optimal institutional arrangements for environmental regulation and management. Some areas of reform essential to all environments considered in previous chapters, such as adapting to climate change, protecting threatened biodiversity and managing invasive species, are also considered.

Section 5.1 outlines the patterns of governance failings in Victoria and section 5.2 outlines the priority reforms needed for environmental laws, institutional structures and processes, federal involvement in protected areas, planning, climate change adaptation, funding and knowledge. Section 5.3 identifies and describes five priority landscapes for nature conservation and section 5.4 summarises the recommended reforms.

Topics covered

5.1 Governance flaws

5.2 Governance reform priorities

- Laws
- Institutional structures and processes
- Federal-state relations on protected areas
- Planning and priorities
- Climate change adaptation
- Funding
- Knowledge needs

5.3 Priority landscape clusters

5.4 Future directions

5.5 Sources

5.1 GOVERNANCE FLAWS

Victoria has the knowledge, wealth and capacity to arrest most current threats to nature and restore environmental health, and there are compelling social, economic and ethical reasons to do so. Climate change, with its likely catastrophic impacts on economic, social and environmental health, amplifies the imperative.

The current backward trajectories on multiple environmental issues are a result of flawed governance systems as well as wilful anti-environmental choices. From the previous three chapters, and from many other analyses such as audits by the auditor general (table 5.1) and state of the environment reports, there emerges a consistent pattern of failures to effectively establish and implement the processes and measures needed to achieve environmental objectives, such as comprehensive planning, meaningful target-setting, risk assessments, adequate data collection and monitoring, relevant performance reporting, robust enforcement and sufficient funding. Following is a brief outline of aspects and examples of this pattern of governance failings, some of which are analysed in more detail in subsequent sections.

Lack of integration: The 2010 draft state biodiversity strategy *Biodiversity is Everybody's Business*, shelved by the current government, acknowledged that the 'biodiversity sector currently lacks [an] integrated approach, leading to fragmented decision-making and conflicting objectives.'[1] The 2009 land and biodiversity white paper, *Securing our Natural Future*, is probably the closest a Victorian government has come to an all-of-government approach to biodiversity but it has never been implemented.[2] *Australia's Biodiversity Conservation Strategy 2010-2030* says that 'by 2015, all jurisdictions will review relevant legislation, policies and programs to maximise alignment with the strategy.[3] Instead of alignment and integration, there has been an increasing rollback of environmental objectives in favour of commercial and political goals.

Integration of sustainability objectives across government programs is also lacking. A 2008 audit by the commissioner for environmental sustainability found that integration of the principles of environmental sustainability within core policies and programs across government had been 'limited'.[4] Only 7% of agencies audited had any processes in place to integrate sustainability into policy development processes. 'Many agencies discussed the absence of explicit and/or sophisticated consideration of the environment within common whole-of-government decision-making processes,' the commissioner noted.

Poor leadership and coordination: Over the past five years, Victoria's auditor general has reported many instances of poor environmental leadership and lack of coordination. An audit on management of invasive species in national parks found that governance arrangements were complicated and poorly coordinated – there was no single point of focus for oversight or to take responsibility for success or failure.[5] On marine biosecurity, there had been poor coordination between the environment and primary industries agencies, and there was no evidence of a detailed operational plan to coordinate responses to new incursions.[6] On soil health, a lack of coordination had led to a patchwork of unaligned and fragmented projects.[7] On managing recreational fisheries, there had been a failure to engage with natural resource managers and peak conservation groups, with consultation and decision-making biased towards recreational fishing interests.[8] Although the new departmental structure merging the environmental and primary industries agencies into the Department of Environment and Primary Industries provides the potential for better coordination across government, it is likely to result in the greater subsuming of environmental priorities in favour of resource exploitation. A new structure is needed (section 5.2.2).

Weak laws: Although many of Victoria's environmental problems could be resolved by effective implementation of existing laws, the system of laws is fragmented and outdated, and there are many gaps (section 5.2.1). They have not been updated to incorporate advances in scientific concepts and community attitudes or to respond to growing threats to the environment. They are deficient in mechanisms to promote accountability, transparency, public participation, and integration of environmental functions across government.[9] Instead of addressing these shortcomings, the current state government has dismissed essential environmental safeguards as inconvenient 'green tape' and further weakened environmental law – to allow commercial development in national parks, entrench logging of native forests and facilitate clearing of native vegetation.

Inadequate enforcement: A 2012 audit by Victoria's auditor general found major systemic failings in compliance monitoring and enforcement of environmental laws by the environmental and primary industries agencies. Neither had a comprehensive, risk-based approach to compliance or clarity about how compliance activities contributed to achieving legislative objectives (section 5.2.1).

Limited planning: Turning broad environmental objectives into outcomes needs to be mediated by planning to develop clear targets and performance indicators and specify strategies and measures to achieve them. There is a particular paucity of planning in environmental domains, with the most startling deficiency being the lack of a current biodiversity strategy for the state, despite it being a requirement under the Fauna and Flora Guarantee Act (section 5.2.4). The 2010 draft strategy acknowledged a lack of clarity regarding the state's biodiversity targets and goals. [10] The 2012 Catchment Condition and Management Report found that the lack of 'long-term goals and targets for land and water condition...remains a critical weakness', and the 2013 state of the environment report found 'there is no clear articulation of statewide priorities and objectives for managing the state's natural resources' and an absence of targets.[11]

The auditor general has identified many examples of planning failure: the lack of a strategic plan to identify priorities, policies and guiding principles for managing recreational freshwater fishing;[12] outdated plans for invasive species management in national parks that lacked detail and did not address new and emerging threats;[13] the lack of a policy to direct management of the marine environment and lack of detailed action plans for marine protected areas;[14] and ad hoc planning for management of contaminated sites.[15] In 2012, the management plans for about a third of protected areas managed under the National Parks Act were at least 15 years old.[16]

Inadequate data: Knowledge of Victorian biodiversity is deficient in many areas, including the conservation status and trends of many species, and the effectiveness of management techniques.[17] Areas in particular need of improved monitoring, evaluation and reporting are the national vegetation management framework and vegetation offsets, threatened taxa and ecological communities, invasive species, and management of reserves.[18] In several audits, the auditor general has identified major deficiencies in monitoring, and data collection and management. The information base for recreational fishing was 'neither comprehensive nor robust'; Parks Victoria data for invasive species management was 'inadequate and increasingly out of date'; and there was no marine pest monitoring system to detect marine biosecurity incidents.[19] The 2009 Victorian Bushfires Royal Commission highlighted a need for better knowledge of the ecological impacts of different fire regimes.[20] The Catchment Management Council found that processes for assessing the condition of land and water resources and the effectiveness of protection measures, were 'either absent or insufficient'.[21] The council stressed the need for an independent body to report annually on progress toward achieving robust processes for assessing the condition of land and water resources. The 2013 state of the environment report highlighted the need for a 'systematic, environmental data collection plan'.[22]

Limited disclosure: It is not possible to gain a clear understanding of the state government's environmental performance from its public reporting. Although the Flora and Fauna Guarantee Act requires annual reporting on the progress made towards achieving its conservation and management objectives, a lack of data and reporting led the auditor general to conclude it was not possible to determine whether the primary objectives were being achieved (section 5.2.1).[23] In a 2013 audit, the auditor general found that the Department of Environment and Primary Industries reported on only a subset of performance indicators and primarily on outputs and activities rather than outcomes. Reporting processes do not provide confidence in the consistency and reliability of reported performance information.[24] State agency performance measures in the annual budget papers are not linked to longer-term environmentally meaningful measures in state of the environment or catchment condition reporting. For example, budget paper indicators for the performance of land management relate to the area managed, asset condition, visitor numbers, area treated for invasive species, which are too limited or bear too little relationship to environmental outcomes to give a true picture of the effectiveness of conservation programs.[25]

Low commitment and priority: The preceding problems with governance are all symptomatic of a low level of political commitment to the state's environmental objectives, particularly when they are perceived to be in conflict with economic goals. Victoria has a multitude of admirable environmental objectives and has achieved much in the half century or so in which there have been environmental-specific governance structures. But the current governance failings leading to backward environmental trajectories will continue unless the environment is accorded much higher priority within government. The low priority is exemplified by the lack of a current biodiversity strategy (section 5.2.4) and the failure to modernise the 25 year old Flora and Fauna Guarantee Act. A 2002 departmental review found it needed a major overhaul but its recommendations continue to be ignored more than a decade later, and 2009 recommendations by the auditor general have similarly been ignored.[26] In other examples, the auditor general found that the Department of Primary Industries prioritised the interests of recreational fishers over sustainability objectives of the Fisheries Act and that protecting fossil fuel industries has been prioritised over fostering renewable energy and reducing greenhouse gas emissions. [27] Protecting feral deer for hunters has been prioritised over protecting the environment and agriculture from deer damage; subsidised logging of native forests has been prioritised over protecting forests and preventing the extinction of Leadbeater's possum, and a yearly burn target that does little to improve public safety has been prioritised over ecologically sustainable fire regimes. Inadequate funding for essential environmental functions (section 5.2.6) is another symptom of low commitment.

Table 5.1 Some audits by Victoria's auditor general with an environmental focus in the past five years[28]

Topic (year)	Audit focus	Findings
Performance reporting (2013)	The effectiveness of public performance reporting by Department of Environment and Primary Industries, Environmental Protection Authority and Parks Victoria	• Reporting only on a subset of performance indicators • Reporting on mainly outputs and activities rather than outcomes • Inadequate data selection, data management, reporting controls and processes
Recreational freshwater fishing (2013)	Whether the Department of Primary Industries is managing recreational freshwater fisheries in an ecologically sustainable manner	• Failure to deliver balanced and sustainable outcomes for recreational freshwater fisheries • Insufficient focus on conservation of ecological processes, habitats and supporting ecosystems in fisheries
Compliance (2012)	The effectiveness and efficiency of compliance activities within the environment, primary industries and natural resources sectors	• Lacking a comprehensive risk-based approach to compliance responsibilities • Failure to identify how compliance activities contribute to achieving legislative objectives and corporate outcomes, how to measure success, and how to monitor and report compliance performance
Contaminated sites (2011)	How contaminated and potentially contaminated sites are managed	• Ineffective management of contaminated sites
Marine protected areas (2011)	The environmental management of marine protected areas	• No evidence to show that marine biodiversity is being protected • Little environmental management activity is evident, pointing to systemic weaknesses with planning, program management and resource allocation
Renewable energy (2011)	Whether the development of renewable energy has been facilitated effectively	• Efforts to increase the proportion of electricity generated from renewable sources have been ineffective • Growth in the state's capacity to generate renewable energy is not on track to meet future targets
Invasive species in national and state parks (2010)	The effectiveness of invasive plant and animal pest programs in Victoria's national and state parks	• Good progress in managing some invasive species in some parks, but generally unclear how well invasive species threats are being managed in national and state parks
Soil health (2010)	How effectively and efficiently soil health programs have been implemented across private land	• Focus has been on delivery of outputs rather than achievement of outcomes • Soil health outcomes are not measured in any meaningful way, it is unknown whether soil health programs have improved the health of Victoria's soil
Groundwater (2010)	Whether the use of groundwater resources is sustainable	• Inadequate groundwater monitoring, and delayed development and implementation of management tools • Insufficient data to know whether groundwater use is sustainable
Hazardous waste (2009)	Whether the EPA's control and regulation of hazardous waste has reduced inappropriate disposal	• Ineffective regulation of industry's management of hazardous waste • Monitoring and inspection activities lack coherence, purpose and coordination; data management, analysis and reporting are poor
Flora and Fauna Guarantee Act (2009)	How effective administration of the Flora and Fauna Guarantee Act has been in preserving the state's native flora and fauna	• Patchy data indicates that act has not achieved its primary objectives • Tools available under the act are not being used. • Lack of data to determine if the conservation status of threatened species has improved because of their listing under the act.

Note: These audits are not all relevant to nature conservation but are useful to indicate systemic governance weaknesses.

5.2 G0VERNANCE REFORM PRIORITIES

5.2.1 Environmental laws

'The principles underpinning biodiversity law have not been updated in over twenty years, in which time our understanding of environmental systems has continued to move on, especially in light of climate change pressures.'

Environment Defenders Office (Victoria), 2014[29]

Modernising and integrating environmental laws

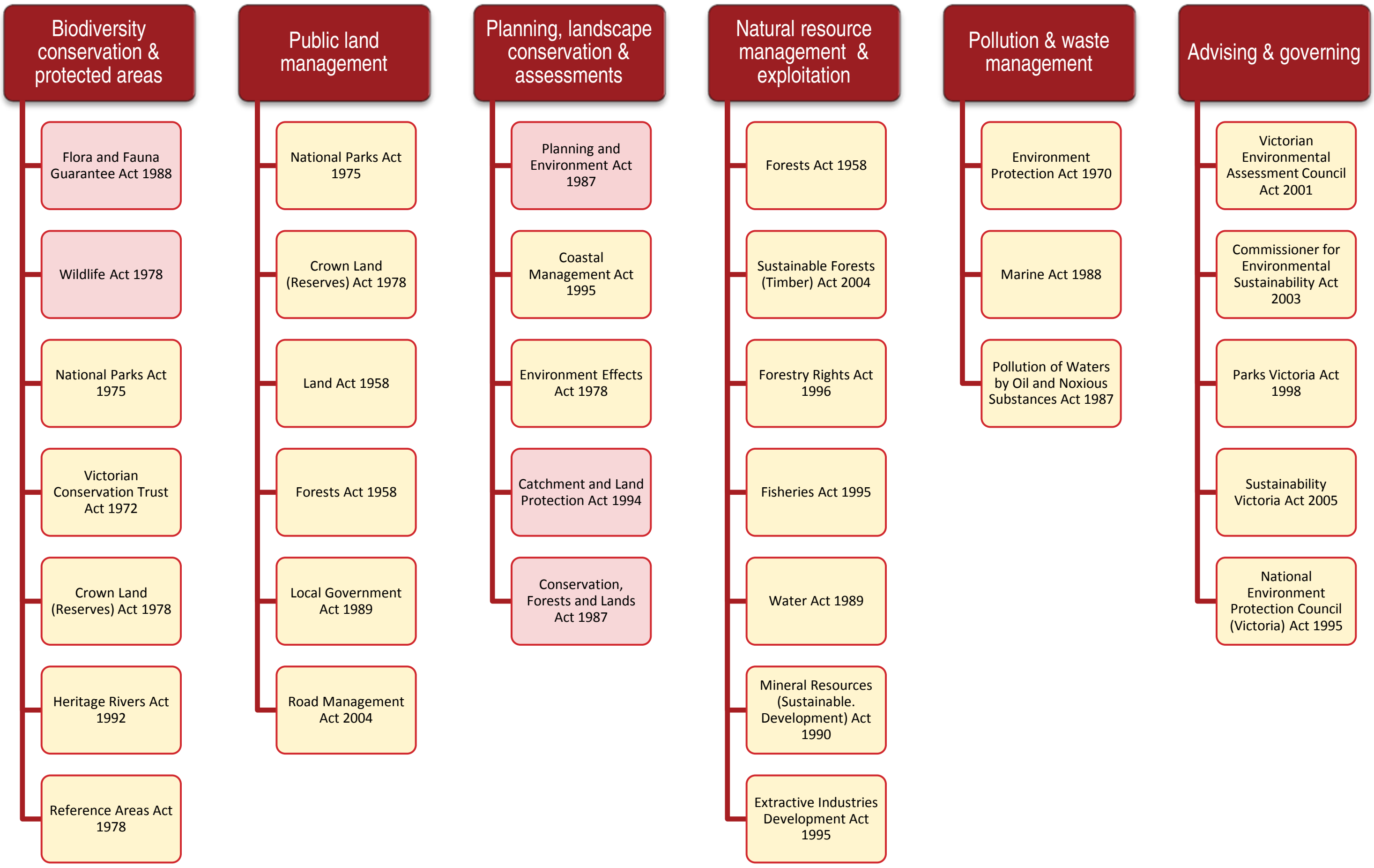
Outdated, complex, fragmented and failing, Victoria's various laws for nature conservation need updating, strengthening and integrating. They result from an 'incremental accumulation of different legislative regimes rather than any attempt to consider how it should all fit together and work effectively' (Figure 5.1).[30] The entire system is fragmented, says the Victorian Competition and Efficiency Commission.[31] Other deficiencies include a lack of clear objectives and modern conservation principles, a failure to address cumulative impacts, and too much discretion for decision-making that is inconsistent with conservation objectives.[32] Clearly, Victoria's conservation laws need an overhaul to provide a robust basis for protecting nature and optimising resilience in the face of climate change and other growing threats.

To modernise Victoria's environmental law system, this review recommends reviewing, strengthening and integrating some existing laws, particularly those relevant to protection of native vegetation and biodiversity. It would incorporate the Flora and Fauna Guarantee Act, the Wildlife Act, provisions of the Planning and Environment Act relevant to native vegetation management, the Conservation, Forests and Lands Act, and part of the Catchment and Land Protection Act (with biosecurity elements of the latter being incorporated into a proposed strengthened new Biosecurity Act).

The new legislation should:[33]

- function as a clear public statement about the importance of biodiversity conservation and ecological sustainability
- define clear overarching principles that build upon ecologically sustainable development (ESD) to include principles and duties around ecological integrity, adaptive management, evidence-based decision-making, collaborative decision-making, integrated planning and action, accountability and proportionality
- provide a framework for developing, implementing and evaluating strategies and plans at appropriate temporal and spatial scales, and effective instruments for implementing them
- provide clarity about the roles and responsibilities of different agencies and organisations
- guarantee monitoring, evaluation, accountability and public participation
- require public reporting on performance, including on outcomes for relevant regulations, policies and plans, and compliance and enforcement.

Figure 5.1 The complexity of Victoria's system of environmental and sustainability laws, including the laws proposed for review and partial or full integration into a Victorian Environment and Conservation Act



Note: This is not a comprehensive list of all relevant laws, and some are placed in more than one category. The laws proposed for review and integration into the proposed Environment and Conservation Act are marked in pink. It is proposed to include only the vegetation provisions of the Planning and Environment Act and the non-biosecurity elements of the Catchment and Land Protection Act.

Table 5.2 Proposed changes to environmental laws

	Biodiversity conservation	Vegetation protection	Catchment planning	Landscape management	Biosecurity	Marine & coastal
Existing laws	Flora & Fauna Guarantee Act Wildlife Act	Planning & Environment Act (part)	Catchment & Land Protection Act (part)	Conservation, Forests & Lands Act (part)	Catchment & Land Protection Act (part)	Coastal Management Act
Proposed strengthened new laws	Environment and Conservation Act				Biosecurity Act	Marine & Coastal Planning & Management Act

Conserving threatened biodiversity

[The] legal powers to protect threatened species set out in the [Flora and Fauna Guarantee] Act are almost never used, and … both the FFG Act and the Wildlife Act are administered without transparency or accountability.

Environment Defenders Office (Victoria), 2012[34]

The Flora and Fauna Guarantee Act offers some powerful tools but suffers from extremely poor implementation, as documented in a 2009 audit by the auditor general and a 2012 analysis by the Environment Defenders Office (Victoria).[35]

The FFG Act provides a framework for the protection of threatened biodiversity and mitigation of threats. The first object is the 'guarantee' for Victoria's flora and fauna (Box 5.1), worthy of striving for, according to the law's designers, because 'the employment of any lesser concept is to give advance warning of our intention to fail'.[36] The FFG Act operates in conjunction with the Wildlife Act, whose objects include promoting the conservation of wildlife, prevention of extinction and sustainable use of and access to wildlife.

Box 5.1 Objectives of the Flora and Fauna Guarantee Act

a) to guarantee that all taxa of Victoria's flora and fauna ..... can survive, flourish and retain their potential for evolutionary development in the wild

b) to conserve Victoria's communities of flora and fauna

c) to manage potentially threatening processes

d) to ensure that any use of flora or fauna by humans is sustainable

e) to ensure that the genetic diversity of flora and fauna is maintained

f) to provide programs:

- of community education in the conservation of flora and fauna
- to encourage co-operative management of flora and fauna through, amongst other things, the entering into of land management co-operative agreements under the *Conservation, Forests and Lands Act 1987*
- of assisting and giving incentives to people, including landholders, to enable flora and fauna to be conserved

(g) to encourage the conserving of flora and fauna through co-operative community endeavours.

Victoria's auditor general found that the environment department was not using most of the processes and measures available under the FFG Act and that it no longer provided 'an effective framework' for conservation of native flora and fauna'.[37] The 'patchy' data available indicated to the auditor general that its primary objectives were not being achieved.

Listing threatened species and ecological communities under the FFG Act is a first step for their protection and recovery. As of June 2013, 667 taxa and communities were listed as threatened (Table 5.3). Although this is a grim figure, it does not represent a genuine measure of threatened biodiversity. Listings are not systematic or independent and rely on nominations – these days mostly from members of the public (government officers were responsible for most nominations in earlier years).[38] The environment department also maintains advisory lists of species considered threatened, on which there are almost twice as many taxa (1087, see Table 5.3). The department has been unable to determine the conservation status for 350 species on the advisory lists because there is too little information about them.

Contrary to the promise implicit in the name of the FFG Act and in the objects, listings seem to guarantee very little. The FFG Act requires that an action statement be developed 'as soon as possible' for each listed species, ecological community and potentially threatening process. Action statements are brief management plans 'designed to apply for three to five years, after which time they will be reviewed and updated'.[39] More than half (57%) of listed species and communities lack any action statement and more than two-thirds (69%) of threatening processes lack one. Most action statements have not been reviewed within the specified timeframe. In 2009 the auditor general found that at the then-rate of progress, with existing resources, it would take 22 years to complete action statements for listed entities. An average of just 15 were approved each year from 1991 to 2008, and the rate has dropped since then to an average of less than five a year, at which rate (with no extra listings) it will take more than 80 years to complete action statement. However, a court case brought by Environment East Gippsland in 2013 seeking to compel the government to prepare action statements for four threatened species (glossy black cockatoo, long-nosed potoroo, large brown tree frog and eastern she oak skink) that had been without action statements for more than a decade resulted in the government developing a three-year plan to finalise many more action statements.[40] However, once an action statement has been prepared, there is no guarantee it will be implemented. Recommended measures are generally not legally binding. However, the code of practice for timber production does require timber harvesting to comply with measures specified in action statements.[41] The auditor general found that there were no appropriate performance measures to indicate whether the actions in action statements had been effective.

Table 5.3 Threatened biodiversity and threatening processes: advisory and formally listed under the Flora and Fauna Guarantee Act[42]

	Extinct (advisory lists)(1)	Threatened (advisory lists)(2)	Data deficient (advisory lists)	Listed under the FFG Act June 2013	Number of action statements	Listed entities with no action statement June 2013 (%)
Mammals	19	38	5	40	27	33
Birds	2	128	0	78	40	49
Reptiles	1	42	4	29	11	62
Frogs	0	15	3	11	4	64
Fish	3	32	1	25	12	52
Invertebrates	6	134	38	72	28	61
Vascular plants	49	745	228	350	148	58
Non-vascular plants	2	28	77	20	0	100
Fungi & lichens	0	5	0	3	0	100
Ecological communities	-	-	-	39	17	56
Total	82	1087	356	667	287	57
Threatening processes	-	-	-	42	13	69

Source: Department of Sustainability and Environment, Department of Environment and Primary Industries. Notes: (1) The most recent government advisory lists were published for plants in 2005, for invertebrates in 2009 and for vertebrates in 2013. Extinct includes extinct over the entire range, extinct just in Victoria and extinct in the wild (where a species survives in captivity). (2) This excludes rare and data deficient but includes near threatened.

The listing process is compromised by a lack of up-to-date scientific data. Much of the information on threatened species is over 20 years old, and information on marine invertebrates is particularly scant. There is limited information on the condition of most of Victoria's flora and fauna. The auditor general also commented on the limited stakeholder participation and a lack of expertise in biodiversity due to reductions in research staff.

Several essential tools for conservation provided by the FFG Act are not used. Although the FFG Act requires a Flora and Fauna Guarantee Strategy the one and only strategy is 17 years old and obsolete. The declaration of 'critical habitat' provides a legal basis for protecting the habitat of a threatened species but has been used just once in the 25 year history of the FFG Act and was revoked soon after. This failure leaves the FFG Act 'substantially weakened, particularly as it relates to private land'.[43] The government has never used its capacity to issue 'interim conservation orders' to protect critical habitat. Although they are powerful tools that should be used, they are also limited by a requirement for compensation for financial loss suffered due to the making of the order. Much more reasonable would be to require compensation only if the order requires actions beyond what could be expected under a duty of care, or to remove the compensation clause, as is the case for stop work orders and interim protection orders under NSW's national parks and threatened species laws.[44]

However, the government has used its powers to undermine protection for biodiversity by creating orders (legally binding instruments under the FFG Act setting out exemptions or additional requirements), including the Flora and Fauna Guarantee (taking, trading in, keeping, moving and processing protected flora) Order 2004, which removes protection for most threatened plants on private land, and the Flora and Fauna Guarantee (Forest Produce Harvesting) Order No. 2/2004, which authorises the taking of protected flora in state forests and on crown land where it results from or is incidental to harvesting operations or associated road works.[45]

The FFG Act requires the department's annual report to report on progress in implementing the flora and fauna conservation and management objectives but this is ignored.

Permits and licences to take species under the Wildlife Act are 'rarely refused', there is no publicly available data on the degree of compliance with conditions, and 'it does not appear that [the environment department] conducts any compliance monitoring of permits'.[46] Undermining the conservation goals of the Wildlife Act, some damaging invasive species – feral deer in particular – are protected for the benefit of hunters, resulting in a massive increase in deer populations and environmental and agricultural damage (section 3.4.2). Feral deer receive more protection than some native species exempted from protection under the Wildlife Act in some regions (wombats, long-billed corellas, sulphur-crested cockatoos, galahs and brushtail possums).[47]

Compliance monitoring and enforcement under both laws have been 'very limited'.[48] There is no policy or strategy, and no reporting of such activity specific for each act.

A 2002 review by the department found that the Flora and Fauna Guarantee Act was in need of an overhaul. More than a decade later, nothing has been done and the act is in even greater need of reform. The auditor general and the Environment Defenders Office have each made several recommendations, which VNPA endorses. These changes can be made through the incorporation of the FFG Act into the proposed Environmental and Conservation Act. Essential reforms include addressing the deficiencies identified here: improving the listing and recovery planning processes for threatened species and ecological communities to ensure they are systematic and reflect biological reality and ensuring that tools such as critical habitat determinations and interim conservation orders are used as intended.

However, the focus of biodiversity legislation also needs to expand, with new objectives, principles and tools to more effectively protect biodiversity and ecological processes to foster resilience and adaptation to climate change (addressed below).

Managing invasive species

Invasive species laws in Victoria are under review as a result of national reforms to biosecurity. An Invasive Species Management Bill is proposed for introduction into parliament in 2014. Comments were sought on a discussion paper in 2012 but the government has rejected most of the feedback received and no further opportunities for input will be offered prior to the legislation being introduced into parliament.

Australian biosecurity was long focused primarily on protecting agriculture, and although the focus now encompasses the natural environment, the approach and institutional arrangements are still dominated by agricultural priorities and approaches. Biosecurity regulation and policy have been primarily administered by the agricultural agency while the environmental agency attempts to manage some of the environmental consequences of an increasing flow of invasive species into Victoria. Because biosecurity is of extremely high priority to both the agricultural and environmental sectors, the most rational institutional arrangement is a joint agricultural-environmental biosecurity unit. The environment minister and environmental staff should have primary responsibility for decisions, policy and programs for environmental biosecurity.

Although Victoria's environment is already heavily burdened with invasive species, the Victorian government guarantees a growing problem by an inadequate focus on prevention. Only a small subset of the 30,000 or so exotic plant species in Australia have been assessed for their invasive risk in Victoria, and only about 120 are declared noxious weeds (requiring control and/or restricting sale and movement). Rather than banning just a few high priority species, Victoria needs to move to a permitted list approach, which prohibits the introduction of plants into Victoria unless they have been assessed as 'safe' (at low risk of becoming invasive). This includes plants native to Australia but not indigenous to Victoria. The declaration of pest species should be systematic and efficient, based on criteria consistent with principles of ecological sustainability and advice by a scientific committee that includes ecologists and other environmental experts.

As one of Victoria's most important environmental laws, the biosecurity legislation should include best practice environmental tools. A broad duty of care requirement is important because there is no way of explicitly regulating all actions potentially leading to invasive species impacts and one person's irresponsible action with an invasive plant or animal can ultimately have adverse impacts across vast areas for centuries to come. A legal obligation needs to be complemented by public education to motivate a more serious approach to biosecurity akin to that of hygiene and public health. The precautionary principle is of fundamental importance for environmental biosecurity because of the prevalent high levels of uncertainty about invasive species impacts in the natural environment, the long timeframes over which invasions occur and the often-limited management options. Because of the importance of community involvement for effective biosecurity, there needs to be meaningful engagement of the community (including the environmental sector) in biosecurity processes, transparency in decision-making and open legal standing to enforce biosecurity laws.

Adapting laws for climate change

Adapting environmental laws for climate change requires both doing much better what is already needed to conserve nature under existing pressures and adopting new approaches. Here are some principles for optimising environmental laws for climate change, adapted from five principles advocated by Robin Craig (Box 5.2), and given more context in section 5.2.5 on climate change.

Box 5.2 Five principles for climate change adaptation law[49]

'Altering the basic paradigms of environmental and natural resources law …to a paradigm of increasing resilience and adaptive capacity, based on assumptions of continuing, unpredictable, and nonlinear change, will necessarily require different kinds of legal amendments, and perhaps even new laws, for different regulatory contexts.'

Robin Craig, 2010[50]

- Monitor and study everything all the time.
- Eliminate or reduce non-climate change stresses and otherwise promote resilience.
- Plan for the long term with much increased coordination across media, sectors, interests, and governments.
- Promote principled flexibility in regulatory goals and natural resource management.
- Accept – really accept – that climate change adaptation will often be painful.

Promote resilience and adaptation options: A fundamental principle of resilience is to eliminate or reduce other stresses on nature and optimise environmental health (section 5.2.5). All environmental laws should have resilience objectives. It requires going beyond saving species and ecological communities from extinction to optimising conditions for their long-term viability. Fostering natural adaptation will require protecting refugia and ecological processes, such as pollination, seed dispersal and species movement, that assist in adaptation. As discussed in chapter 2, it requires amending planning laws to protect sites for inland retreat of coastal habitats as sea levels rise. It requires stronger protection for habitats across marine, terrestrial and freshwater habitats, and private and public tenures.

Promote principled flexibility in regulatory goals and natural resource management: Principled flexibility means that laws and regulators 'implement consistent principles for an overall climate change adaptation strategy, even though the application of those principles in particular locations in response to specific climate change impacts will necessarily encompass a broad and creative range of adaptation decisions and actions'.[51]

Require a long-term focus to account for climate change over ecologically relevant timeframes: Examples of where a long-term focus is essential include decisions relevant to coastal developments likely to be inundated by sea level rises or that compromise inland retreat, introduced species likely to become invasive under future climates, and resources such as water likely to become scarcer under climate change. The precautionary principle is essential because too little is known to predict many future changes. A range of possible long-term futures should be considered.

Require research and monitoring to inform adaptation measures: Because information is essential to effective and adaptive management, research and monitoring should a legal requirement.

Compliance monitoring and enforcement

The overall extent of enforcement and compliance with the native vegetation regulations is unknown because data on compliance is not collected and reported. However… there was a widespread view that illegal clearing is occurring, and that many individuals and businesses are failing to comply with offset agreements.

Victorian Competition and Efficiency Commission, 2009

Laws are generally effective only if enforced. A 2011 audit by the auditor general found systemic failings in compliance monitoring and enforcement of environmental laws by the then departments for primary industries and environment.[52] Neither department had a comprehensive, risk-based approach to compliance: they had not clearly identified how compliance activities contributed to achieving legislative objectives, how to measure success, or how to report compliance performance. In other audits, the auditor general found deficient compliance monitoring and enforcement for management of contaminated sites and groundwater.[53] Vegetation regulations have also been pooly enforced. In 2009 the Victorian Competition and Efficiency Commission found that the extent of non-compliance was not monitored or reported although illegal clearing was widely assumed to occur. The Municipal Association of Victoria said that 'significant resource constraints' and 'features of the regulatory framework' made it difficult for councils to undertake enforcement.[54]

VNPA endorses the auditor general's recommendations on compliance and enforcement. Environmental agencies should develop and publish a compliance monitoring and enforcement policy for all environmentally relevant legislation, and comprehensively and publicly report on enforcement activity and outcomes for each law and regulation.

A 2011 independent review of Victoria's Environmental Protection Authority (EPA) highlighted the importance of organisational culture, leadership, systems, procedures and training for effective compliance and enforcement.[55] Two major investigations (in 2009 by the ombudsman and 2010 by the auditor general) found that the EPA was failing to meet its statutory duties – it had a weak regulatory system and a culture which did not facilitate enforcement. The 2011 review highlighted the concern that 'EPA had been too close to industry'. A concerted attempt is now being made to turn the EPA into a 'modern regulator', which will require 'rigour and discipline in decision making and the policies and procedures that underpin this'.[56] The reviewer proposed eight principles for effective enforcement and compliance measures:

- targeted (to prevent the most serious harm)
- proportionate (proportionate to the problem they seek to address)
- transparent (to promote the sharing of information and build credibility)
- consistent (so that similar circumstances and breaches lead to similar enforcement outcomes)
- accountable (decisions will be explained and open to public scrutiny)
- inclusive (engage with community, business and government to promote environmental laws, set standards and provide opportunities to participate in compliance and enforcement)
- authoritative (set clear standards and be an authoritative source of information)
- effective (seek to prevent environmental harm and impacts to public health and improve the environment).

Independence of enforcement functions from potentially conflicting roles in government such as policy formulation and industry support is essential for effectiveness and credibility. This is best achieved by establishing an independent Environmental Regulator (as recommended in section 5.2.2).

5.2.2 Institutional structures and processes

Given the complexity and breadth of environmental issues and the potential for conflicts of interest over environmental functions, it is important to optimise government structures to deliver high priority environmental outcomes. The recent merging of the environmental and primary industries agencies to form the super-agency Department of Environment and Primary Industries could improve coordination but is likely to facilitate greater domination of the environment by production and economic interests. Even as a standalone department, the previous environment department was often unable to fulfil its statutory obligations because of a lack of political support, poor internal processes and inadequate resources. This will be exacerbated by its inclusion in the department that also manages and promotes exploitation of natural resources, and merges resource management and regulatory roles. The Victorian Competition and Efficiency Commission noted the inherent conflict in combining policy and regulatory functions for vegetation management and forestry within the one agency.[57] Another structural flaw is that Parks Victoria, a separate authority with responsibility for management of protected areas, is unable to set its own policies and priorities, despite having the greatest knowledge of protected area management. Its priorities and targets are set by the Department of Environment and Primary Industries in a performance agreement.

A new structure is needed for Victoria's environmental and sustainability agencies to limit conflicts of interest and to better focus their work on meeting their obligations and community expectations. The following principles should apply:

- Define lines of responsibility so that each agency has clear objectives, functions and targets.
- Separate regulatory roles from policy setting and management to avoid conflicts of interest and foster impartial and consistent decision-making.
- Maximise the independence of environmental regulators to minimise interference.
- Embed ecological sustainability and biodiversity conservation as core principles for all government departments through their enabling legislation, mission statements and strategic plans.
- Establish accountability measures including transparency, regular reporting and independent audits of performance.

Recent changes to Victoria's Environmental Protection Authority, made as a result of critical reports by the ombudsman and auditor general, provide one potential model for limiting conflicts of interest.[58] The roles of chief executive officer and chairman of an independent board are separate (occupied by different people), with the chairman's role to set the standards and strategic direction for the authority, liaise with stakeholders and monitor the organisation's performance, including governance and risk management, and the CEO's role to manage the EPA and be responsible for statutory delegated decisions, risk management, financial and resourcing decisions and advising the chairman on issues of management.[59] An EPA advisory board reports to the environment minister. Other government agencies are responsible for policy, legislative reforms and supportive environmental programs.

Independent bodies play a very important role in Victoria's environmental governance, and mostly function very well. They may require only minor structural changes and more resources to function optimally. For example, as proposed in chapter 2, at least one third of board members of catchment management authorities encompassing coastal regions should have coastal or marine expertise and, as proposed in chapter 3, the role of the Victorian Environmental Assessment Council should expand to include investigations of private land conservation. Chapter 3 highlights the increasingly essential role of private land conservation in Victoria. This is often most effectively facilitated not by government but by independent community-focused bodies such as Trust for Nature, catchment management authorities and Landcare (they engender greater trust by landholders, who tend to view government with suspicion). Trust for Nature is well connected to the community and if properly resourced, could play a greater role in facilitating private land conservation, guided by its statewide conservation plan.

The role of the sustainability commissioner has had limited influence on the culture and performance of government agencies, and should be expanded to include a 'watchdog' focus: auditing and reporting on whether environmental law and policy objectives are being met, identifying priorities and policy goals, forecasting the impact of current activities and emerging trends, and investigating community concerns about significant environmental issues.[60]

Environmental and sustainability agencies

Figure 5.2 outlines a proposed new structure consisting of three state government agencies for delivery of conservation and sustainability functions, two independent regulators for native vegetation management and enforcement of environmental laws, an independent environmental audit office, and independent bodies for private land conservation, coastal and marine management, environmental investigations and catchment management (these include existing bodies). Their structure, role and main functions are outlined in more detail below.

Nature Victoria

Role: Conservation management and delivery.

Structure: A statutory government agency reporting directly to the environment minister (rather than through another department via a performance contract as is the arrangement for Parks Victoria).

Functions:

- Manage national parks, marine national parks and marine sanctuaries and other reserves under the National Parks Act.
- Deliver conservation programs.
- Develop and implement a state nature conservation strategy.
- Develop wildlife and threatened species policy and recovery and threat abatement plans.
- Manage Melbourne's parks, public foreshores and jetties.
- Undertake environmental data collection, monitoring and scientific research.
- Provide service support for the proposed Marine and Coastal Authority and the Environmental Regulator, including scientific advice, enforcement and logistical support.

Communities & Landscapes Victoria

Role: Landscape and risk management within an environmental framework.

Structure: A statutory government agency with its own minister.

Functions:

- Apply a broad environmental framework (eg the biodiversity strategy) to government activities.
- Coordinate effort across all tenures to tackle threats to the environment, productivity and human health and safety, including invasive species, bushfires, climate change, droughts and floods.
- Implement management programs, with a strong focus on prevention and early action (fires, invasive species, climate and floods).
- Prepare for emerging and future threats identified by the Environmental Audit Office.

Production Victoria

Role: Support for primary production within an ecological sustainability framework.

Structure: A statutory government agency with its own minister.

Functions:

- Set policy for natural resource activities (forestry, mining and fishing) on public land, within an ecological sustainability framework.
- Provide support, advice and guidelines for sustainable production (agriculture, fishing, forestry and mining) on private land.
- Support primary industries and their contribution to a thriving economy.

Environmental Regulator

Role: Compliance monitoring and enforcement of environmental regulations.

Structure: A statutory government authority, which incorporates and retains the structure of the Environmental Protection Authority, with a chair reporting to the environment minister, a chief executive officer, and an independent advisory board that also reports to the minister.

Functions (in addition to existing functions of the Environmental Protection Authority):

- Conduct compliance monitoring and enforcement of regulations for native vegetation, fishing, forestry, river and groundwater use, environmental aspects of mining, pollution and waste management.

- Regulate licencing under the Wildlife Act and Flora and Fauna Guarantee Act (or the equivalents under the proposed Environment and Conservation Act)
- Publicly report on compliance activities and outcomes.

Native Vegetation Regulator

Role: Operational functions of native vegetation management

Structure: An independent authority reporting to the environment minister.

Functions:

- Assess clearing applications.
- Oversee monitoring programs for native vegetation**.**
- Administer offset schemes.
- Provide expert advice for vegetation assessments and policy-making.

Environmental Audit Office

Role: Independent reviews of environmental performance (expanding the role of the sustainability commissioner by adding functions similar to those of Victoria's auditor general and increasing its independence).

Structure: Independent office of the parliament with the auditor appointed by a parliamentary committee and reporting directly to parliament.

Functions:

- Report to parliament on the condition of Victoria's natural environment via five-yearly state of the environment reports and other more frequent and specialist reports.
- Produce five-yearly state of the bays reports.
- Promote ecological sustainability and the adoption of sound policies by the state and local governments.
- Review the implementation of environmental legislation and policies.
- Hold inquiries based on complaints and self-initiated assessments.
- Undertake foresighting, including on future trends and emerging threats.
- Collate, manage and publicly disseminate environmentally relevant information.

Victorian Environmental Assessment Council

Role: Independent investigations on the protection and sustainable use of public and private land (expanding on the current scope of public land).

Structure: Council of five members appointed by the environment minister, with a community reference group to advise each investigation, reporting to the environment minister and parliament.

Functions (including current functions):

- Conduct assessments at the request of the environment minister.
- Conduct systematic bioregional assessments of landscape values on a rolling 10-year cycle.
- Investigate ecologically sustainable management of public and private land.
- Advance proposals for improving conservation of biodiversity.

Marine and Coastal Authority

Role: Integrated planning and management of marine and coastal areas.

Structure: A statutory independent body with a board with expertise including marine and coastal planning, protection and management. It would replace the Victorian Coastal Council and the three coastal boards, and structure its administration around five regions: South-west, Otway, Central (Port Phillip Bay and Western Port), West Gippsland and East Gippsland, the boundaries aligned with those of the coastal catchment management authorities.

Functions:

- Produce a marine and coastal strategy (a statutory planning instrument) that provides ecologically based parameters for all recreational and extractive activities including fishing, mining and aquaculture.
- Conduct statutory planning for public lands and marine areas.
- Manage marine areas outside marine national parks and marine sanctuaries.
- Coordinate responses to marine disasters.

Trust for Nature

Role: Facilitator of conservation on private land.

Structure: Statutory body with expertise-based independent board reporting to the environment minister.

Functions (including current functions):

- Provide covenant and stewardship services on private land.
- Manage Trust for Nature conservation reserves.
- Manage a revolving fund for purchase, covenanting and on-sale of properties.
- Manage the Land for Wildlife extension program
- Facilitate landscape conservation by supporting conservation management networks.
- Provide environmental market services such as offsets

Catchment management authorities

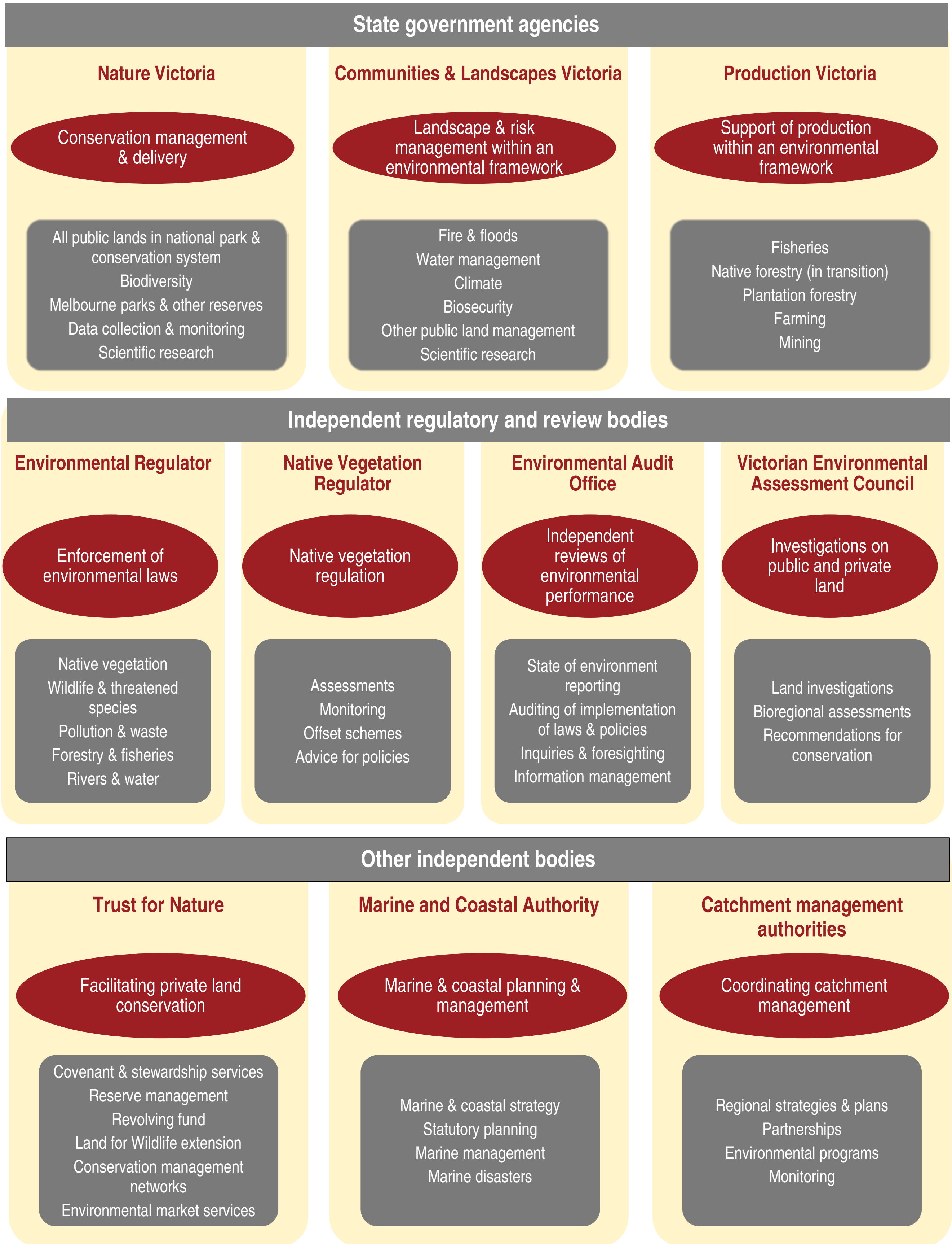
Role: Facilitation and coordination of the integrated and sustainable management of catchments.

Structure: Each with a board with up to nine members appointed by the environment minister.

Functions (including current functions):

- Set a strategic direction for regional land, water and biodiversity management.
- Develop partnerships with land managers, regional institutions, organisations, communities and local governments.
- Deliver programs that improve environmental condition and bring long-term environmental benefits**.**
- Monitor the outcomes and evaluate the effectiveness of programs.

Figure 5.2 Proposed structure for conservation and sustainability agencies and organisations



Local governments

Local governments have a pivotal role in regulating land use and environmental management, through the following functions:

- Planning: they determine land use and assess applications for development, subdivisions and vegetation clearing under the Planning and Environment Act.
- Land management: they own and manage substantial areas of high conservation value lands.
- Natural resource management and conservation programs: they administer or support bush regeneration and invasive species management programs, conduct community education and offer incentives for private land conservation.

Local governments' interest in and capacity for environmental management vary considerably – Hindmarsh Shire Council has a budget of $20 million for an area of 7530 km^2 with a population of 6000 while Melbourne City Council has a budget 20 times higher ($357 million) for an area 200 times smaller (38 km^2) with 105,000 residents and 430,000 visiting workers.[61]

Although local governments have major environmental responsibilities under state planning laws, they often lack access to sufficient expertise or resources to effectively fulfil their obligations. This is the case in many local government areas for native vegetation management (one reason for transferring decision-making about clearing applications to the proposed native vegetation regulator).[62]

Local governments also have insufficient conservation tools under the planning system. In particular, there is no conservation zone available for land located outside the public national park and conservation system. The rural conservation zone is the best available to restrict development but is inadequate for protection of high conservation value vegetation on private and council-owned properties. Local governments need a statutory mechanism under the planning system or local government laws to achieve permanent protection of council-owned lands with high conservation values as 'local conservation reserves'. There also needs to be greater alignment with catchment management planning, with local government plans incorporating and implementing catchment management planning priorities.

As the tier of government closest to the community, local governments have the potential to foster community involvement in environmental programs but conservation is often a low priority amongst many other responsibilities and demands on budgets. A national study in 1997 found that just 3% of local government expenditure was for conservation initiatives.[63] There are many ways the state government could encourage and support councils to play a greater role in environmental protection.[64] One useful model is the global Cities for Climate Protection program, which assists local governments to take 'local action for global sustainability and supports cities to become sustainable, resilient, resource-efficient, biodiverse, low-carbon; to build a smart infrastructure; and to develop an inclusive, green urban economy'.[65] Victorian councils could work with the community to develop and implement local biodiversity action plans. The state government should encourage this by offering matching funds for implementation of such plans.

5.2.3 Federal-state relations on protected areas

Although the major focus of this report is state level reforms, the federal government also has considerable influence through its environmental laws, policies and funding programs. It lacks a specific constitutional head of power for 'the environment', but has a substantial role through its constitutional responsibility for implementing international conventions such as the 1992 United Nations Convention on Biological Diversity and the 1971 Convention on Wetlands of International Importance. The Environment Protection and Biodiversity Conservation Act (EPBC Act) specifies matters for which it has assumed some regulatory responsibility, including world heritage sites, national heritage places, Ramsar wetlands, nationally threatened species and ecological communities, migratory species and Commonwealth marine areas. Despite a 10 year review in 2009 finding that the EPBC Act needed strengthening, the federal government has been weakening the law under an agenda to reduce so-called green tape.[66] The brief focus here is the federal government's role in national park management.

Despite the pivotal role of national parks in conservation (and despite the 'national' in their name), they are not a matter for which the federal government takes responsibility. The 1993 Intergovernmental Agreement on the Environment states that their management is largely the responsibility of the states. There is, however, a clear legal rationale for the federal government to have a greater role, as national parks help fulfil international obligations under the Convention on Biological Diversity. There is also the need for a Commonwealth role, particularly when state governments disregard their obligations to protect and effectively manage national parks. Currently, the federal government has no legal means to intervene unless some other matter relevant under the EPBC Act, such as a nationally threatened species, is affected by activities in a national park. Environment groups, including VNPA, have recommended that national parks become a 'matter of national environmental significance' under the EPBC Act.

Box 5.3 Australia's protected area obligations

As a party to the Convention on Biological Diversity, Australia agreed to establish a system of protected areas to conserve biodiversity; develop guidelines for the selection, establishment and management of protected areas to conserve biodiversity; promote the protection of all ecosystems, natural habitats; and manage land to maintain viable populations of species.

The national targets in Australia's Strategy for the National Reserve System 2009–2030 are to protect:

- examples of at least 80% of all regional ecosystems in each bioregion by 2015
- examples of at least 80% of all regional ecosystems in each sub region by 2025
- core areas for the long-term survival of threatened ecosystems and threatened species
- habitats in each of Australia's bioregions by 2030
- critical areas for climate change resilience, such as refugia.

There is also a rationale for the federal government to fund special management programs in the national park estate. Despite the extremely high conservation values of the national park estate, the federal government provides almost no funding to assist with their management, in part out of understandable concern that the states will engage in cost shifting if other funding is available for functions traditionally undertaken by state agencies. This could be avoided if funding was made available for 'above duty of care' initiatives or cross-border programs or for works to foster climate change adaptation under a Natural Icons Resilience Program proposed by VNPA. Protecting water flows in the Australian Alps would be a prime candidate for such funding (Box 5.4).

Box 5.4 Australian Alps catchments[67]

The high quality water flowing from the Australian Alps is of national importance. The average 3980 gigalitres of water delivered annually from the Victorian Alps to the Murray-Darling Basin were estimated in 2005 to be worth at least $4 billion, which means that the water flowing from all Australian Alps catchments (about 9600 gigalitres annually) would be worth, in 2005 terms, as much as $9.6 billion a year. These waters sustain the high mountain ecosystems, provide environmental flows for downstream rivers and help dilute salt- and silt-laden waters from Murray-Darling Basin catchments. Degradation of the alpine national parks could thus seriously undermine water quality, water yield and natural flow regimes.

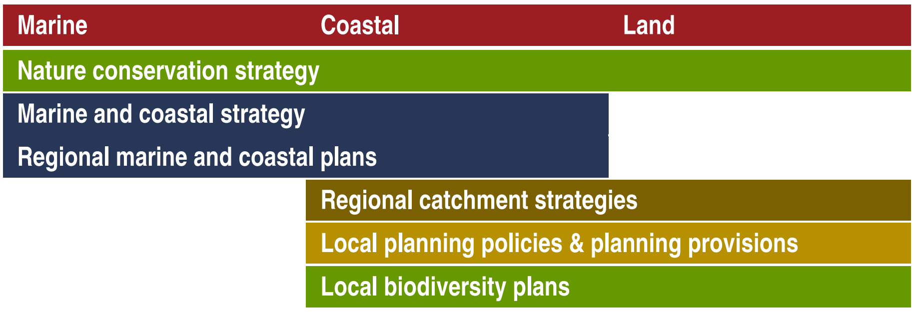
The Alps have outstanding biodiversity and geodiversity. Many of the wildlife species are unique, and many are threatened. Landscape and scenic qualities are also diverse and outstanding – summer wildflower displays in alpine herbfields, gnarled snow-gums at the snowline, tall wet eucalypt forests and rainforests, limestone caves, deep gorges, broad river valleys and rugged winter-snow-covered mountains, the highest in Australia.

Climate change is predicted to compromise these natural values and reduce the flows of high quality water. A 2011 report on the condition 235 sub-catchments in the Australian Alps identified climate change risks and priority actions.[68] These priorities, costing about $100 million over 15 years, include protecting and enhancing water yields by removing weeds, restoring snow gums, protecting water quality and minimising soil erosion; and protecting water flow regimes by conserving natural vegetation cover.

5.2.4 Planning and priorities

Planning is essential for setting the direction of conservation in Victoria at state, regional and local levels. But there is no current state biodiversity strategy, no action statements for about half the listed threatened species and out-of-date or non-existent management plans for many protected areas. Many existing plans are also poorly integrated – particularly across marine, coastal and terrestrial environments, and across public and private tenures. Figure 5.3 shows some of the major strategies and plans needed to direct and integrate environmental management across land and seascapes.

Figure 5.3 Relationships between land, coastal and marine planning



Note: This is not a comprehensive compilation of environmental strategies and plans needed.

Very high on the priority list is a Victorian nature conservation strategy. The Flora and Fauna Guarantee Act requires the development of a 'flora and fauna guarantee strategy' but the one and only such strategy ever developed is now 17 years old. It was one of the earliest Australian biodiversity conservation policies, and was influential in promoting a bioregional approach to conservation, tools for assessing native vegetation (eg ecological vegetation class mapping) and the native vegetation framework.[69] However, the auditor general (and others) have critiqued the strategy for lacking measurable objectives and guidance on how to achieve those goals.[70] A draft updated strategy 2010-2015 (*Biodiversity is Everybody's Business*) was released for public comment in June 2010 but has been shelved since the change of government later that year.

The Flora and Fauna Guarantee Act requires that the strategy includes proposals for 'guaranteeing the 'survival, abundance and evolutionary development in the wild of all taxa and communities of flora and fauna'. This 'guarantee' objective needs to be matched with long-term measurable targets and outcome-focused performance indicators. It needs to include policies and measures to drive conservation at landscape and seascape scales across public and private tenures, harnessing the resources and skills of government, business and community to create solutions, and to promote resilience and adaption to climate change. Best practice public accountability measures are required, such as independent auditing of outcomes and regular reviews and reports on progress. Departmental performance targets need to be closely aligned to targets in the biodiversity strategy.

5.2.5 Climate change adaptation

As outlined in the preceding chapters, climate change will have profound and multiple impacts on marine, coastal, terrestrial and freshwater habitats. Many impacts will be due to the exacerbation of existing threats – such as harmful fire regimes and invasive species – and other climatic impacts will cause greater harm because native species and ecological communities are already under severe pressure from other threats. Climate change will profoundly challenge governance in economic, social and environmental domains. Victoria should be responding to the threat of climate change by:

- reducing the state's greenhouse gas emissions to a globally fair share (eg per capita) of safe levels (*mitigation*)

- ensuring that responses to climate change are *ecologically sustainable*
- eliminating and reducing current threats to nature to promote *resilience* to climate change
- fostering *adaptation* to climate change.[71]

This will require climate change adaption and resilience to be an extremely high priority consideration across all government agencies and programs. It heightens the urgency to address existing threats by more effective implementation of current commitments but will require institutional and other governance reforms to provide more capacity for managing and responding to a dynamic system.

Mitigation: Measures to reduce greenhouse gas emissions by curbing the use of fossil fuels are not addressed in this review. Victoria also has many mitigation options by conserving natural carbon sinks, such as forests (including the world's most carbon-rich forests, mountain ash), seagrass meadows and streams – and preventing harmful, carbon-emitting activities such as logging, land clearing, and severe fire regimes. Protecting and restoring habitats are valuable both for conservation and climate change mitigation.

Sustainability: Climate change is driving changes in human activity and will drive many more – new crops (biofuels and drought-resistant pastures), new products and services (wind energy, carbon sequestration plantings), movement of people and agriculture, and increasing demands for scarce resources such as water. Unless ecological sustainability and a long-term perspective is embedded in laws, policies and government programs, many responses to climate change will exacerbate pressures on nature, undermining the potential for adaptation.

Resilience: Ecosystems with intact ecological processes and low threats are likely to have greater capacity to 'resist and recover from the effects of climate variability' – in other words to be more resilient.[72] It requires reducing other pressures on biodiversity in the multitude of ways identified in previous chapters (eg limiting exploitation, controlling invasive species, implementing beneficial fire regimes). Enhancing the resilience of birds in box and ironbark forests, for example, requires improving habitat quality in remnant forest, particularly in fertile areas (as noted in section 3.4.1). Under climate change, protected areas – on both public and private lands – are more important than ever for they offer the greatest opportunity to mitigate many threats and restore ecological processes.

Adaptation: Many climatic changes are inevitable, but their consequences will depend on whether human actions increase or decrease the potential for species to adapt – by retreating to refugia, evolving new tolerances, migrating to more suitable habitats or exploiting new resources, for example. At particular risk in the near term are alpine, coastal and moist habitats, and species with low ecological tolerances, specialised requirements, low genetic variability, long generation times or narrow geographic ranges.[73] Protecting habitat, on public and private tenures, to provide adaptation options is essential – 'the greater the total area of habitat available, and the more diverse that habitat, the greater the number of ecosystems and species that will be able to survive'.[74] The national park and conservation system is essential for safeguarding climate refuges, including sites providing temporary refuge (during climatic extremes and ecological disturbance) and long-term refuge for species with contracting ranges.[75] One high priority is to identify and protect freshwater refugia (section 4.5.3). Conservation beyond protected areas is, of course, also essential, to maintain or restore large-scale ecological processes essential to adaptation, such as pollination, seed dispersal, species movement and natural water flow regimes. All measures to promote resilience and adaptation need to be based on much better information about natural systems, the impacts of climate change and the effectiveness of management.

5.2.6 Funding

Environmental standards should not be compromised for the sake of an agency saving money.

Ombudsman Victoria, 2009[76]

As the popular saying goes, 'the economy is a wholly owned subsidiary of the environment, not the other way around.'[77] The natural environment directly and indirectly sustains the Victorian economy – as the basis for industries such as tourism, fishing and primary production and by providing a multitude of ecosystem services. Failures to maintain Victoria's 'natural capital' have exacted an enormous financial cost, exemplified by the billions of dollars spent trying to rescue the Murray-Darling system, mitigate salinity, restore vegetation and reduce greenhouse gas emissions. Yet, there is far from sufficient investment of public funds to arrest environmental decline, condemning future Victorians to spiralling costs for restoration and threat mitigation.

A 2002-03 valuation found that the gross value to the Victoria economy from the use of public lands (excluding intangible values and environmental services) was about $3.5 billion and the net value about $2.5 billion (Table 5.4). The economic benefits came primarily from the more than 110 million visits each year to Victoria's national parks, beaches and piers (worth $1.5 billion), and from resource harvesting and extraction (worth $1.8 billion), mainly from the use of water for irrigation and urban purposes. The state was spending about $900 million on management of public lands.

Table 5.4 Annual economic value of the public land estate (2002-03)[78]

Benefits	$ million
Natural resource extraction & commercial use	1,836
Visitation benefits	1,525
Recreational fishing	102
Visual amenity value	18
Local ports	6
Gross benefits	3,487
(less) Management costs	(893)
(less) Opportunity cost of land	(106)
Net benefit to Victoria	2,488
Minimum benefit cost ratio	3.5

Source: Marsden Jacobs and Associates.

Note: ecosystem services and intangible values are additional uncosted benefits.

Because of insufficient funding, government agencies are not able to meet many fundamental environmental obligations.[79] The auditor general has highlighted a few cases. A 2010 audit found that invasive species threats in national parks would escalate if resource constraints were not addressed, and that the reliance on short-term funding to address a long-term problem was detrimental to management effectiveness.[80] A 2011 audit found that the environment department had not allocated sufficient resources to plan for or respond to marine biosecurity incidents, and that dedicated funding for managing marine parks had been used for other activities.[81] A 2009 audit found that with existing resources, it would take 22 years for the environment department to complete basic action statements for the then-listed threatened species.[82] Since then, the funding situation has worsened, and there is a backlog of about 370 listed species lacking action statements (Table 5.3).

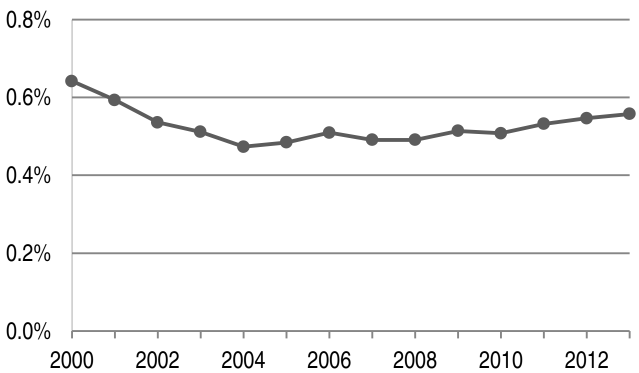
Only a small proportion of the Victorian budget goes to support nature conservation, at a level that is far from proportionate to the value of ecosystem services and the resources needed to arrest decline in and restore biodiversity.

Funding in 2012-13 for Parks Victoria – including from the state government budget, the Parks and Reserves Trust and other sources – was about $260 million.[83] Equivalent to just 0.6% of the state budget – and about the size of the budget for a medium-sized local government area – it is for managing about 18% of the state's land area and 5% of marine waters: about 4 million hectares of land, 50,000 hectares of marine waters, and 35 million visits to national and state parks (Figure 5.4). It equates to just $45 per Victorian, or about the cost of a cup of coffee per Victorian per month. It also equates to about $5 per visit to Victoria's parks. Visiting a national park is not only one of the most popular recreational choices, it is one of the cheapest.

The funding available to manage the national park estate for conservation outcomes is substantially less than the total $260 million revenue of Parks Victoria. About one third ($88 million) is spent on just 5000 hectares of metropolitan parks (from the levy

Melbourne residents pay for managing these parks) and considerable sums are spent on managing visitors and facilities, including 44 visitor centres, 703 shelters, 845 toilets, 515 viewing lookouts, 55 playgrounds, 14,000 kilometres of roads, 1213 pedestrian and vehicular bridges, 3700 kilometres of walking tracks, 110 sporting facilities, 217 piers and jetties, 98 water access points and 937 navigation aids.[84] Parks Victoria provided education and interpretation services to more than 180,000 visitors and students in 2012-13. Fewer than 1000 staff (full-time equivalent) are employed by Parks Victoria, which averages out to more than 4000 hectares of land managed per employee (many of whom are not field staff). The government cut 120 jobs from Parks Victoria in 2013.[85]

Figure 5.4 Funding for Parks Victoria (from state government sources) as a percentage of the state budget, 2000-2013



Notes: The funding includes state government budget allocations to Parks Victoria and funding from the Parks & Reserves Trust.

Principles for investment

Essential to environmental planning is the realistic costing of actions needed to fulfil Victoria's environmental obligations as well as the costing of current unsustainable practices. Long-term investments are needed for long-term problems. The following principles should be applied to funding decisions.

- Establish clear links between policy and funding, so that policy is translated into actions and outcomes. Much environmental policy is mere rhetoric because too little funding is provided to implement it. Funding must be increased to match the increase effort required to meet the desired outcomes.
- Commit resources for ecologically realistic timeframes. Most biodiversity programs require long-term commitment of resources. Several years' investment may be wasted if ongoing and follow-up works and regular maintenance is not undertaken.[86]
- Allocate 'core funding', with long-term security, to central elements of public land management rather than short-cycle 'initiative' funding.
- Identify the core environmental functions of government – those required under treaties, legislation, regulation and policy – that should be funded by government, to ensure that funding obtained from external, non-public sources is used to enhance these functions and not replace them.
- Make funding decisions transparent with details available for public review. There is currently almost no publicly accessible information about how funds are spent. For example, annual Parks Victoria action plans, which allocate the budgets to implement management plans, are not publicly available.
- Avoid funding or subsidising activities that undermine environmental objectives, such as subsidies for fossil fuel industries.
- Include realistic in-kind and volunteer contributions in programs and ensure there is sufficient budget to support, train and encourage volunteers.

Options for increasing funding

Funding and resourcing available for biodiversity fall far short of what is required to achieve effective long-term biodiversity conservation outcomes.

Ecology Australia, 2011[87]

Most recommendations in this nature conservation review encompass a stated or unstated requirement for increased and longer-term funding. This may appear unreasonable in the context of budget cutting but state government expenditure on conservation and environmental programs is only a small proportion of the state budget and warrants a much higher priority. Nonetheless, the gap between public resources available and the resources required is substantial, and will need to be addressed by multiple sources. An optimal strategy will employ a mix of complementary measures tailored to achieve specific policy goals.[88]

Here, the broad merits of various funding options are briefly addressed.[89]

Increased public funding: Given the importance of a healthy environment to Victoria's future and government failures under existing levels of funding to discharge their legislated environmental obligations, there is a strong rationale for substantially increasing public funding, from both the state and federal government.

More effective prioritisation: Many programs have not adequately targeted conservation priorities, although there has recently been a greater policy focus on directing available resources to the most important biodiversity conservation tasks. Further development of NaturePrint (or similar modelling systems) is needed to assist with prioritisation.

More effective use of resources: As well as focusing effort on the highest priorities, efficiency can be gained by increasing staff skills, purchasing skills on an as-needs basis (although this can undermine institutional capacity), developing protocols, guidelines and procedures for delivering high-quality outcomes, and adopting a 'continuous improvement' approach. 'Cuts in resources and programs are often … dressed up as "efficiency" measures,' but instead undermine efficiency.[90]

Commercialisation of biodiversity: There has been increasing focus on commercial uses of the reserve system and public estate, epitomised by opening parks to cattle grazing and commercial tourism developments. Such activities can undermine the value of natural assets and ultimately cost the state more in threat management and restoration.

Privatisation of conservation: Measures promoting private conservation, such as the creation of markets for environmental services and biodiversity credits, and a focus on 'multi-outcome' programs are effective in some circumstances. A Trust for Nature covenant, for example, may in some instances be more cost-effective in securing a small private land remnant than purchase and addition to the public reserve system. But under some programs such as offsets under the native vegetation management framework, the security and longevity of biodiversity outcomes are doubtful.

Market schemes: Examples are auction-based schemes such as Bush Tender and EcoTender, and offset schemes for vegetation clearing and greenhouse gas emissions. The scale so far is too small to be a major driver of environmental management and restoration. The Victorian Competition and Efficiency Commission concluded that 'significant additional funding for incentives' is required if the government wishes to 'achieve the broader net gain policy objective for native vegetation, without imposing the additional costs on landholders'.[91]

Certification schemes: Environmental labelling and certification schemes can generate resources for conservation but they require independent auditing and verification, and the benefits may not justify the set up and maintenance costs.

Multi-objective projects: Promoting private-sector funding of biodiversity by piggybacking on commercial activities, or undertaking commercial landscape-scale 'biolink' plantings of biodiverse species for carbon-sequestration has been proposed. This could increase resources directed to biodiversity without extra funding.

Use of community groups: Community groups have long contributed to conservation works on the public estate. But they will never replace the need for public investment or contribute more than a fraction of the resources required. Community involvement has many indirect benefits – promoting connections to reserves, education and awareness – but also has costs such as for supervision and capacity building. There will always be committed people, but an over-reliance on volunteerism can place unfair pressure on community members and lead to burn out.

Voluntary stewardship: Increasing private-sector conservation has been the focus of government programs such as Land for Wildlife and Landcare, and is vital to achieving biodiversity outcomes. Unfortunately, many schemes and projects by individual landholders have not targeted priority biodiversity assets, and little is known about the biodiversity outcomes. Issues include skills, monitoring, maintenance, and security of gains in biodiversity value.

Incentives to leverage further expenditure: Some grants and incentives for private land require an equal contribution of resources from the landholder, and some catchment management authorities believe that incentives encourage recipients to also contribute resources (the 'two times' assumption). This appears to be an effective way of increasing spending on conservation.

Philanthropic funding: There are several good examples of philanthropic involvement, including the

Wettenhall Foundation's contribution to the 'connecting country' program, and charitable land purchase programs that add to the reserve system, such as the Trust for Nature, Bush Heritage and Australian Wildlife Conservancy, often supported by supplementary grants from other foundations or individuals. A recent study found that the 'current level of philanthropic funding for the environment is not enough to achieve fundamental and long-term change'.[92] Issues include a lack of coordination between funding sources, limitations in types of projects that can be funded under restrictive trust deeds, philanthropists' lack of knowledge about conservation, and failure to identify priority areas and fund activities with a reasonable probability of delivering successful outcomes. Philanthropic involvement should never replace core government responsibilities for funding conservation.

Environment reparation fund: The 2009 review of the federal Environment Protection & Biodiversity Conservation Act proposed a reparation fund, to receive fines for breaches of the act and to disburse for repair or compensation.[93] Funds would need to be directed to biodiversity outcomes, rather than simply ending up in consolidated revenue. The Victorian Heritage Act has provision for a heritage fund to receive payment of fines for breaches; the same principle could be applied in the biodiversity sector.

Parks levy: Management of urban parks is supported by a 'parks charge' on residential and commercial properties in greater Melbourne. Opportunities for distributing this funding more widely, in line with biodiversity priorities, and widening the collection of the levy, should be investigated.

Park fees: Most fees for park use in Victoria have been abolished. The costs of collecting fees are often too high to make it financially worthwhile. Fee for service or fee for visitor funding models can also pervert park management away from conservation priorities towards visitor management.

Funding from tourism: It is arguable that the nature-based tourism industry should contribute to managing the landscape from which it benefits. One option is a bed levy. A second is to direct a proportion of the GST raised from tourism towards environmental management. The annual expenditure on acquiring and managing national parks in Australia is less than 40% of the GST revenue earned from nature-based international tourists.[94]

Biodiversity foundation: A foundation could be established to raise money from a wide variety of sources for conservation programs beyond core government functions. One potential source of funding is an environmental lottery.

Biodiversity lottery: Examples of environmental lotteries include:

- Britain's Heritage Lottery Fund, which has disbursed more than £5.5billion to 35,000 projects since 1994[95]
- Western Australia's Lotterywest, established in 1932, which disbursed $270 million to over 1300 community organisations in 2011-12 to support health, arts, sporting and environmental projects[96]
- Netherlands Postcode Lottery, established in 1991, which disbursed about 300 million Euros in 2013 for environmental and charitable projects.[97]

Tax deductions and rate relief: Primary producers receive special tax concessions, which require commercial use of the property. Managing farms for conservation or to generate eco-services does not qualify. There are some capital gains tax concessions for when an individual enters into a perpetual conservation covenant, but there must be a reduction in the market value of the property for it to apply. Tax incentives for conservation farming as a form of primary production (supporting ecosystem services) would help stimulate conservation investments.[98] Rates relief for conservation land is available in some municipalities, and could also stimulate conservation covenanting if it applied across all municipalities.

Conservation in Victoria requires substantially more funding – from both traditional and new sources. In recognition that environmental health is essential to Victoria's future and underpins economic and social wellbeing, a certain proportion of the state budget should be guaranteed for environmental and conservation functions. Core funding needs should be identified from an audit of essential environmental functions that arise from national and international commitments, including recovery of threatened biodiversity and mitigation of threatening processes. Long-term funding commitments should be made to permit conservation management over ecologically meaningful timeframes.

Establishment of a Victorian Biodiversity Fund is proposed here to support programs necessary to build the resilience of Victoria's ecosystems. New or expanded sources of funding should be investigated, including lotteries and levies such as a 'bed tax' from tourism.

5.2.7 Knowledge needs

The limited amount of specific data, particularly on which areas are being impacted by degrading processes and where these issues are being actively addressed, is a clear limitation on how well we currently understand progress towards policy objectives.

Department of Sustainability and Environment, 2008[99]

Conservation requires knowledge – of what biodiversity exists, its status and threats, how ecological processes function and what management methods are effective. Monitoring, evaluation and reporting are essential for accountability, performance assessment, identification of effective practices, and adaptive management. A consistent theme from the previous three chapters is inadequate or non-existent baseline information and insufficient monitoring to evaluate whether policies and programs are achieving their goals and whether laws are being complied with.

Knowledge of Victorian biodiversity is particularly poor for: (1) conservation status and trajectories of biodiversity, particularly for neglected taxonomic groups such as fungi, non-vascular plants and invertebrates, (2) ecological requirements of taxa and the threats to them, (3) interactions between taxa, communities and abiotic elements (soil, groundwater, atmosphere) and ecological processes, (4) the effectiveness of different management techniques for different situations and (5) conservation assets on private lands.[100] Areas in particular need of improved monitoring, evaluation and reporting are the national vegetation management framework and vegetation offsets, threatened taxa and ecological communities, invasive species, and management of reserves.[101] Large sums have been spent on environmental works and revegetation on private land under Landcare and other programs, but there has been a lack of monitoring to evaluate biodiversity outcomes.

The auditor general has also identified major deficiencies in monitoring, and data collection and management. For recreational freshwater fisheries, there was a lack of 'systematic and quality assured or ecologically focused' data collection, with significant gaps in assessing the impacts of fishing on freshwater ecosystems, and the ecological impacts of the fish stocking program.[102] For invasive species management, Parks Victoria data in 2010 was 'inadequate and increasingly out of date', with about 75% of plant data and 57% of animal data over 10 years old, and about 30% of plant and animal data over 20 years old.[103] For marine biosecurity in 2011, there was no marine pest monitoring system to detect and respond to marine biosecurity incidents, and no systematic or routine monitoring in any Victorian port. The environment department had not comprehensively monitored the Port of Melbourne or Portland for over a decade.[104] For groundwater in 2010, there was insufficient data about reserves and sustainable extraction rates, and inadequate monitoring.[105] For soil health in 2010, there was no monitoring and soil health data was fragmented, inconsistent and varied in quality.[106] For threatened species in 2009, there was a lack of baseline data, and existing information was often more than 20 years old.[107]

Another area of knowledge deficiency is in understanding the value and methods of traditional land management by Indigenous Victorians and how best to capture and incorporate that knowledge into decision-making and management. Joint management arrangements established recently for some protected areas provide opportunities to acknowledge and apply the knowledge of Traditional Owners. As discussed in chapter 3, Victoria needs more effective approaches for collaborative governance, planning and joint management with Traditional Owners.

Expertise and skills

The sustainability of scientific capacity, particularly within government, is … a serious concern.

Victorian Coastal Council Science Panel, 2011[108]

Managing the natural environment and the multiple threats and pressures on it requires high level expertise and diverse skills. Several reviews have identified a lack of skills and expertise in state and local governments that limit their capacity to fulfil their obligations.[109] Long-term funding deficiencies have been exacerbated by recent budget and staff cuts, and organisational knowledge has declined due to outsourcing and rapid staff turnover. The auditor general, for example, found there was a lack of staff and expertise to protect the marine environment and achieve the objectives of management plans. Of 18 dedicated marine positions established in 2003, only six park rangers with marine-specific skills remained in 2011, and only two had roles focused wholly on marine park management.[110]

There are major expertise gaps in Victoria, particularly for neglected groups such as invertebrates and fungi, for neglected habitats such as groundwater and in particular disciplines such as taxonomy and oceanography. Emerging issues, particularly climate change, will require additional skills.[111] Failing to address these serious skills gaps will have long-term consequences, for it takes many years to build scientific capacity. Some gaps can be addressed by more resources; others such as the dearth of taxonomists (a nation-wide problem) will need long-term programs to attract and support the next generation of scientists. The gaps are not only biological and environmental; building capacity in social sciences is essential too – for example, to improve the effectiveness of educational programs and build support for climate change adaptation. Environmental management also needs to be bolstered by greater use of expert advisory bodies for functions that require diverse knowledge such as national park management.

Skills and expertise in conservation can be bolstered through: [112]

- developing training modules and certification consistent with national competency standards
- requiring key competencies and specifying certifications required in job descriptions and contracts
- developing a consistent, integrated set of standards, guidelines and protocols for crucial biodiversity management functions that are transportable within the sector
- auditing skills of organisations and service providers and providing training where gaps are identified
- developing codes of practice and certification for biodiversity consultants, and requiring they have specified skills and professional expertise, as a condition of engagement
- providing extension and support for private landholders who manage high value and priority biodiversity assets.

Monitoring

We need a considerable increase in effort to establish baselines and commence periodic monitoring of trends in native species populations and habitat quality. Ideally we require across the landscape assessment of changes in native vegetation and other habitat condition which can be linked to land management practice

Victorian Catchment Management Council, 2002[113]

The need for more comprehensive and meaningful monitoring has become a constant refrain in environmental reports for the obvious reason that tracking the status of biodiversity and evaluating outcomes of management are essential for guiding planning and future action. In recent years, the Victorian Catchment Management Council, the Victorian Coastal Council, the Commissioner for Environment Sustainability and the Auditor-General's Office have each stressed that improved monitoring is essential for effective environmental management.[114] 'It is critical that baseline monitoring is improved and a stable, long-term source of funding to support this monitoring is ensured,' said the *State of the Environment Victoria 2013*. It recommended that the state government 'audit the scope, quality and accessibility of environmental monitoring' and establish a 'systematic environmental data collection plan'.[115] The *Catchment Condition and Management Report 2012* called for the establishment of an independent body and robust processes to determine the condition of Victoria's land and water resources and the effectiveness of land-protection measures.[116] The Victorian Coastal Council identified the following problems in coastal monitoring, which also apply to other environments:[117]

- disparate monitoring programs by different agencies
- no central data storage
- no coordination of what is to be monitored
- no systematic assessment of whether, even if the variables are right, sufficient data are being collected to detect change.

The council recommended a technical review of monitoring efforts to assess whether data generated was meeting current and future needs. A gap analysis is recommended here to identify priority monitoring needs, including surveys of poorly known and threatened biodiversity; monitoring to better understand interactions between taxa, and between taxa and the biotic and abiotic environment, ecological processes, and the effectiveness of conservation techniques; and systematic surveys for invasive species.

Recommendations to address specific gaps in monitoring and to promote knowledge dissemination have been made in previous chapters in this report, including a monitoring program for marine and coastal environments and the establishment of a Marine and Coastal Research and Information Service.

'There is a critical role for citizen science in monitoring, information dissemination and gathering, and knowledge creation.'

State of the Environment Victoria 2013

Community groups and citizens have been increasingly contributing to monitoring, through programs such as VNPA's Reef Watch and Nature Watch, Parks Victoria's Sea Search, the national Reef Life Survey developed by the University of Tasmania, and BirdLife Australia's bird atlas project. Apart from collection of valuable data, citizen science programs offer benefits that derive from meaningful involvement of people in positive environmental activities. It is important to be clear about the ways in which community science programs can help address priority knowledge needs, to ensure good quality control over data and to provide resources and training for them.

Reporting

Much of the environmental information accumulated by and for the state government is either difficult or impossible to access. A centralised reporting system and reporting protocols are needed to optimise the value and use of environmental information.

The preparation of 'a standardised, consistent set of environmental indicators, used across jurisdictions' is needed 'so that all data collected at all levels can be aggregated or disaggregated to make data usable at local, catchment, regional, bioregional, state and national levels'.[118] This would make environmental reporting at all government levels consistent and comparable.

Data collected by departments, contracted consultants and scientists, and acquired through publicly funded programs on private land should conform to this framework. There is need for standards, guidelines and protocols to measure performance and compliance and much more comprehensive and meaningful reporting. The condition, status and conservation trajectories of the state's biodiversity should be tracked and publicly reported. Budgetary allocations are needed to ensure that agencies perform monitoring, evaluation and reporting functions.

A body such as the proposed Environmental Audit Office should oversee the collation, management, and dissemination of information. The 2013 state of the environment report recommended the development and maintenance of a public access environmental data portal to serve as a single point access for information such as all state-funded research, common technical standards, publications from agencies that report to the government, all government publications and submissions to policy reviews and reports on prosecutions. The Atlas of Living Australia is one good model for its use of open source methods for collecting, managing and presenting data from a wide range of sources, including community groups and individuals.

5.3 PRIORITY LANDSCAPE CLUSTERS

This nature conservation review has made a large number of recommendations, and some prioritisation of focus is needed. A handful of areas in Victoria stand out as having very high conservation values and facing high threats. By grouping them into regional clusters, the case for action is made clearer and more compelling.

VNPA has identified priority 'at risk habitats' by applying the framework outlined in Box 5.5. These priorities are areas with high-value intact vegetation and high biodiversity values and with poor representation in the national park and conservation system. The biodiversity values are as identified by NaturePrint (see Figure 5.6 for an explanation). Adjacent marine areas subject to major threats have also been added to the priority clusters. Five 'priority clusters' for action have been identified; their values and status are summarised in Table 5.5 and their location is shown in Figure 5.6. They are proposed as primary 'focus areas' for the next two decades. Their boundaries are indicative only. Over the next 10 to 20 years the following outcomes are sought for each cluster:

- *Completion of the reserve system on public lands*: Secure conservation management by addition to the national park and conservation system (to prevent logging, mining, agriculture, fishing in marine areas and other intensive uses) and improve management of intact areas on public land to reduce threats.
- *Conservation management for private lands:* Prevent further clearing or degrading uses, promote conservation management (secured by a perpetual conservation covenant or similar means), enhance connectivity and restore habitats.
- *A focus for community action:* Support the community to be involved in advocacy, on-ground works and citizen science; and foster public awareness, access to information and engagement.

Box 5.5 A framework for prioritising terrestrial conservation

Conservation priorities for different regions depend largely on the extent and condition of remnant vegetation and the extent to which it is protected. Victorian habitats range from the extremes of highly intact and highly protected to almost all cleared or degraded with little protection. VNPA uses a broad three-tier classification of habitats to inform conservation priorities: (1) critical core habitats, (2) at-risk habitats, (3) restoration habitats (see Figure 5.5).

The temptation is often to direct most resources at the most threatened habitats. But this neglects the importance of also protecting the least-damaged habitats and maintaining their ecological processes. Each habitat category encompasses places with irreplaceable values that are important for achieving state conservation objectives. Public funds and focus should be directed, using appropriate policy tools, to the priority habitats within each of the three categories.

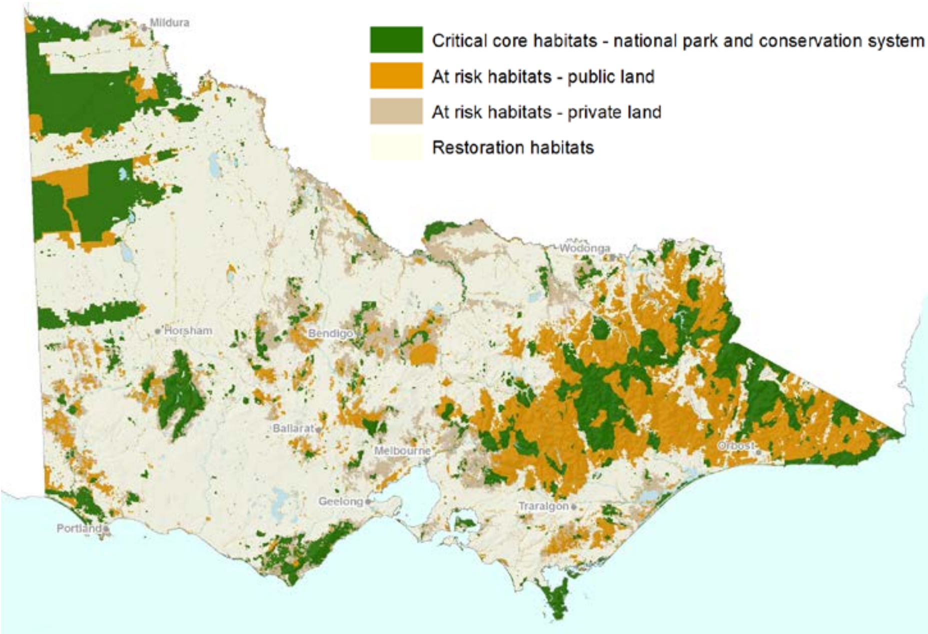
Habitat type	Description	Conservation goal	Priority focus
Critical core habitats	Largely intact vegetation, ecological processes still functioning, permanently protected.	Maintain biodiversity values and ecological processes.	Prevent damage from high-impact recreation, invasive species, inappropriate fire regimes and climate change.
At risk habitats	Habitats with still extensive native vegetation but values at risk or declining due to unsustainable exploitation.	Permanently protect from intensive and exploitative land-use and manage for conservation.	For public lands: upgrade tenure to prevent logging, mining and other damaging uses. For private lands: implement schemes for permanent conservation management.
Restoration habitats	Habitats used primarily for economic activities; highly cleared and often degraded but with important values.	A net improvement in native habitat within a productive landscape.	Maintain extent and quality of vegetation and restore priority sites (including by facilitating natural regeneration) to protect important values.

Table 5.5 VNPA's five priority cluster areas

Subregions included in cluster	EVCs meeting NCR target[1]	Subregion adequacy target[2]	Cluster area (hectares)	Biodiversity values[3]	Features	Threats
South West cluster						
Glenelg Plains	× (21%)	× (13%)	1,458,190	High in southern central spine	Links large remnants via rainfall gradient. Red-tailed black cockatoo.	Firewood collection, fire management, mining, weeds & feral animals
Dundas Tablelands	× (5%)	× (2%)				
Wimmera (part)	× (16%)	× (3%)				
Central Victoria cluster						
Goldfields	× (8%)	× (9%)	1,827,300	High on public lands in north	See VNPA *Special Places*.[4] Grey box grassy woodlands, white box-yellow box-Blakleys red gum grassy woodlands	Rural residential blocks, firewood collection, prospecting & mining, intensive recreation, weeds & feral animals
Central Victorian Uplands (part)	× (7%)	× (6%)				
Melbourne Metro, Central Highlands and Catchments cluster						
Gippsland Plains (part)	× (9%)	× (8%)	1,900,420	High on northern and western grasslands, Yarra Ranges	Grassy woodlands & grasslands. Growling grass frog, striped legless lizard, golden sunmoth, spiny riceflower, Leadbeaters possum. Forest giants. Melbourne's water catchment	Logging, urban development, fire management, intensive recreation, weeds & feral animals, fishing, coastal development & infrastructure, dredging & oil spills
Victorian Volcanic Plains (part)	× (3%)	× (2%)				
Highlands Southern Fall (part)	× (21%)	✓ (20%)				
Central Victoria (marine)	NA	NA				
South Gippsland Plains and Strzelecki cluster						
Gippsland Plains (part)	× (9%)	× (8%)	820,396	High on Strzelecki Ranges	Spot-tailed quoll, long-footed potoroo, Strzelecki gums, orange-bellied parrot.	Coastal development, coal mines & port, agriculture, weeds & feral animals
Strzelecki Ranges (part)	× (5%)	× (2%)				
East Gippsland cluster						
East Gippsland Lowlands (part)	× (31%)	✓ (23%)	741,725	High on all public lands	Smoky mouse, growling grass frog, long-footed potoroo, ground parrot, spot-tailed quoll	Logging, firewood collection, biomass energy, fire management, weeds & feral animals
East Gippsland Uplands (part)	× (28%)	✓ (34%)				
Monaro Tablelands (part)	× (33%)	✓ (18%)				

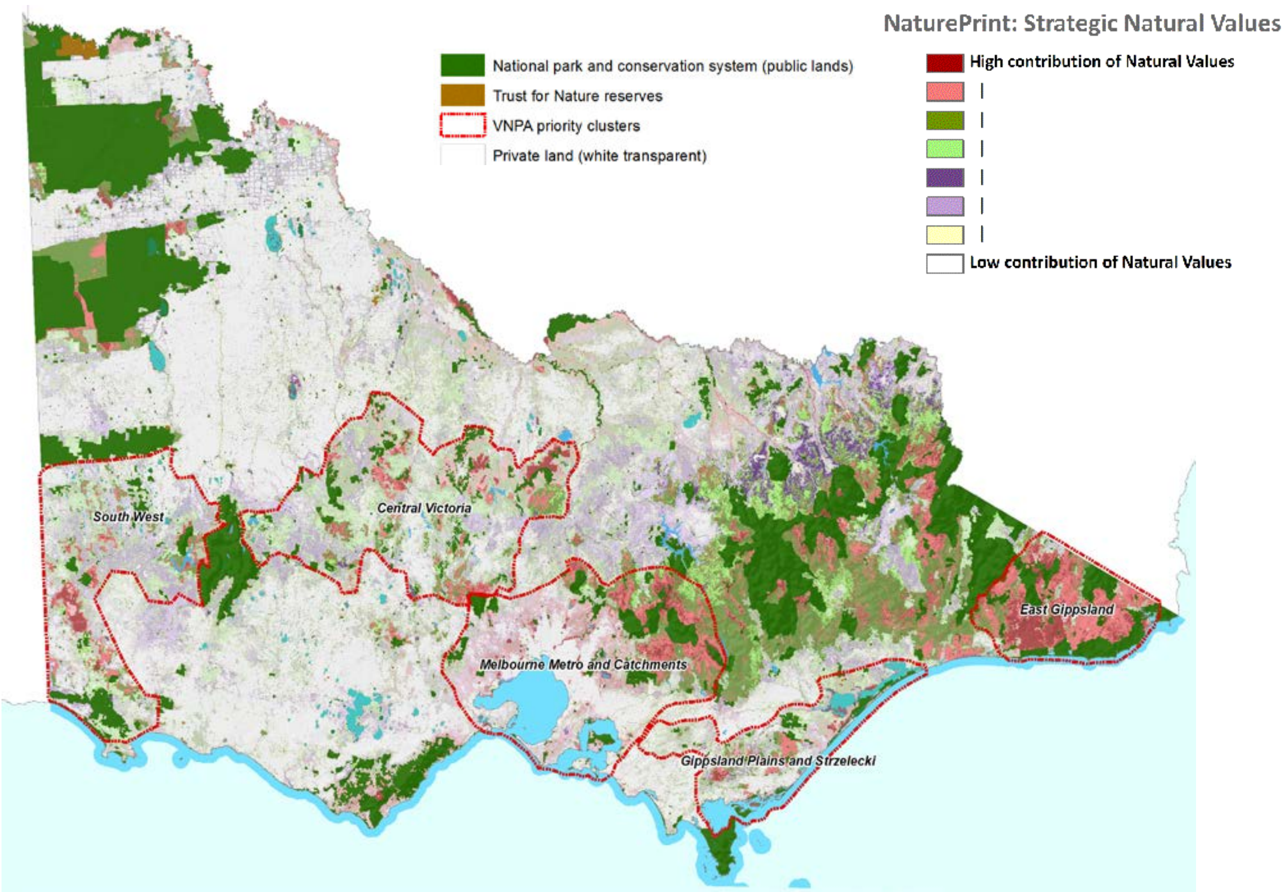
Notes: [1] The goal is that 100% of ecological vegetation classes meet the nature conservation review (NCR) targets for protection in the national park and conservation system (see Tables 3.21 and 3.22). [2] The subregional adequacy target is based on the Aichi target (see Box 3.4 and Table 3.15) and requires protection of at least 17% of each subregion in the national park and conservation system. [3] Biodiversity values are based on NaturePrint.[119] [4] VNPA's 2010 report *Protection for Special Places* describes the values of this region.[120]

Figure 5.5 VNPA habitat classification: critical core, at risk and restoration habitats



Map & analysis: VNPA. Data sources: Department of Environment and Primary Industries; Trust for Nature.

Figure 5.6 Location of VNPA five priority clusters



Map: VNPA. Data source: VNPA for priority clusters analysis. Department of Environment and Primary Industries for NaturePrint and protected areas data. NaturePrint identifies areas that contribute most to protecting the full range of biodiversity values and the relative contribution of all areas to protecting the full range of biodiversity values. The analysis incorporates information from the government's databases on species distributions for all Victorian plants and animals, combined with habitat connectivity and recoverability layers. It considers rare and threatened species.

5.4 FUTURE DIRECTIONS

Underpinning the continued decline of nature in Victoria is a consistent pattern of failed governance. Reforming the system of laws, implementation mechanisms, accountability regimes, and institutional arrangements is an essential foundation for delivering the planning, policies, decisions and programs necessary to achieve nature conservation and a healthy environment.

Victoria's environmental laws are complex, fragmented and outdated, and fail to mandate sufficient priority for biodiversity conservation. A new consolidated law – an Environment and Conservation Act – is proposed to provide a comprehensive framework for conservation, to integrate existing laws on vegetation, biodiversity and wildlife, and to apply best practice elements of environmental law.

Substantial reforms are needed in particular areas of environmental law. The Flora and Fauna Guarantee Act needs more effective processes and tools to guarantee action to reverse biodiversity declines – to protect critical habitats and ecological processes, prevent threats and foster resilience and adaptation to climate change. A new biosecurity law is needed to give appropriate priority to preventing new invasive species and provide the structures and tools to manage existing invasive threats more effectively.

With environmental governance being so complex and politically and socially challenging, it is vital to have optimal institutional structures to develop and implement policies and deliver effective programs. A new structure – four government agencies and several independent bodies – is proposed to improve accountability, reduce conflicts of interest and increase the independence of regulators for conservation and natural resource management. They need to be guided by targets that define a measurable pathway to improving the natural condition of Victoria. A new nature conservation strategy is an urgent priority to match aspirations for nature conservation with well-defined targets and effective measures.

With catastrophic heat waves, fires and floods forewarning of the momentous changes that climate change will bring to Victoria's environment and economy, now is the time to do our utmost to foster resilience and adaptation in nature and human societies. This should be a high priority across all government agencies and programs. The national park and conservation system has a central role to play in helping nature adapt to climate change.

The failure to invest sufficient public funds to arrest environmental decline in Victoria is exacting enormous economic as well as environmental and social costs. There needs to be much greater recognition that the natural environment provides essential services, and directly and indirectly sustains the Victorian economy. Most recommendations in this nature conservation review encompass a requirement for increased and longer-term funding. A certain proportion of the state budget should be guaranteed for core environmental functions identified from an audit of obligations that arise from national and international commitments, and potential new sources of funding should be investigated.

Following is a summary of reforms recommended as high priorities over the next decade to improve environmental governance in Victoria.

Environmental laws

Integration and modernisation

G1 Develop new consolidated legislation – a Victorian Environment and Conservation Act – to provide a comprehensive framework for the conservation of biodiversity and native vegetation, and management of public lands. The new consolidated law should:

- function as a clear public statement about the importance of biodiversity conservation and ecologically sustainable management
- provide clear overarching principles and a framework for developing, implementing and evaluating strategies and plans at appropriate temporal and spatial scales
- establish effective instruments for implementing strategies and plans
- provide clarity about the roles and responsibilities of different agencies and organisations
- guarantee monitoring, evaluation, accountability and public participation
- require public reporting on performance, including on outcomes for relevant regulations,

policies and plans, and compliance and enforcement.

Biodiversity

G2 Strengthen the Flora and Fauna Guarantee Act, including in ways recommended by the auditor general and the Environment Defenders Office (Victoria), and incorporate it into the new Environment and Conservation Act. [121] Essential reforms include:

- an improved and accelerated process to identify and list threatened biodiversity and threatening processes, and to develop, implement and review action plans for recovery
- a focus on protection of biodiversity at all levels – ecosystems and ecological processes as well as species and population
- a procedure (including public consultation) and statutory timeline for developing and reviewing a state biodiversity strategy
- improvements to processes for critical habitat determinations, interim conservation orders and other conservation measures to ensure they are effectively used
- processes and tools to facilitate adaptation to rapid climate change.

Biosecurity

G3 Develop new biosecurity legislation to more effectively prevent, eradicate, control invasive species that threaten the natural environment that includes:

- a lead role for the environment department and environment ministers in developing policy and administering legislation and policy for invasive species that threaten the natural environment
- ecologically sustainable development as a guiding principle, which includes the precautionary principle, conservation of biodiversity, intergenerational equity, valuation and pricing and public participation
- a permitted (safe) list approach to define which non-indigenous taxa (including species native to Australia but not to Victoria) can be introduced, sold, moved or kept in Victoria on the basis of risk assessment, with the precautionary principle applying where information is lacking
- a requirement for systematic risk assessment and categorisation of already introduced species to optimise the potential to prevent establishment, eradicate, contain or control harmful species
- an independent expert committee to advise on risk assessments, declarations and policy
- a 'duty of care' obligation to require all biosecurity participants to exercise a general biosecurity obligation to take reasonable and practical measures to prevent and minimise biosecurity risks.

Enforcement and compliance

G4 Strengthen the compliance framework for environmental laws by:

- developing whole-of-department and specific regulator compliance monitoring and enforcement policies,
- transparently identifying and monitoring high compliance risks across all legislation,
- improving oversight of compliance functions – by monitoring, regular external review and assigning clear accountability for compliance responsibilities, and
- publicly reporting on compliance monitoring and enforcement activities and outcomes for each relevant law and regulation.

Institutional structures and processes

G5 Restructure Victoria's institutions for conservation and natural resource management to establish clear lines of accountability, to separate regulatory roles from policy setting and management and to maximise the independence of environmental regulators. The recommended structure includes the following bodies:

- Nature Victoria (statutory government agency): conservation management and delivery
- Communities & Landscapes Victoria (statutory government agency): landscape management within an environmental framework
- Production Victoria (statutory government agency): support for sustainable production within an ecological sustainability framework

- Environmental Regulator (statutory government authority with independent board): compliance monitoring and enforcement of environmental regulations
- Native Vegetation Regulator (independent authority): operational functions of native vegetation management
- Marine and Coastal Authority (statutory independent body): integrated planning and management of marine and coastal areas
- Victorian Environmental Assessment Council (independent council): investigations on the protection and sustainable use of public and private land
- Environmental Audit Office (independent office of the parliament): reviews of environmental performance
- Catchment management authorities: facilitation and coordination of the integrated and sustainable management of catchments
- Trust for Nature (independent statutory body): facilitation of conservation on private land.

G6 Set targets to define a measurable pathway to improving the natural condition of Victoria:

- Focus targets on measurable outcomes for conservation priorities such as native vegetation (condition and extent), ecological vegetation classes, private land protection and protected areas management.
- Incorporate five-year rolling targets into state budget portfolio service delivery targets and agency director performance agreements.
- Independently audit agency performance against targets in each state of the environment report.
- Embed ecological sustainability and biodiversity conservation as core principles for all departments through their enabling legislation, mission statements and strategic plans. Require high-level biodiversity objectives to be addressed in all relevant government programs and projects. Take an integrated whole-of-government approach to biodiversity management.

Local government

G7 Encourage local governments to prepare local biodiversity action plans and offer matching funds for implementation of these plans.

G8 Provide a statutory mechanism under the planning system or local government laws for local governments to achieve permanent protection of council lands with high conservation values as 'local conservation reserves'.

G9 Strengthen the implementation of catchment management plans by aligning local government land-use planning with catchment management plans and priorities.

Planning and priorities

Nature conservation strategy

G10 Develop a Victorian nature conservation strategy that includes the following elements:

- long term, measurable targets that can be adapted as conditions change or as monitoring suggests changes are required
- outcome-focused performance indicators
- strategies to drive conservation at landscape and seascape scales (to avoid ad hoc decision making)
- a requirement for publicly accessible and independent auditing of program implementation and outcomes
- a mixture of conservation tools including regulation, enforcement and market-based initiatives
- strategies to integrate biodiversity conservation and ecologically sustainable development across public and private land tenures,
- a commitment to long-term allocation of resources to enable organisations to implement strategies
- a requirement for regular five-yearly reviews.

Management plans and action plans

G11 Closely align departmental performance targets to the outcomes defined in the biodiversity strategy and subsidiary plans and strategies.

G12 Provide the resources necessary for the environment department to systematically list threatened species, ecological communities and threatening processes, and develop action plans for all listed entities within five years.

G13 Ensure that all protected areas have up-to-date management plans and publicly accessible web-based maps and information about their values.

Climate change

G14 For climate change mitigation, identify carbon sequestration opportunities that complement biodiversity protection and restoration:

- Assign value to biodiversity assets that reflects sequestration opportunities and invest in biosequestration projects in rural landscapes.
- Identify carbon sinks such as forests, seagrass meadows and streams. Manage native forests to conserve carbon stocks instead of logging them.
- Recognise the important role played by streams and their environs in landscape connectivity and as carbon sinks by incorporating them into broader connectivity, restoration and carbon sequestration programs.
- Require assessment of the greenhouse gas implications of land use changes.

G15 To foster ecological resilience and promote adaptation to climate change:

- Develop regional climate adaptation plans (every 5 to 10 years) and incorporate measures into all relevant plans, strategies and programs, including the biodiversity strategy, coastal plans, regional catchment management strategies and national park plans.
- Develop statewide targets for biodiversity and land health that drive investment in resilience.
- Ensure that the condition of biodiversity assets is maintained at a very high level to ensure maximum resilience and adaptability to change, including by reducing invasive species threats, implementing ecologically appropriate fire regimes, and addressing the needs of priority taxa and communities.
- Put in place a systematic and long-term ecological monitoring program to monitor progress against biodiversity targets and ensure high quality data to assist with adaptive management.
- Incorporate climate change criteria into all relevant plans, strategies and programs, including the biodiversity strategy, coastal plans and regional catchment management strategies.
- Build the knowledge base about the impacts of climate change on biodiversity, and management approaches and techniques to foster resilience and adaptation.
- Adopt a 'foresighting' approach to planning for climate change; plan for possible outcomes taking account of potential interactions and worst-case scenarios.

G16 Investigate and implement measures to preserve the biodiversity values of the national park and conservation system under climate change:

- Expand the national park and conservation system area and improve management to foster resilience and adaptation (refer to recommendations in previous chapters).
- Identify important climate refugia and protect them within the national park estate.
- Link the national park estate along environmental gradients.

Federal protected area policy

G17 Amend the federal Environment Protection and Biodiversity Conservation Act to make national parks a matter of national environmental significance, requiring assessment of any activities likely to have a significant environmental impact.

G18 Establish a Natural Icons Resilience Program with federal government funding for management of strictly protected areas on public or private lands that goes beyond 'duty of care or baseline management' or for special programs to improve the resilience and conservation value of protected areas. Funding could be directed to areas that meet one or more of the following criteria:

- their conservation values are of national conservation significance
- management is cross-jurisdictional
- they provide significant ecosystem services
- they are highly vulnerable to climate change.

Funding

G19 Establish a Victorian Biodiversity Fund to improve environmental program delivery, management of public conservation reserves and measures to build the resilience of ecosystems. Investigate potential sources of revenue, including lotteries and new or expanded charges and levies such as a 'bed tax' from tourism.

G20 Increase funding to the environment. To identify core funding needs, conduct an audit of essential environmental functions arising from national and international commitments, including recovery of threatened biodiversity and mitigation of threatening processes. Make long-term funding commitments to guarantee conservation management over ecologically relevant timeframes.

G21 In recognition that a healthy environment is essential to Victoria's future and underpins economic and social health, allocate a defined proportion of the state budget to maintaining and restoring Victoria's environment.

G22 Increase the transparency of funding arrangements, including for management of the public reserve system and the allocation of resources for different functions such as visitor and facility management and conservation.

Knowledge needs

Skills

G23 Conduct a training needs assessment by auditing the skills and expertise within the biodiversity sector, especially of state and local government personnel and contractors. Address the gaps identified, and improve skills and expertise at all levels.

Research

G24 Maintain a fixed proportion of departmental budgets to employ research staff and run research programs.

Monitoring and reporting

G25 Support the community to undertake scientifically robust monitoring by providing expert advice and feedback, protocols to ensure the data is effectively used and databases accessible to the public and researchers.

G26 Ensure collection, storage and management of information is subject to standard protocols and guidelines and is freely accessible to all users.

G27 Establish a long-term ecological monitoring network to monitor and report on conditions and trends in ecosystem components and processes, especially those most susceptible to climate change

G28 Identify priority gaps in information collection and monitoring through consultation with the biodiversity sector, to include a focus on:

- systematic surveys prioritising poorly known and threatened biodiversity
- interactions between taxa, and between taxa and the biotic and abiotic environments, ecological processes, and effective techniques for biodiversity conservation
- systematic surveys for weeds and invasive animals that threaten biodiversity
- integrated and standardised data collection and management framework for biodiversity to facilitate evaluation of long-term trends.

G29 Implement statewide standards to be developed by the Environmental Audit Office for the collection, management and dissemination of environmental data and reports.

G30 Make greater use of Indigenous knowledge in all areas of conservation management.

5.5 SOURCES

Endnotes

[1] Department of Sustainability and Environment (2010)
[2] Department of Sustainability and Environment (2009b)
[3] Natural Resource Management Ministerial Council (2010)
[4] Commissioner for Environmental Sustainability (2008)
[5] Victorian Auditor General (2010a)
[6] Victorian Auditor General (2011a)
[7] Victorian Auditor General (2010c)
[8] Victorian Auditor General (2013b)
[9] Environment Defenders Office (Victoria) (2014)
[10] Department of Sustainability and Environment (2010)
[11] Victorian Catchment Management Council (2012); Commissioner for Environmental Sustainability (2013)
[12] Victorian Auditor General (2013b)
[13] Victorian Auditor General (2010a)
[14] Victorian Auditor General (2011a)
[15] Victorian Auditor General (2011c)
[16] Parks Victoria (2012). There was no equivalent information provided in the 2012-13 annual report.
[17] Matthews et al (2011)
[18] Matthews et al (2011)
[19] Victorian Auditor General (2011a)
[20] Teague et al (2010)
[21] Victorian Catchment Management Council (2012)
[22] Commissioner for Environmental Sustainability (2013)
[23] Victorian Auditor General (2009)
[24] Victorian Auditor General (2013a)
[25] Victorian Budget Papers 2012-13 Service Delivery, Environment and Primary Industries pp 94-116
[26] Victorian Auditor General (2009)
[27] Victorian Auditor General (2011b); Victorian Auditor General (2013b)
[28] Victorian Auditor General (2009); Victorian Auditor General (2010d); Victorian Auditor General (2010a); Victorian Auditor General (2010b); Victorian Auditor General (2011c); Victorian Auditor General (2011a); Victorian Auditor General (2011b); Victorian Auditor General (2012); Victorian Auditor General (2013b); Victorian Auditor General (2013a)
[29] Environment Defenders Office (Victoria) (2014)
[30] Environment Defenders Office (Victoria) (2008)
[31] Victorian Competition and Efficiency Commission (2009)
[32] Victoria Naturally Alliance (2007)
[33] Environment Defenders Office (Victoria) (2008); Environment Defenders Office (Victoria) (2014)
[34] Environment Defenders Office (Victoria) (2012a)
[35] Victorian Auditor General (2009); Environment Defenders Office (Victoria) (2012b)
[36] Sutton (1987)
[37] Victorian Auditor General (2009)
[38] Victorian Auditor General (2009)
[39] Department of Environment and Primary Industries (2014a).
[40] Department of Environment and Primary Industries (2013)
[41] Department of Sustainability and Environment (2007)
[42] Department of Sustainability and Environment (2005); Department of Sustainability and Environment (2009a); Department of Sustainability and Environment (2013)
[43] Environment Defenders Office (Victoria) (2012b)
[44] Environment Defenders Office (Victoria) (2008);
[45] Environment Defenders Office (Victoria) (2012b)
[46] Environment Defenders Office (Victoria) (2012b)
[47] The Wildlife Act defines ‘wildlife’ as indigenous vertebrate animals, invertebrate animals listed under the FFG Act and ‘all kinds of deer, non-indigenous quail, pheasants or partridges’.
[48] Environment Defenders Office (Victoria) (2012b)
[49] Craig (2010)
[50] Craig (2010)
[51] Craig (2010)
[52] Victorian Auditor General (2012)
[53] Victorian Auditor General (2010d); Victorian Auditor General (2011c)
[54] Victorian Competition and Efficiency Commission (2009)
[55] Krpan (2011)
[56] Krpan (2011)
[57] Victorian Competition and Efficiency Commission (2009)
[58] Ombudsman Victoria (2009); Victorian Auditor General (2010b)
[59] EPA Victoria (2013)
[60] Hawke (2009); Environment Defenders Office (Victoria) (2013). A National Environment Commission was proposed by the Hawke 2009 review of the EPBC Act but rejected by the federal government.
[61] The figures come from the 2012-13 annual reports of Hindmarsh Shire Council and Melbourne City Council.
[62] Municipal Association of Victoria (2004); Victorian Competition and Efficiency Commission (2009); Matthews et al (2011)
[63] Heycox et al (1997)
[64] Binning & Young (1999)
[65] ICLEI (nd)
[66] Hawke (2009)
[67] Warboys & Good (2011)
[68] Warboys & Good (2011)
[69] Clear Horizon (2007)
[70] Victorian Auditor General (2009)
[71] Resilience and adaptivity are closely related, for resilient systems are inherently more adaptable.
[72] Bernhardt & Leslie (2013)
[73] Department of Sustainability and Environment (2010)
[74] Dunlop & Brown (2008)
[75] Dunlop et al (2012)
[76] Ombudsman Victoria (2009)
[77] Attributed to Gaylord Nelson, the US founder of Earth Day
[78] Marsden Jacobs and Associates (2004)
[79] Matthews et al (2011)
[80] Victorian Auditor General (2010a)
[81] Victorian Auditor General (2011a)
[82] Victorian Auditor General (2009)
[83] Parks Victoria (2013)

[84] Parks Victoria (2013)

[85] ABC News (2012)

[86] The rabbit elimination program on Lady Julia Percy Island was abandoned when only 15 rabbits remained, thus squandering 100% of the resources allocated to this laudable program.

[87] Matthews et al (2011)

[88] Gunningham & Young (1997)

[89] Most are from Matthews et al (2011)

[90] Matthews et al (2011)

[91] Victorian Competition and Efficiency Commission (2009)

[92] Australian Environmental Grantmakers Network (2009)

[93] Hawke (2009)

[94] Martin Taylor, WWF Australia (pers. comm.) 21 Jan 2014; Taylor et al (2011). Victoria attracted 29% of the market share of Australia's international overnight nature-based tourism visitors in June 2007.

[95] Heritage Lottery Fund (2014)

[96] Lotterywest (2012)

[97] Nationale Postcode Loterij (2014)

[98] Land & Water Australia (2007)

[99] Department of Sustainability and Environment (2008)

[100] Matthews et al (2011)

[101] Matthews et al (2011)

[102] Victorian Auditor General (2013b)

[103] Victorian Auditor General (2010a)

[104] Victorian Auditor General (2011a)

[105] Victorian Auditor General (2010d)

[106] Victorian Auditor General (2010c)

[107] Victorian Auditor General (2009)

[108] Victorian Coastal Council Science Panel (2011)

[109] Natural Resource Management Ministerial Council (2001); Municipal Association of Victoria (2004); Victorian Competition and Efficiency Commission (2009)

[110] Victorian Auditor General (2011a)

[111] Victorian Coastal Council Science Panel (2011)

[112] Matthews et al (2011)

[113] Victorian Catchment Management Council (2002)

[114] Victorian Auditor General (2009); Victorian Auditor General (2010d); Victorian Auditor General (2010c); Victorian Auditor General (2011a); Victorian Coastal Council Science Panel (2011); Victorian Catchment Management Council (2012); Commissioner for Environmental Sustainability (2013)

[115] Commissioner for Environmental Sustainability (2013)

[116] Victorian Catchment Management Council (2012)

[117] Victorian Coastal Council Science Panel (2006)

[118] Matthews et al (2011)

[119] Department of Environment and Primary Industries (2014b)

[120] VNPA (2010)

[121] Victorian Auditor General (2009); Environment Defenders Office (Victoria) (2012b)

References

ABC News (2012) *Parks Victoria slashes 120 jobs.* http://www.abc.net.au/news/2012-09-21/parks-victoria-slashes-120-jobs/4274580. Accessed January 2014

Australian Environmental Grantmakers Network (2009) *Green Philanthropy 2009.* Australian Environmental Grantmakers Network, Melbourne

Bernhardt JR, Leslie HM. (2013) Resilience to climate change in coastal marine ecosystems. *Annual Review of Marine Science* 5: 371-92

Binning C, Young M (1999) *Beyond Roads, Rates and Rubbish: Opportunities for local government to conserve native vegetation. National R&D Program on Rehabilitation, Management and Conservation of Remnant Vegetation.* Australian Government Environment Australia

Clear Horizon (2007) *Evaluation of the Victorian Biodiversity Strategy 2007.* Clear Horizon

Commissioner for Environmental Sustainability (2008) *Strategic Audit of Victorian Government Agencies' Environmental Management Systems.* Commissioner for Environmental Sustainability

Commissioner for Environmental Sustainability (2013) *State of the Environment Victoria 2013.* Commissioner for Environmental Sustainability Victoria

Craig RK. (2010) 'Stationarity is dead' - long live transformation: five principles for climate change adaptation law. *Harvard Environmental Law Review* 34: 9-75

Department of Environment and Primary Industries (2013) *Action Statement Three Year Plan: A Three Year Implementation Plan for Action Statements.* Victorian Government Department of Environment and Primary Industries

Department of Environment and Primary Industries (2014a) *Action Statements.* http://www.depi.vic.gov.au/environment-and-wildlife/threatened-species-and-communities/flora-and-fauna-guarantee-act-1988/action-statements. Accessed February 2014

Department of Environment and Primary Industries (2014b) *NaturePrint.* http://www.depi.vic.gov.au/environment-and-wildlife/biodiversity/natureprint. Accessed January 2014

Department of Sustainability and Environment (2005) Advisory List of Rare or Threatened Plants in Victoria - 2005. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2007) *Code of Practice for Timber Production 2007.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2008) *Net Gain Accounting. First Approximation Report.* Victorian Government Department of Sustainability and Environment

Department of Sustainability and Environment (2009a) Advisory List of Threatened Invertebrate Fauna in Victoria - 2009. Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2009b) *Securing Our Natural Future. A White Paper for Land and Biodiversity in a Time of Climate Change.* Victorian Government Department of Sustainability and Enviroment

Department of Sustainability and Environment (2010) *Biodiversity is Everybody's Business: Victoria's Biodiversity Strategy 2010 – 2015, Consultation Draft.* Victorian Department of Sustainability and Environment

Department of Sustainability and Environment (2013) Advisory List of Threatened Vertebrate Fauna in Victoria 2013. Victorian Department of Sustainability and Environment

Dunlop M, Brown PR (2008) *Implications of Climate Change for Australia's National Reserve System: A Preliminary Assessment. Report to the Department of Climate Change Rep.* Department of Climate Change, Canberra, Australia

Dunlop M, Hilbert DW, Ferrier S, House A, Liedloff A, et al (2012) *The Implications of Climate Change for Biodiversity Conservation and the National Reserve System: Final Synthesis.* CSIRO Climate Adaptation Flagship, Canberra

Environment Defenders Office (Victoria) (2008) *Land and Biodiversity at a Time of Climate Change: Submission in Response to the Green Paper.* Environment Defenders Office (Victoria)

Environment Defenders Office (Victoria) (2012a) *Report finds Victorian Government ignoring key environmental laws.* http://www.edovic.org.au/news/report-finds-victorian-government-ignoring-key-environmental-laws. Accessed January 2014

Environment Defenders Office (Victoria) (2012b) *Where's the Guarantee? Implementation and Enforcement of the Flor aand Fauna Guarantee Act 1988 & Wildlife Act 1975.* Environment Defenders Office (Victoria)

Environment Defenders Office (Victoria) (2013) *A Proposal for the Establishment of a National Environment Commission.* Environment Defenders Office (Victoria)

Environment Defenders Office (Victoria) (2014) *A New Framework for Nature Protection Laws in Victoria.* Environment Defenders Office (Victoria)

EPA Victoria (2013) *Year Two – Change-ready and Facing the Challenges. EPA Annual Report 2012-2013.* Victorian Government Environmental Protection Authority

Gunningham N, Young M. (1997) Towards optimal environmental policy: the case of biodiversity conservation. *Ecology Law Quarterly* 24: 243-98

Hawke A (2009) *The Australian Environment Act: Report of the Independent Review of the Environment Protection and Biodiversity Conservation Act 1999.* Australian Government Department of the Environment, Heritage and the Arts

Heritage Lottery Fund (2014) *About Us.* http://www.hlf.org.uk/aboutus/Pages/AboutUs.aspx#.U0NFLFfQv0d. Accessed January 2014

Heycox J, Meadows P, Vernon B (1997) *Measuring Environmental Expenditures and Revenues in Local Government: Report on a pilot project with 21 local governments in Australia.* Australian Bureau of Statistics, The Australian Centre for Regional and Local Government Studies, University of Canberra

ICLEI (nd) *Local Governments for Sustainability.* http://www.iclei.org. Accessed January 2014

Krpan S (2011) *Compliance and Enforcement Review: A Review of EPA Victoria's Approach.* Victorian Government EPA Victoria

Land & Water Australia (2007) *Concepts for Private Sector Funded Conservation Using Tax-effective Instruments.* Land & Water Australia, Canberra

Lotterywest (2012) *Lotterywest Annual Report 2012.* Western Australian Government Lotterywest

Marsden Jacobs and Associates (2004) *Economic Analysis of the Value of Public Land in Victoria.* Victorian Government Department of Sustainability and Environment

Matthews S, Carr G, McMahon A (2011) *VNPA Nature Conservation Review: Terrestrial Ecosystems.* Ecology Australia

Municipal Association of Victoria (2004) *Native Vegetation Management and Local Government - Statutory Planning Report. A Report on the Capacity of Victorian Local Government to Undertake Native Vegetation Management.* Municipal Association of Victoria

Nationale Postcode Loterij (2014) *Dutch Postcode Lottery Factsheet.* http://www.postcodeloterij.nl/organisatie/perscentrum/factsheet-english.htm. Accessed March 2014

Natural Resource Management Ministerial Council (2001) *National Framework for the Managing and Monitoring of Australia's Native Vegetation.* Australian Government Department of Environment and Heritage

Natural Resource Management Ministerial Council (2010) *Australia's Biodiversity Conservation Strategy 2010-2030.* Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra

Ombudsman Victoria (2009) *Brookland Greens Estate: Investigation into Methane Gas Leaks.* Victorian Ombudsman

Parks Victoria (2012) *Parks Victoria Annual Report 2011–2012.* Victorian Government Parks Victoria

Parks Victoria (2013) *Parks Victoria Annual Report 2012–2013.* Victorian Government Parks Victoria

Sutton P (1987) *Designing the Proposed Victorian Flora and Fauna Guarantee Legislation.* Presented at Conference of the National Environmental Law Association, Melbourne

Taylor M, Sattler P, Curnow C, Fitzsimons J, Beaver D, et al (2011) *Building Australia's Nature Net: The State of Protected Areas for Australia's Wildlife and Ecosystems.* WWF Australia, Sydney

Teague B, McLeod R, Pascoe S (2010) *2009 Victorian Bushfires Royal Commission Final Report.* Victorian Parliament

Victoria Naturally Alliance (2007) *Submission to Land and Biodiversity White Paper.* Victoria Naturally Alliance

Victorian Auditor General (2009) *Administration of the Flora and Fauna Guarantee Act 1988.* Victorian Auditor-General's Office

Victorian Auditor General (2010a) *Control of Invasive Plants and Animals in Victoria's Parks.* Victorian Auditor-General's Office

Victorian Auditor General (2010b) *Hazardous Waste Management.* Victorian Auditor-General's Office

Victorian Auditor General (2010c) *Soil Health Management.* Victorian Auditor-General's Office

Victorian Auditor General (2010d) *Sustainable Management of Victoria's Groundwater Resources.* Victorian Auditor General's Office, Melbourne

Victorian Auditor General (2011a) *Environmental Management of Marine Protected Areas.* Victorian Auditor-General's Office

Victorian Auditor General (2011b) *Facilitating Renewable Energy Development.* Victorian Auditor-General's Office

Victorian Auditor General (2011c) *Managing Contaminated Sites.* Victorian Auditor-General's Office

Victorian Auditor General (2012) *Effectiveness of Compliance Activities: Departments of Primary Industries and Sustainability and Environment.* Victorian Auditor-General's Office

Victorian Auditor General (2013a) *Environment and Sustainability Sector: Performance Reporting.* Victorian Auditor-General's Office

Victorian Auditor General (2013b) *Management of Freshwater Fisheries.* Victorian Auditor-General's Office

Victorian Catchment Management Council (2002) *The Health of our Catchments: A Victorian Report Card.* Victorian Catchment Management Council

Victorian Catchment Management Council (2012) *Catchment Condition and Management Report 2012.* Victorian Catchment Management Council

Victorian Coastal Council Science Panel (2006) *Emerging Scientific Issues on Victoria's Coast.* Victorian Coastal Council

Victorian Coastal Council Science Panel (2011) *Emerging Scientific Issues on Victoria's Coast: 2011 Update.* Victorian Coastal Council

Victorian Competition and Efficiency Commission (2009) *A Sustainable Future for Victoria: Getting Environmental Regulation Right.* Victorian Competition and Efficiency Commission

VNPA (2010) *Better Protection for Special Places. Victorian National Parks Association Small Parks Project.* Victorian National Parks Association

Warboys G, Good R (2011) *Caring for our Australian Alps Catchments: Summary Report For Policy Makers.* Australian Government Department of Climate Change and Energy Efficiency

6. Consolidated Recommendations

A GUIDE TO CHAPTER 6

This is a compilation of the recommendations from the 'Future directions' section at the conclusion of each of the three previous chapters.

Topics covered

6.1 MARINE AND COASTAL ECOSYSTEMS

Research and information sharing

M1 Prepare and implement a marine and coastal research strategy and action plan, and establish a website to provide public access to all information relevant to marine and coastal protection, planning and management.

M2 Establish a long-term scientific research and monitoring program for marine national parks and sanctuaries and other coastal and marine environments, which includes:

- completion of a systematic biodiversity assessment program across Victorian waters to map all marine and intertidal habitats at a fine scale
- a state-wide 1:10,000 scale map showing predominant community types for reef and sediment areas and locations for seagrass beds, produced within two years.

M3 Establish a marine and coastal research and information service to address high priority knowledge gaps, promote the value of research, and function as a clearing house for information and advice.

National park and conservation system

M4 Commission the Victorian Environmental Assessment Council (or other independent credible body) to conduct an inquiry into biodiversity across all Victorian marine and coastal ecosystems with the purpose of recommending new targets and new protected areas to achieve a comprehensive, adequate and representative national park and conservation system and to foster resilience to climate change. The latest science and expert opinions, taking into account the threats in Victorian ecosystems, suggest the following targets are warranted:

- protection for at least 30% of each habitat type in each marine bioregion
- protection of 100% of remnant coastal vegetation
- protection of additional areas that will assist in protecting biodiversity from the future impacts of climate change
- greater levels of protection for the habitat of threatened species and special features, including Ramsar wetlands and sites identified in the nature conservation review gap analyses (in sections 2.4 and 2.5)
- configuration to provide connectivity and secure movement pathways.

M5 Implement all outstanding recommendations from the 2011 inquiry by the Victorian auditor general into the environmental management of marine protected areas.

M6 Prohibit mining exploration in the marine national park estate.

M7 Establish a coastal private land conservation program with a fund to buy, lease or covenant private land abutting coastal conservation reserves, coastal crown land reserves or the high water mark for restoration and inclusion in reserves or, in the case of leases and covenants, to be managed consistently with such reserves.

M8 Strengthen protection of coastal crown land reserves for conservation and public purposes by:

- developing regulations and coastal management plans specific to their purpose
- applying a zoning scheme to coastal reserves consistent with the recommendations of the Land Conservation Council (1978), with the location of the zones to be identified by the Victorian Coastal Council through a project similar to the Coastal Spaces Initiative
- progressively removing from coastal reserves infrastructure that is not dependent on a coastal location, and restoring the land with indigenous vegetation.

M9 Improve protection for lighthouse reserves by incorporating them within adjoining national or state parks.

Iconic bays and inlets

M10 Establish a Two Bays Board for strategic oversight of the health of Port Phillip and Western Port and their catchments. The board should be an independent authority and amalgamate the catchment management functions of Melbourne Water, Central Coastal Board and the Port Phillip Westernport Catchment Management Authority.

M11 Produce a stand-alone five-yearly *State of the Bays* report covering the four main bays and inlets (Port Phillip, Western Port, Corner Inlet and Gippsland Lakes) and the smaller bays of Victoria, to complement state of the environment reports. The first report should include a detailed condition study, comprehensively review all pressures and describe existing and planned responses.

M12 Develop improvement targets for bays and inlets with water quality, ecosystem health and open space and recreation criteria that are easy to measure and include some highly visible outcomes (for example the return of whales and other flagship species to the bays and the recovery of threatened terrestrial fauna). Link the improvement targets to statutory planning instruments and controls on future development through local environmental improvement plans or similar instruments.

M13 Set up a scientific monitoring program to assess and publicly report every two years on progress made towards meeting the bays and inlets improvement targets.

M14 Establish an ongoing educational program to build awareness of and support for conservation measures proposed for the iconic bays and inlets.

M15 Prepare and implement a state environment protection policy for estuaries.

M16 Determine the boat carrying capacity of Port Phillip Bay, Western Port and other bays and estuaries in Victoria, and set limits on boat numbers consistent with carrying capacity.

M17 Develop a shorebird protection strategy.

Marine and coastal management

Legislation and institutions

M18 Develop a Victorian Marine and Coastal Planning and Management Act with objectives and strategies to implement ecosystem-based and ecologically sustainable management of all marine and coastal waters.

M19 Establish a Victorian Marine and Coastal Authority (absorbing and expanding the functions of the existing Victorian Coastal Council) and regional marine and coastal boards (replacing the existing coastal boards).

M20 Mandate processes that guarantee transparency and community participation in marine and coastal planning and decision-making.

M21 Require that all coastal catchment management authorities have at least one-third of their board members with coastal or marine expertise.

M22 Merge the many small committees of management along the following sections of coast into combined community committees of management:

- Narrawong to Port Fairy
- Breamlea to Clifton Springs (Barwon Coast and Bellarine Bayside committees)
- Mt Eliza to Mt Martha
- Safety Beach to Portsea
- Flinders to Hastings
- Cannons Creek to Tooradin
- Lang Lang to Coronet Bay
- Seaspray to Loch Sport
- San Remo to Inverloch
- Walkerville to Sandy Point
- Port Franklin to Woodside Beach
- Gippsland Lakes.

Strategies and plans

M23 Develop a Victorian marine and coastal strategy, coordinated by the proposed Victorian Marine and Coastal Authority, to provide an over-arching framework for ecologically sustainable, ecosystem-based management of all human uses and impacts affecting Victoria's oceans and coast.

This strategy should take precedence over and inform regional catchment strategies and local planning policies for coastal areas.

M24 In the longer-term, seek inter-governmental agreement for an over-arching national framework consisting of an Australian Oceans Act and National Oceans Commission established through a joint agreement between the federal government and state and territory governments. The commission would develop and coordinate a strong regional plan for Victorian oceans that incorporates the Victorian marine and coastal strategy.

M25 Prepare and implement regional marine and coastal plans (which encompass the current multiple coastal action, estuary and boating action plans). Include strategies to prepare for the impacts of climate change on coastal and marine ecosystems by identifying areas at risk and measures to limit damage and promote adaptation.

M26 Better integrate marine, coastal and catchment management by aligning the boundaries of coastal regions with those for catchment management authorities (splitting the three coastal regions into five regions) and by establishing close links between policies and plans for marine, coastal and terrestrial environments.

M27 Develop ecosystem-based management plans for marine and coastal invasive species threats, including a strong focus on prevention and rapid responses to new incursions, and integration with management of other processes and threats (fire, nutrient enrichment, fishing, disturbance, hydrology included).

M28 Ensure that protection of the environment and the marine and coastal national park estate are high priorities in oil spill prevention and response plans.

Coastal protection and restoration

Stewardship programs

M29 Expand and strengthen the BushBroker, CoastalTender and saltmarsh protection projects, with an emphasis on protection and restoration of vegetation on private land abutting the high water mark and coastal conservation and crown land reserves.

Coastal infrastructure

M30 Commission an independent review of infrastructure (including access tracks, car parks, roads, buildings and utilities) within and adjacent to the coastal national park estate and crown land reserves with the aim of relocating or removing infrastructure or better managing it to minimise impacts on natural values.

M31 Amend the National Parks Act to rule out 99 year leases that allow commercial tourism development within national, state and coastal parks along the Victorian coast.

M32 Establish a coastal infrastructure unit with an objective of ensuring that coastal infrastructure is assessed, designed, constructed and maintained within the principles of ecologically sustainable development and ecosystem-based management. The unit would carry out works, assess and manage boating infrastructure, coastal defensive/protection works, artificial reefs and the planned retreat of coastal infrastructure for all coastal locations except for the major ports of Portland, Geelong, Melbourne and Hastings.

M33 Require rigorous environmental impact assessments of proposed development or upgrade of boat ramps, including the impacts of any recreational fishing enabled by the infrastructure.

Climate change adaptation

M34 Foster the capacity of coastal nature to adapt to sea level rise and other impacts of climate change by:

- mapping current settlements, priority areas for coastal nature protection and enhancement, and predicted sea level rises
- identifying where coastal settlements and nature can move to as a result of sea level rise
- reviewing the zoning and conservation status of all identified priority areas for coastal nature protection and enhancement to determine

whether they will adequately protect coastal nature.

M35 Include in the Victorian planning provisions and the state planning framework an objective to protect coastal nature to help adaptation and retreat in response to sea level rise and other climate change impacts. Amend coastal statutory zoning and overlays to aim for in situ protection of coastal nature for as long as possible and assist inland retreat as sea levels rise.

Vegetation

M36 Introduce a vegetation restoration overlay to the Victorian planning provisions, to protect a 100-200 metre buffer around vegetated coastal public land, including estuaries and wetlands. Within that buffer:

- prohibit development
- require management of harmful invasive species and encourage vegetation maintenance and restoration
- identify and progressively remove infrastructure at risk of erosion and inundation from sea level rises (rather than build defensive structures)
- encourage fencing of buffers and boundaries between private and public land to encourage vegetation restoration.

M37 Amend the Planning and Environment Act to require the planning minister to refer any changes in land use zones for coastal lands to the environment minister.

Fishing

M38 Implement ecosystem-based management of commercial and recreational fisheries by:

- establishing a program to identify and declare 'key fishery habitat' to become part of marine and coastal planning and protection
- implementing whole-of-catchment plans to maintain coastal habitat and water quality
- establishing criteria to assess the ecological sustainability of individual commercial and recreational fisheries
- conducting location-specific ecological risk assessments of recreational and commercial fisheries, mitigating identified risks and taking a precautionary approach where information is lacking
- developing a policy framework to follow up and manage important risks uncovered in environmental risk assessments
- monitoring the community ecology of important benthic and pelagic ecosystems.

M39 Assess recreational fishing catch and impacts by:

- conducting large-scale surveys of participation and catch every 3 to 5 years
- requiring all recreational fishers to be licenced, with no licence fees for current exempt groups, and with licences endorsed for particular coastal regions (to enable measurement of participation and catch levels)
- conducting onsite surveys at all major boat ramps
- expanding the angler diary program to focus on key species and major recreational estuaries
- implementing fisheries-independent monitoring for key recreational species
- re-establishing annual trawl surveys of Port Phillip Bay
- investigating the impacts of fishing discards on declining target species (eg sand flathead, dusky flathead) and non-target species of low abundance (eg rare rays and sharks).

M40 Improve enforcement of fishing laws, with a strong focus on protecting marine national parks and sanctuaries from illegal fishing.

M41 Reduce risks associated with stocking, movement of invasive species and fishing gear by:

- requiring all stock enhancement proposals to be subject to a public environmental impact assessment supported by a comprehensive, independent risk assessment
- prohibiting the transport of live invasive species (eg European green shore crabs) as bait
- phasing in over five years the use of biodegradable hooks and fishing lines.

M42 Allocate a substantial proportion of fishing licensing fees to support long-term fish habitat recovery projects.

6.2 TERRESTRIAL ECOSYSTEMS

Victoria's national park and conservation system

Comprehensive, adequate and representative protection

T1 Commission the Victorian Environmental Assessment Council to investigate how to most effectively achieve a comprehensive, adequate and representative national park and conservation system in Victoria across both public and private lands. High priority areas for protection include:

- Central Victoria: 20 areas recommended in VNPA's Small Parks report
- Melbourne Metro and catchments: a Great Forests National Park, Wombat Forest, a western Melbourne grassland reserve and a network of smaller reserves
- East Gippsland: forest reserves (transfer state forest to the national park estate)
- South West Victoria: a Greater Glenelg National Park (west of the Grampians between the Princes Highway and Little Desert National Park)
- South Gippsland and Strzelecki Ranges: forest reserves (transfer state forest to the national park estate)
- Riverina: Red gum parks as previously recommended by the Environmental Assessment Council – the Murray River park and the Leaghur-Koorangie, Loddon and Avoca River floodplains.

T2 Upgrade protection for conservation reserves listed in schedules of the Crown Land (Reserves) Act:

- Transfer nature conservation reserves to schedule 2C (with protection equivalent to that for properties under schedules 2, 2A and 2B) of the National Parks Act.
- Transfer all other relevant reserves – cultural and natural heritage reserves, natural features reserves, historic and cultural features reserves, regional parks, miscellaneous reserves, water reserves and forest parks – to the National Parks Act, listing them temporarily as a new schedule.
- Commission the Victorian Environmental Assessment Council to assess the most appropriate future management arrangements for these properties.

T3 Establish an acquisition fund for the purchase of high priority lands for addition to the national park estate.

Indigenous land conservation

T4 Actively engage with Indigenous owners to develop land management agreements for biodiversity conservation.

T5 Provide ongoing financial support for joint and co-operative management agreements over existing national parks and reserves.

T6 Work with Indigenous representatives to determine how to better support Indigenous aspirations for conservation management.

Private land conservation

T7 Commission the Victorian Environmental Assessment Council to conduct a review of private land conservation, with a focus on:

- the potential contribution of private land conservation to achieve a comprehensive, adequate and representative national park and conservation system
- priorities for private land conservation and incentives needed to achieve these priorities
- barriers to private land conservation and how to overcome them
- the role of government in promoting private land conservation.

T8 Implement measures and incentives to support conservation on private land:

- exempt properties with Trust for Nature covenants from local government rates
- exempt sales of properties with Trust for Nature covenants from stamp duty
- pay for Trust for Nature covenants in priority areas through the BushTender program
- fund a base transaction fee for all new Trust for Nature covenants

- establish a land improvement fund to support landholders to maintain and improve the conservation values of covenanted properties.

T9 Provide support for non-government organisations that manage large areas for conservation (eg Trust for Nature and Bush Heritage Australia) through capacity building, collaboration with Parks Victoria and other measures.

T10 Ensure that conservation gains on private lands secured with public funds are monitored and maintained into the future, by mechanisms such as permanent conservation covenants.

Planning and management

T11 Develop a strategic plan to guide the future of Victoria's national park estate that also communicates its role and importance.

T12 Improve community education to build broad support for national parks.

T13 Promote conservation-compatible, broad community uses of national parks to encourage physical and mental well-being rather than high-end tourism uses.

T14 Strengthen protection of the national park and conservation system from activities incompatible with the primary purpose of nature conservation:

- Amend the National Parks Act to prohibit mineral exploration and fossicking in the national park estate.
- Maintain a ban on cattle grazing.
- Rule out commercial-scale ecological thinning or logging by stealth.
- Reverse the decision to allow private commercial developments and limit leases to existing structure in parks (no new buildings and structures for commercial purposes).
- Amend the Nature Conservation Trust Act to prohibit mining and mineral exploration in areas under a perpetual conservation covenant and in Trust for Nature reserves.

T15 Strengthen the focus on management planning for national parks and improve the policy development capacity within the parks agency.

T16 Increase the scientific skills base of staff employed by the parks agency, including for monitoring.

T17 Set up scientific advisory panels for specific national park management issues as they arise.

T18 Upgrade and expand invasive plant and animal control programs, and monitor their effectiveness.

T19 Conduct ecologically beneficial fire management with advice provided by an expert panel.

T20 Provide dedicated funding for management and monitoring of national parks, with a specific budget line to allow tracking of spending levels.

T21 Review existing state charges and levies, such as the parks and waterways levy, to identify funding options for improving management of the national park and conservation system.

T22 Build the resilience of the national park and conservation system to climate change by improving the knowledge base, protecting climate refugia, connecting the national park estate along environmental gradients and including a climate adaptation focus in national park management plans (other recommendations in section 4).

T23 Implement recommendations by the Victorian Environmental Assessment Council to facilitate stewardship agreements with organisations and individuals for small public land reserves, including voluntary and payment-based agreements. They should clarify appropriate public land uses, and provide training programs and additional resources if required for conservation outcomes.

Native vegetation protection

Effective regulation

T24 Develop new vegetation laws, as part of the proposed Victorian Environment and Conservation Act (described in chapter 5) that include the establishment of an independent Native Vegetation Regulator to assess clearing applications, oversee monitoring, conduct enforcement, administer offset schemes and provide expert advice for policy-making.

T25 Strengthen the native vegetation management framework, including by the following measures:

- Revert to a clear state-wide objective of 'net gain'.
- Reinstate the three-step hierarchical approach of (1) avoid adverse impacts, (2) minimise impacts and (3) offset impacts.
- Assess the indirect impacts of agricultural activities (cropping, grazing) on vegetation and hydrology.
- Develop a knowledge base to predict the likely responses of different vegetation types to climate change.

T26 Implement a systematic approach to compliance monitoring and enforcement of vegetation rules at local and state levels:

- Establish a native vegetation monitoring program, with oversight by the Native Vegetation Regulator.
- Audit the performance of permit-holders, including at offset sites.
- Establish environmental monitors to ensure compliance with approval conditions, especially for large developments.
- Publish online all relevant information, including permits, plans, assessment and monitoring reports, enforcement notices and actions.
- Provide resources to local governments to perform their duties.
- Regularly audit and report on the effectiveness of the system, including estimates of illegal clearing.

T27 Improve the offsets framework to deliver genuine conservation gains:

- Commission an independent audit of offsets under the native vegetation management framework to assess the extent to which offset targets are being achieved, their degree of permanence, and improvements needed to deliver a state objective of 'net gain'.
- Require offsets for all approved actions that are likely to be detrimental to species on the state government's advisory lists of threatened plants and animals.
- Establish a long-term monitoring program for offsets.
- For low risk activities in low value areas, require offset payments according to a fixed rate and where the funds can be used to support existing protected areas.
- Support the accreditation of pooled services that can bank offset credits and source required offset outcomes.
- Ensure that any offsets to provide for improved management of existing protected areas will achieve genuine 'additionality'.

Biolinks and stewardship

T28 Develop a statewide biolinks plan to enhance landscape connectivity and manage and restore conservation values at the landscape level:

- Build on the flagships and biolinks identified in the 2009 Securing Our Natural Future: A White Paper for Land and Biodiversity at a Time of Climate Change.
- Incorporate focal landscapes and priority biodiversity zones identified in the Trust for Nature's Statewide Conservation Plan.
- Supports the community to undertake detailed landscape, regional and local biolink ecological assessments and planning.
- Include a framework for engaging the community, building land manager capacity and communication.

T29 Expand the use of ecomarkets, such as BushTender and offsets, within a framework of delivering genuine, permanent conservation gains (by perpetual covenants).

T30 Review the Land for Wildlife program to recommend how it can be expanded and its environmental outcomes improved.

T31 Commission research on how to increase the ecological and evolutionary resilience of native vegetation in the face of climate change, including consideration of changes in local provenance requirements and the role of connectivity.

Native forest protection

Timber harvesting and forest protection

T32 Transition Victoria's wood products industry from native forests to plantations. For woodchip, pulp and paper customers complete the transition within five years and for sawn timber customers within 10 years. Aim to be employment positive in five years and economically positive in 10 years. Provide security of supply to the restructured timber industry and support the use of leading-edge technology. Elements of this transition would include:

- an immediate moratorium on logging of high-value conservation sites, such as Leadbeater's possum habitat in the Central Highlands
- industry assistance and a regional development package to support the transition to plantations and investment in new technology
- additions to the national park and conservation system after detailed regional investigations by an appropriately qualified independent body such as the Victorian Environmental Assessment Council.

T33 Immediately ban logging in western Victoria and cancel the regional forest agreement applying to south-west Victoria.

T34 Apply the federal Environment Protection and Biodiversity Conservation Act to all relevant forestry activities by removing the exemption for forestry conducted under regional forest agreements.

T35 Reform forestry policies and guidelines including the regional forest agreements, the code of timber production and timber contracts to require that all threatened species are protected, and climate change and invasive species threats are properly considered.

T36 Establish Victoria as a world-leader in protecting forest-based carbon stores that assist the state in meeting carbon pollution reduction targets.

T37 Incorporate informal forestry reserves such as 'special protection zones' into the national park and conservation system by protecting them under the National Parks Act.

Firewood collection

T38 Introduce a new approach to managing firewood in Victoria that ensures continued firewood supply and protection of native forests:

- Establish a regional development program to provide incentives to support private farm forestry growers to provide firewood.
- Phase out firewood collection from public land.
- In the interim, require all collection from public land to be licenced with stringent conditions to protect conservation values.

Bushfire management

Planning for public safety and biodiversity

T39 Assess the need for prescribed burning programs at a local level in the context of other potentially more useful public safety measures, such as building designs, public and private fire shelters, fire-wise planning provisions, building regulations, powerline maintenance and location and public education.

T40 Do cost-benefit assessments of a range of safety measures when planning fire management, acknowledging that strategies other than fuel reduction are likely to be more useful and cost-effective in some areas.

T41 Give priority in fuel reduction planning to prescribed burns that are (a) critical for public safety and (b) beneficial to both public safety and biodiversity.

T42 Replace any annual state-wide target (5% or otherwise) for prescribed burning by a risk-based approach, focussed on meeting local objectives in regional fire operation plans that reduce risks to life, property and biodiversity.

T43 Apply strong planning rules and building codes in bushfire prone areas to avoid placing homes and people at risk and to reduce the need to remove or modify native vegetation. Take climate change predictions for more frequent and more severe fire events into account.

Ecologically beneficial fire regimes

T44 Establish a suitable range of age classes for each ecological vegetation division (or ecological vegetation class as appropriate) and incorporate this into long-term fire operations planning, making provision for wildfire events as well as planned burns. In particular, this applies to the retention of adequate long-unburnt areas as they cannot be recovered for decades or, in some cases, centuries. Apply the precautionary principle to these decisions.

T45 Revise minimum and maximum tolerable fire intervals for each ecological vegetation division (and in critical cases, for each ecological vegetation class) allowing as far as possible for the full range of species likely to be affected. Develop clear guidelines for burn severity and patchiness for different ecological vegetation classes.

Prescribed burning practices and responses to wildfire

T46 Plan fuel reduction across all land tenures, including private land, and include slashing and other methods as well as burning.

T47 Include both planned burns and wildfire, and the effectiveness of burns, in assessing whether fuel reduction aims and biodiversity protection have been achieved.

T48 Take account of the condition of ecological vegetation classes (such as drought stress) at the time of proposed burning.

T49 In fire plans require protection of a sufficient number and range of hollow-bearing trees for the long-term protection of hollow-dependent fauna. Apply this requirement also to tree clearing that is conducted for safety reasons in advance of prescribed burns.

T50 Include fire-sensitive species and ecological communities (eg rainforest) as 'assets' warranting protection from both wildfire and planned burns.

Research, monitoring and adaptive management

T51 Include adaptive management, in response to short term and long-term monitoring, as an essential component of fire management planning.

T52 Develop rapid monitoring methods (such as DNA sampling) for invertebrates, non-vascular plants, fungi and microbes, to assess short and long-term impacts of fires on biodiversity.

T53 Conduct research and/or monitoring to investigate:

- the effectiveness of fuel reduction burns in different ecological vegetation classes
- whether fire regimes are trending towards or away from long-term maintenance of an appropriate range of age classes, with particular reference to old age classes
- the effects of different fire regimes (frequency, severity, patterns and scales of patchiness) on different species and ecological vegetation classes
- changes in vegetation composition after repeated fires, including changes in flammability
- seasonal differences in post-fire recovery, and post-fire pest plant and animal invasion
- how long seeds and eggs remain viable in soil
- the effects of below-ground fire.

Education and communication

T54 Conduct ongoing public education on the following topics:

- the full range of options for increasing personal safety in the face of fire, especially local options for increasing safety
- the limitations of fuel reduction burn programs in relation to public safety, especially in severe fire weather
- an understanding of the impacts of different fire regimes on an area's natural values
- the need for adaptive management in the face of new knowledge.

Invasive species management

T55 Develop stand-alone biosecurity legislation to strengthen the approach to harmful invasive organisms (details in section 4):

T56 Establish regional weed committees involving local governments, other land managers and community representatives to develop strategies and allocate resources for weed eradication and control.

T57 Develop training and certification systems for weed control to be required for all workers and contractors involved with weed control on public lands, modelled on the DPI Weedstop certification.

T58 Expand programs facilitating community engagement in pest plant and animal management and ecological monitoring.

T59 Reclassify deer, a 'game' species currently protected under the Wildlife Act, as a pest species, map current populations and implement coordinated control programs, eradicating populations where feasible.

T60 Undertake a control program to rapidly reduce the population of feral horses in the alpine national parks and surrounding areas, primarily using aerial shooting under RSPCA-endorsed protocols.

T61 Develop guidelines for managing native species whose distribution is changing dramatically as a consequence of climate change or other anthropogenic drivers and which may have adverse impacts on biodiversity.

6.3 FRESHWATER-DEPENDENT ECOSYSTEMS

Environmental flows

F1 Establish sustainable environmental flow targets based on ecological criteria for surface water and groundwater systems.

F2 Purchase water entitlements in a staged program aiming to reliably achieve sustainable environmental flow targets.

F3 In over-allocated rivers, accord high security and reliability to environmental water and use it to improve natural flow variability, including natural flood frequencies and high and low flows.

F4 Remove legal and other barriers to environmental watering of wetlands on private land.

F5 Establish a program to strategically remove barriers, such as artificial structures, that prevent environmental water from reaching high conservation value floodplains and downstream areas.

F6 Undertake a systematic assessment of the condition of Victorian aquifers, including identification of linkages between groundwater and surface water, and establish base-level data for ongoing monitoring and to inform management.

F7 Develop watering strategies to protect and recover flood-dependent natural values on floodplains, with priority sites including those with threatened taxa, high species richness, colonial breeding sites or corridors important for movement of biota, and sites in poor condition with the potential to recover significant natural values.

Riparian protection

More details are in the VNPA *Riverside Rescue* report.

F8 Establish a 'special offer' assistance program to crown water frontage licence holders to fence boundaries, set up off-river watering and improve management for environmental outcomes.

F9 Establish a 'waterway guardians' program to offer incentives to landholders with significant conservation assets on private land adjacent to crown water frontages or with privately owned frontages with high conservation values to manage these areas for conservation.

F10 Strategically add riparian areas that meet conservation criteria (for biodiversity values, connectivity and management integrity) to the national park and conservation system, and manage them accordingly.

F11 For areas in moderate to good condition, but not suitable for addition to the national park and conservation system, issue a conservation licence that specifies minimum management actions, such as fencing, stock removal or grazing regimes and weed control.

F12 Enforce Victoria's laws to prevent unauthorised activities on riparian public land. Cancel licences where there is evidence of no improvement or action to improve conditions.

F13 Cancel riparian grazing licences where there is evidence of significant damage or no improvement or lack of action to improve conditions.

F14 Provide funding of $20 million per year for four years to accelerate the implementation of good management and assist landholders to take positive steps to repair, restore and protect riparian lands.

Freshwater protected areas

F15 Develop a state-wide process for classifying freshwater communities (akin to terrestrial vegetation communities) and systematically identify high priority areas for protection by applying criteria for assigning biodiversity and conservation value (such as in Table 4.12).

F16 Systematically identify freshwater refugia likely to facilitate survival of organisms under threat from climate change and provide them with a high level of protection.

F17 Create freshwater reference areas under the Reference Areas Act to optimise protection of freshwater ecosystems which are highly intact and have high biodiversity.

F18 Review and revamp the Heritage Rivers Act, including by extending it to wetlands, improving its capacity to prevent damaging land use changes, and requiring monitoring.

F19 Protect the 16 'representative rivers' recommended by the Land Conservation Council in 1991 by amending the Heritage Rivers Act or by protecting them in the national park and conservation system.

Wetlands

F20 Develop a Victorian wetlands strategy that sets policy goals, targets and reporting regimes.

F21 Require land use planning schemes to contain wetland overlays to prohibit destruction or modification of high-value wetlands, as identified by catchment management authorities and including all Ramsar sites.

F22 Use the Flora and Fauna Guarantee Act to protect high-value wetlands that provide habitat for threatened species by declaring them as critical habitat and, where they are under imminent threat, by issuing Interim Conservation Orders.

F23 Protect all Ramsar wetland sites on public land within the national park estate.

F24 Amend the Water Act to include all wetlands on private land in the definition of 'waterway'.

Catchment management

F25 Strengthen catchment management strategies, including by adopting an ecosystem-based approach, identifying clear targets and indicators, developing a long-term monitoring program and clearly linking catchment management to the health of marine and coastal environments and the Murray River.

F26 Strengthen links between catchment management strategies and land-use planning.

F27 Revise and strengthen the Victorian waterway management strategy to define clear indicators and targets for regional river health and restoration.

F28 Recognise the important role played by streams and their environs in landscape connectivity and as carbon sinks by incorporating them into broader connectivity, restoration and carbon sequestration programs.

F29 Minimise land use impacts on rivers and streams by removing grazing from sensitive areas, promoting low impact agriculture and controlling weeds and feral animals. Complement these measures with education to promote improved management practices.

F30 Ensure that public land managers lead the way in complying with regional catchment strategies and their catchment condition targets developed by catchment management authorities.

6.4 ENVIRONMENTAL GOVERNANCE

Environmental laws

Integration and modernisation

G1 Develop new consolidated legislation – a Victorian Environment and Conservation Act – to provide a comprehensive framework for the conservation of biodiversity and native vegetation, and management of public lands. The new consolidated law should:

- function as a clear public statement about the importance of biodiversity conservation and ecologically sustainable management
- provide clear overarching principles and a framework for developing, implementing and evaluating strategies and plans at appropriate temporal and spatial scales
- establish effective instruments for implementing strategies and plans
- provide clarity about the roles and responsibilities of different agencies and organisations
- guarantee monitoring, evaluation, accountability and public participation
- require public reporting on performance, including on outcomes for relevant regulations, policies and plans, and compliance and enforcement.

Biodiversity

G2 Strengthen the Flora and Fauna Guarantee Act, including in ways recommended by the auditor general and the Environment Defenders Office (Victoria), and incorporate it into the new Environment and Conservation Act. Essential reforms include:

- an improved and accelerated process to identify and list threatened biodiversity and threatening processes, and to develop, implement and review action plans for recovery
- a focus on protection of biodiversity at all levels – ecosystems and ecological processes as well as species and population
- a procedure (including public consultation) and statutory timeline for developing and reviewing a state biodiversity strategy
- improvements to processes for critical habitat determinations, interim conservation orders and other conservation measures to ensure they are effectively used
- processes and tools to facilitate adaptation to rapid climate change.

Biosecurity

G3 Develop new biosecurity legislation to more effectively prevent, eradicate, control invasive species that threaten the natural environment that includes:

- a lead role for the environment department and environment ministers in developing policy and administering legislation and policy for invasive species that threaten the natural environment
- ecologically sustainable development as a guiding principle, which includes the precautionary principle, conservation of biodiversity, intergenerational equity, valuation and pricing and public participation
- a permitted (safe) list approach to define which non-indigenous taxa (including species native to Australia but not to Victoria) can be introduced, sold, moved or kept in Victoria on the basis of risk assessment, with the precautionary principle applying where information is lacking
- a requirement for systematic risk assessment and categorisation of already introduced species to optimise the potential to prevent establishment, eradicate, contain or control harmful species
- an independent expert committee to advise on risk assessments, declarations and policy
- a ‘duty of care’ obligation to require all biosecurity participants to exercise a general biosecurity obligation to take reasonable and practical measures to prevent and minimise biosecurity risks.

Enforcement and compliance monitoring

G4 Strengthen the compliance framework for environmental laws by:

- developing whole-of-department and specific regulator compliance monitoring and enforcement policies,

- transparently identifying and monitoring high compliance risks across all legislation,
- improving oversight of compliance functions – by monitoring, regular external review and assigning clear accountability for compliance responsibilities, and
- publicly reporting on compliance monitoring and enforcement activities and outcomes for each relevant law and regulation.

Institutional structures and processes

G5 Restructure Victoria's institutions for conservation and natural resource management to establish clear lines of accountability, to separate regulatory roles from policy setting and management and to maximise the independence of environmental regulators. The recommended structure includes the following bodies:

- Nature Victoria (statutory government agency): conservation management and delivery
- Communities & Landscapes Victoria (statutory government agency): landscape management within an environmental framework
- Production Victoria (statutory government agency): support for sustainable production within an ecological sustainability framework
- Environmental Regulator (statutory government authority with independent board): compliance monitoring and enforcement of environmental regulations
- Native Vegetation Regulator (independent authority): operational functions of native vegetation management
- Marine and Coastal Authority (statutory independent body): integrated planning and management of marine and coastal areas
- Victorian Environmental Assessment Council (independent council): investigations on the protection and sustainable use of public and private land
- Environmental Audit Office (independent office of the parliament): reviews of environmental performance
- Catchment management authorities: facilitation and coordination of the integrated and sustainable management of catchments
- Trust for Nature (independent statutory body): facilitation of conservation on private land.

G6 Set targets to define a measurable pathway to improving the natural condition of Victoria:

- Focus targets on measurable outcomes for conservation priorities such as native vegetation (condition and extent), ecological vegetation classes, private land protection and protected areas management.
- Incorporate five-year rolling targets into state budget portfolio service delivery targets and agency director performance agreements.
- Independently audit agency performance against targets in each state of the environment report.
- Embed ecological sustainability and biodiversity conservation as core principles for all departments through their enabling legislation, mission statements and strategic plans. Require high-level biodiversity objectives to be addressed in all relevant government programs and projects. Take an integrated whole-of-government approach to biodiversity management.

Local government

G7 Encourage local governments to prepare local biodiversity action plans and offer matching funds for implementation of these plans.

G8 Provide a statutory mechanism under the planning system or local government laws for local governments to achieve permanent protection of council lands with high conservation values as 'local conservation reserves'.

G9 Strengthen the implementation of catchment management plans by aligning local government land-use planning with catchment management plans and priorities.

Planning and priorities

Nature conservation strategy

G10 Develop a Victorian nature conservation strategy that includes the following elements:

- long term, measurable targets that can be adapted as conditions change or as monitoring suggests changes are required
- outcome-focused performance indicators
- strategies to drive conservation at landscape and seascape scales (to avoid ad hoc decision making)
- a requirement for publicly accessible and independent auditing of program implementation and outcomes
- a mixture of conservation tools including regulation, enforcement and market-based initiatives
- strategies to integrate biodiversity conservation and ecologically sustainable development across public and private land tenures,
- a commitment to long-term allocation of resources to enable organisations to implement strategies
- a requirement for regular five-yearly reviews.

Management plans and action plans

G11 Closely align departmental performance targets to the outcomes defined in the biodiversity strategy and subsidiary plans and strategies.

G12 Provide the resources necessary for the environment department to systematically list threatened species, ecological communities and threatening processes, and develop action plans for all listed entities within five years.

G13 Ensure that all protected areas have up-to-date management plans and publicly accessible web-based maps and information about their values.

Climate change

G14 For climate change mitigation, identify carbon sequestration opportunities that complement biodiversity protection and restoration:

- Assign value to biodiversity assets that reflects sequestration opportunities and invest in biosequestration projects in rural landscapes.
- Identify carbon sinks such as forests, seagrass meadows and streams. Manage native forests to conserve carbon stocks instead of logging them.
- Recognise the important role played by streams and their environs in landscape connectivity and as carbon sinks by incorporating them into broader connectivity, restoration and carbon sequestration programs.
- Require assessment of the greenhouse gas implications of land use changes.

G15 To foster ecological resilience and promote adaptation to climate change:

- Develop regional climate adaptation plans (every 5 to 10 years) and incorporate measures into all relevant plans, strategies and programs, including the biodiversity strategy, coastal plans, regional catchment management strategies and national park plans.
- Develop statewide targets for biodiversity and land health that drive investment in resilience.
- Ensure that the condition of biodiversity assets is maintained at a very high level to ensure maximum resilience and adaptability to change, including by reducing invasive species threats, implementing ecologically appropriate fire regimes, and addressing the needs of priority taxa and communities.
- Put in place a systematic and long-term ecological monitoring program to monitor progress against biodiversity targets and ensure high quality data to assist with adaptive management.
- Incorporate climate change criteria into all relevant plans, strategies and programs, including the biodiversity strategy, coastal plans and regional catchment management strategies.
- Build the knowledge base about the impacts of climate change on biodiversity, and management approaches and techniques to foster resilience and adaptation.
- Adopt a 'foresighting' approach to planning for climate change; plan for possible outcomes taking account of potential interactions and worst-case scenarios.

G16 Investigate and implement measures to preserve the biodiversity values of the national park and conservation system under climate change:

- Expand the national park and conservation system area and improve management to foster resilience and adaptation (refer to recommendations in previous chapters).
- Identify important climate refugia and protect them within the national park estate.
- Link the national park estate along environmental gradients.

Federal protected area policy

G17 Amend the federal Environment Protection and Biodiversity Conservation Act to make national parks a matter of national environmental significance, requiring assessment of any activities likely to have a significant environmental impact.

G18 Establish a Natural Icons Resilience Program with federal government funding for management of strictly protected areas on public or private lands that goes beyond 'duty of care or baseline management' or for special programs to improve the resilience and conservation value of protected areas. Funding could be directed to areas that meet one or more of the following criteria:

- their conservation values are of national conservation significance
- management is cross-jurisdictional
- they provide significant ecosystem services
- they are highly vulnerable to climate change.

Funding

G19 Establish a Victorian Biodiversity Fund to improve environmental program delivery, management of public conservation reserves and measures to build the resilience of ecosystems. Investigate potential sources of revenue, including lotteries and new or expanded charges and levies such as a 'bed tax' from tourism.

G20 Increase funding to the environment. To identify core funding needs, conduct an audit of essential environmental functions arising from national and international commitments, including recovery of threatened biodiversity and mitigation of threatening processes. Make long-term funding commitments to guarantee conservation management over ecologically relevant timeframes.

G21 In recognition that a healthy environment is essential to Victoria's future and underpins economic and social health, allocate a defined proportion of the state budget to maintaining and restoring Victoria's environment.

G22 Increase the transparency of funding arrangements, including for management of the public reserve system and the allocation of resources for different functions such as visitor and facility management and conservation.

Knowledge needs

Skills

G23 Conduct a training needs assessment by auditing the skills and expertise within the biodiversity sector, especially of state and local government personnel and contractors. Address the gaps identified, and improve skills and expertise at all levels.

Research

G24 Maintain a fixed proportion of departmental budgets to employ research staff and run research programs.

Monitoring and reporting

G25 Support the community to undertake scientifically robust monitoring by providing expert advice and feedback, protocols to ensure the data is effectively used and databases accessible to the public and researchers.

G26 Ensure collection, storage and management of information is subject to standard protocols and guidelines and is freely accessible to all users.

G27 Establish a long-term ecological monitoring network to monitor and report on conditions and trends in ecosystem components and processes, especially those most susceptible to climate change

G28 Identify priority gaps in information collection and monitoring through consultation with the biodiversity sector, to include a focus on:

- systematic surveys prioritising poorly known and threatened biodiversity
- interactions between taxa, and between taxa and the biotic and abiotic environments, ecological processes, and effective techniques for biodiversity conservation
- systematic surveys for weeds and invasive animals that threaten biodiversity
- integrated and standardised data collection and management framework for biodiversity to facilitate evaluation of long-term trends.

G29 Implement statewide standards to be developed by the Environmental Audit Office for the collection, management and dissemination of environmental data and reports.

G30 Make greater use of Indigenous knowledge in conservation management.

VICTORIAN
NATIONAL PARKS
ASSOCIATION

Address: Level 3, 60 Leicester Street, Carlton, Victoria 3053.
Phone: 03 9347 5188 | **Email:** vnpa@vnpa.org.au | **Website:** www.vnpa.org.au