2013 | SCIENCE POLICY PEOPLE

Victoria: STATE OF THE **ENVIRONMENT**

State Government Victoria

Commissioner *for* Environmental Sustainability Victoria

> As mounting research shows, the stable functioning of Earth systems - including the atmosphere, oceans, forests, waterways, biodiversity and biogeochemical cycles - is a prerequisite for a thriving global society. With the human population set to rise to 9 billion by 2050, definitions of sustainable development must be revised to include the security of people and the planet.

David Griggs, Mark Stafford-Smith, Owen Gaffney, Johan Rockström, Marcus C. Öhman, Priya Shyamsundar, Will Steffen, Gisbert Glaser, Norichika Kanie and Ian Noble. *Sustainable development goals for people and planet. Nature*, 495: 305-307. (21 March 2013). 2013.

> It is *extremely likely [greater than 95% probability]* that human influence has been the dominant cause of the observed warming since the mid-20th century.
>
> Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

IPCC (2013), Working Group I *Climate Change 2013: The Physical Science Basis. Summary for Policy Makers.*

Victoria: STATE OF THE **ENVIRONMENT**

MESSAGE FROM COMMISSIONER

A sustainable society is one that can persist over generations, one that is farseeing enough, flexible enough, and wise enough not to undermine either its physical or social systems of support.

D.H. Meadows, *Beyond the Limits*

I submit the **Victoria State of the Environment Report 2013, *Science Policy People*** (SoE 2013), in accordance with the requirements of the *Commissioner for Environmental Sustainability Act* 2003 (the Act). In my 2010 reporting framework* I undertook to produce this report in a manner which would:

> ***inform the Victorian community*** *about the health of the natural environment and* ***influence government*** *to achieve environmental, social, cultural and economic sustainability.*

To meet this undertaking the SoE 2013 was produced not only through research and data analysis, but also through consultation across sectors, including communities throughout the state.** The trends selected for analysis in Part A of this report are the standard matters considered in state of the environment reporting. The indicators used were selected with the assistance of academic and other experts.***

Discussion and informed narrative are a feature of this report, particularly in Part B. My choice of the goals discussed and recommendations presented was also influenced by the research and consultation undertaken by my office. The case studies and examples from Victoria, other Australian jurisdictions and also from overseas, document innovative solutions and 'best practice' approaches. The complexity of environmental issues is illustrated by the wide ranging discussions referenced in Part B.

In Part B I also detail my recommendations to the Victorian Government. The Act requires the government to table a response to my recommendations no later than the first sitting day 12 months after the SoE is tabled in parliament.

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* Science, Policy, People State of the Environment Reporting 2013, Victoria, Commissioner for Environmental Sustainability Melbourne, Victoria, 2010
** Many Publics, Participation Inventiveness and Change, Commissioner for Environmental Sustainability Victoria, Melbourne, 2012
*** See http://www.ces.vic.gov.au/victorias-environment/state-of-environment-victoria-2009-2013

I recommend a number of organisational, regulatory and policy changes (see SoE 2013 at a Glance summary pages 20, 21). The recommendations I have made are well considered, based on research and consultation. They are strategic, and needed for the health of our ecosystems and the continued wellbeing of our community. The changes are necessary, they are generational choices – investments in our future, and they require leadership and foresight from us all.

Perspective

In my Foundation Paper One – Climate Change Victoria: *the science, our people and the state of play** I commented that:

> ***Independent statutory roles, such as mine, have a unique function in our system of government. They stand at a distance from government and, depending on their legislative accountabilities, undertake independent investigations or analysis and provide impartial reports. Governments can be greatly assisted in their regulatory and decision making processes by independent authorities who provide insights into community aspirations and instructive, balanced comment on the policy process.***

Reflecting on my time as Victoria's second Commissioner for Environmental Sustainability, as my office completed the SoE 2013, I was reminded of this 'unique' role of independent statutory bodies. As we all become more critically aware of the fact that ecosystem services not only sustain our way of life, but are integral to every facet of our well-being, the need for independent integrated ecosystem services and ecological processes reporting is imperative.

As population growth places ever increasing demands upon our natural resources and climate change creates additional stressors 'state of the environment reporting' can no longer be considered an exercise in linear reporting of biophysical environment trends. It requires a whole of system – social, economic and environmental – approach. It is a whole of government, whole of community endeavour.

To ensure that Victoria is well served by independent, integrated 'state of the environment reporting, it is my view that Victoria's next Commissioner for Environmental Sustainability should be funded directly from the state budget and not through a departmental grant. Furthermore, I am strongly of the view that to ensure a whole of government, whole of community reporting framework the next Commissioner for Environmental Sustainability should report to the Premier of the state. Ecosystem services, their protection and management, are integral to all strategic government policy considerations and implementation.

Key concepts of SoE 2013

Throughout the development process of the SoE 2013 a number of recurring themes became evident. These 'key themes' influenced my approach to this report, particularly with regard to making recommendations. Consequently each recommendation can be referenced to two or more of the following:

1. Ecosystem services – imperative for our well-being
2. Leadership – generational choices for government to make and community to influence
3. Alignment and integration – organisational and procedural for efficiency
4. Strategic Adaptive Management (SAM) – enables measurement of progress and supports resilience.

* http://www.ces.vic.gov.au/victorias-environment/state-of-environment-victoria-2009-2013/climate-change

Strategic Adaptive Management

SAM is an iterative process of decision making that is intended to reduce uncertainty over time through robust monitoring and using the most up-to-date information to learn from experience. It is often adopted by natural resource managers as a valuable tool for managing complex systems with high levels of uncertainty.

SAM provides a framework for identifying desired management outcomes and the management actions required to achieve those outcomes. This framework also specifies thresholds for assessing progress towards desired outcomes are being achieved and guidelines for modifying actions if they are not being achieved.

Key SAM processes include:[1, 2]

- engage the relevant stakeholders in the decision making process
- identify the desired management outcomes
- specify assumptions about system responses to management and identify key uncertainties
- establish quantitative and/or qualitative baseline thresholds for desired outcomes
- identify checkpoint levels on path towards baseline thresholds
- determine management actions that will be taken in the future if a given checkpoint level is reached
- implement those actions if the checkpoints are reached
- evaluate, learn from, and re-assess management actions.

The SAM approach allows ecosystem managers to fully engage with communities that benefit from ecosystem services, setting the 'desired future condition' of managed areas. When fully integrated into the SAM process, this supports the position that communities should be given the opportunity to influence decisions that may affect them, and increases the likelihood of success in achieving outcomes by generating public 'buy-in'. In Victoria, this principle has been central to adaptive management of waterways at both state[3] and regional[4] levels.

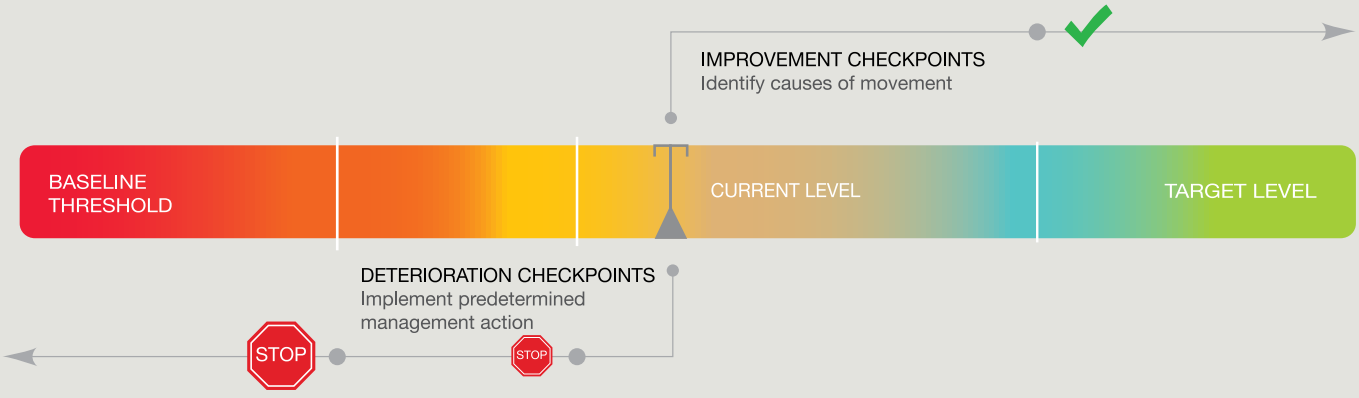

Figure M.1: Strategic Adaptive Management

In closing I would like to acknowledge the contribution made by communities across Victoria to the work of my office. The insights we gained were invaluable, and the efforts of communities and individuals, across sectors, to manage our natural resources are commendable and inspirational.

I would also like to note my appreciation to all the technical experts, academics, representatives of the business sector and local government representatives who contributed their time and expertise to the SoE 2013.

Finally, I would like to acknowledge representatives from across Victorian Government departments and authorities who provided policy background and insights throughout the process. The SoE 2013 benefited greatly from this level of cross-sectoral, multi-disciplinary contribution and commitment.

I present this report to the Victorian Government for action and invite the Victorian community to consider our recommendations.

Professor Kate Auty | PhD, MEnvSc, Dip Int Env Law (UNITAR), BA(Hons)LLB, GAICD

Commissioner for Environmental Sustainability

16 October 2013

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OVERVIEW

Accuse not nature: she hath done her part; do thou but thine.

(Milton, *Paradise Lost*)

The Story of the State of the Environment Report 2013

Ecosystems services and Leadership

Nature gifts us cultural regeneration and recreational possibilities: cerebral and physical delights. Natural systems provide us with clean air, potable water and soils which produce food, fuel and fibre 'through the role of organisms in energy and material cycles': fundamental necessities.[5]

Transformative shifts in our appreciation of the natural world are being encouraged. Internationally, the think tank *The Economics of Ecosystems and Biodiversity* (TEEB) urges us to consider how we 'value' the environment to encourage its protection. On wetlands, for example, TEEB suggests:

'… we should *transform* our approach to wetlands as wetlands *take care* of water [italics added]'.[6]

We need to broaden the general knowledge about the benefits of the environment. For instance, our drinking water – from New York to Melbourne[7] - comes from catchments in forested areas which require our care and consideration as they are vulnerable to fire, flood, drought, climate change[8] and over consumption.

Our responsibility is to value and care for the environment that provides us with these ecosystem services, even as we know that, beyond materiality, the environment has profound intrinsic value. We should all be leaders in this critical endeavour.

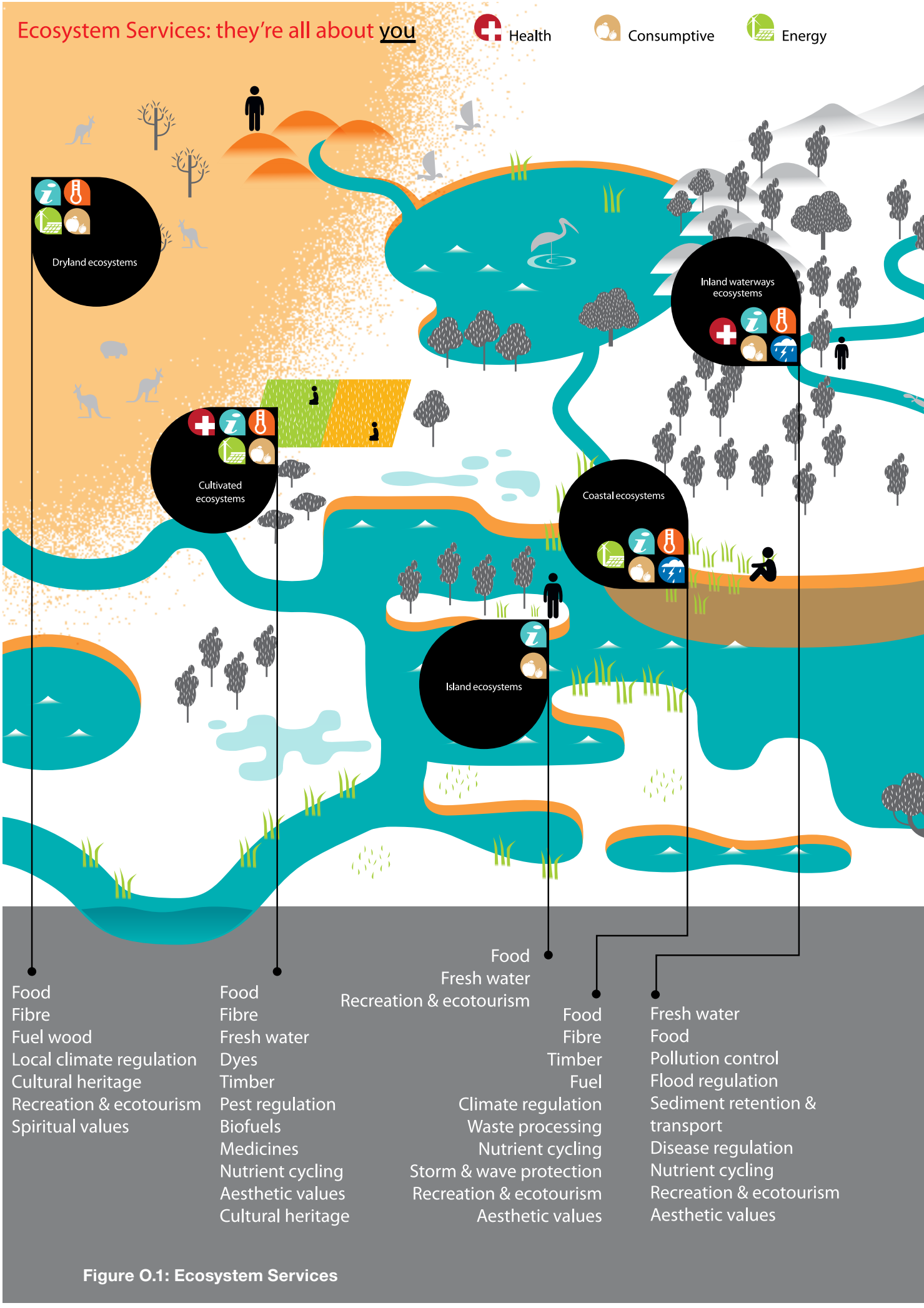
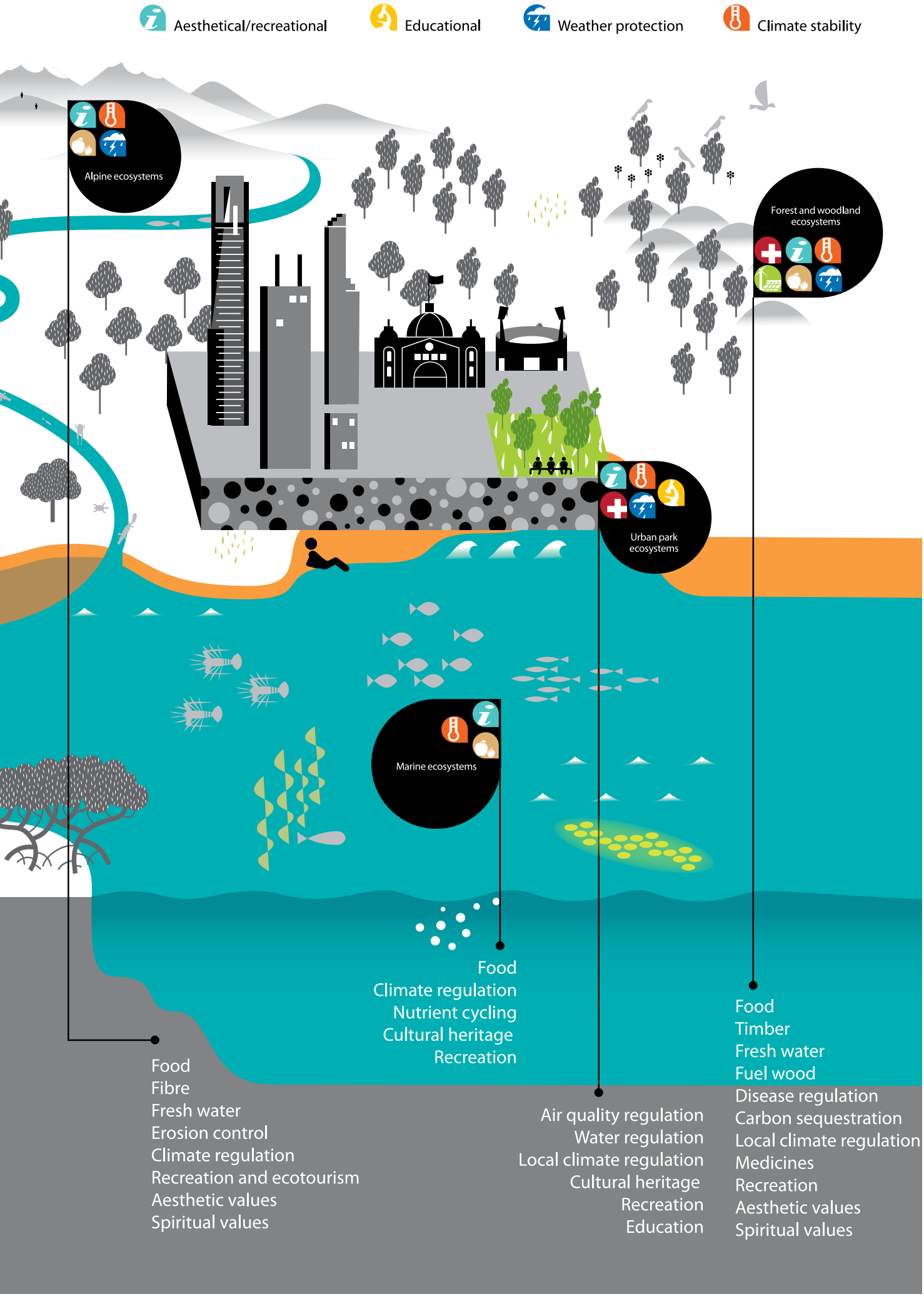


Figure O.1: Ecosystem Services


Aesthetical/recreational
Educational
Weather protection
Climate stability
Alpine ecosystems
Forest and woodland ecosystems
Urban park ecosystems
Marine ecosystems
Food
Fibre
Fresh water
Erosion control
Climate regulation
Recreation and ecotourism
Aesthetic values
Spiritual values
Food
Climate regulation
Nutrient cycling
Cultural heritage
Recreation
Air quality regulation
Water regulation
Local climate regulation
Cultural heritage
Recreation
Education
Food
Timber
Fresh water
Fuel wood
Disease regulation
Carbon sequestration
Local climate regulation
Medicines
Recreation
Aesthetic values
Spiritual values

Reporting on the environment – rationale and sources of data, knowledge and information

Ambitious as we need to be to care for the natural world, one of the significant mechanisms for describing and explaining environmental processes and evaluating and improving our level of care is regular reporting about the *state* of our environment.[9]

To achieve the best science communication and to enable the exploration, explanation and understanding of ***natural capital***, reports concerned with the state of the environment need to reflect data, knowledge and information and blend this ***knowledge capital*** into coherent and useful guides and narratives.

Case studies in real places where the environment is important to people and where information is useful across many sectors provide insights into how we should collect, use and share knowledge. They are also instructive about the meaning and value of ecosystem services.[10] A Goulburn Broken Catchment Management Authority Case Study,[11] studies at Inverloch and Sandy Point[12] and in the North Central CMA area,[13] and the work of Landcare, Greening Australia, Conservation Volunteers and Friends groups across the state (from Brunswick and Boroondara, Bass Coast and Branxholme, to Bruthen, Bendigo and Benalla) illustrate the depth of the potential sources of information and the commitment to caring for the environment. In a range of ways this commitment confirms the environment as the *axis* in our lives and the efforts of these groups exemplify leadership.

Social scientists increasingly contribute to the study of the environment and improve science communication, bringing newer, different, disciplinary perspectives to the reporting process. Their insights and research help us to understand intersections between the natural and built environment,[14] our motivations, and the role of partnerships and less formal collaborations in attaining improved environmental outcomes.[15]

Biophysical scientists scrupulously collect, examine and provide the data upon which state of the environment reports are based. This monitoring and field work may span decades and promote and reflect community partnerships. Their research insights can drive innovative ways of considering the implications of the loss of natural capital and suggest methods for protecting natural capital. They may also involve 'outsiders' in finding and improving solutions. We see this in the collaborative work of the Arthur Rylah Institute and the Yorta Yorta people about the impacts of drought on long neck turtle populations along the Murray (Tungala) River and in the Barmah National Park. Innovative government agency responses can facilitate this work.[16]

Raw data provided by the Australian Bureau of Statistics and the Australian Bureau of Meteorology comprises fundamental building blocks to inform our understanding of the environment and the needed remedial actions.

These 'knowledges', interlinking and sustaining each other, all form the basis of a state of the environment report for our modern, complex, 'wicked problem' times.

Multiple collaborations for biodiversity protection

Emblematic of the issues and the need for multiple voices and a combination of actions, biophysical scientists working alongside the community (sometimes over long periods of time)[17] tell us that two Victorian state emblems are under threat.

Leadbeater's Possum, no more than 40 cm in length, monogamous, related to but 'more primitive' than the sugar glider, has already confounded our belief in its extinction once, after the 1939 Victorian fires.[18] The most recent Victorian fires and forestry practices elevate the level of threat.[19]

Concern was expressed about this possum by the *Land Conservation Council* in 1994,[20] and in 1995 an Action Statement under the *Flora and Fauna Guarantee Act* 1988 (Action Statement no 62)[21] was formulated as was a *Recovery Plan* in 1997.[22] Its status on The IUCN Red List is 'Endangered'.[23]

Leadbeater's possum

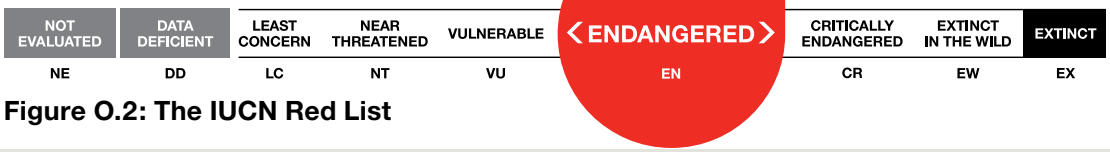


Figure O.2: The IUCN Red List

> **'This species is endemic to Australia, where it has a limited distribution (<3,500 km²) near the western limit of Victoria's eastern highlands from 500-1,500 m asl. There is a small, isolated population that occupies swamp forest at Yellingbo Conservation Nature Reserve at around 80 m (Smith and Harley 2008).'[24]**

Victorian efforts will determine its survival –

> **Leadbeater's Possum is the only member of the genus Gymnobelideus and wild populations are confined to Victoria. This means that the survival of the species in the wild is totally dependent on conservation measures undertaken in Victoria.[25]**

A committee involving Zoos Victoria has been tasked with determining the best means of protecting this possum. Captive breeding programs are a consideration.

Our state bird emblem – the helmeted honeyeater, *Lichenostomus melanops cassidix* – a small bird with a big voice – is variously described as 'threatened' (Schedule 2 FFG Act 1988), 'endangered' (EPCA Act 1999) or 'Critically Endangered' (The IUCN Red List).[26] Three 'small semi-wild populations' continue 'in remnant streamside swamp forest to the east of Melbourne'.[27] Its:

> **'population comprises about 20 breeding pairs and their recent offspring. Fourteen breeding pairs inhabit the Yellingbo Nature Conservation Reserve with a small re-introduced colony of 23 individuals, including 6 breeding pairs, at a site in Bunyip State Park, 30 km south-east of Yellingbo. There are also currently 15 pairs held in captivity at two locations – Healesville Sanctuary, 18 km north of Yellingbo, and Taronga Zoo, Sydney.'[28]**

The *Flora and Fauna Guarantee Act* 1988 Action Statement Number 8 was published in 1992 and 'remains current'.[29] The 2008 National Recovery Plan prepared pursuant to the *Environment Protection and Biodiversity Conservation Act* 1999 is also current.[30]

Monitoring and independent studies commissioned by organisations such as the Port Phillip and Western Port CMA demonstrate the level of ongoing concern and action.[31]

The build up of knowledge and responses has not only, however, been reflected in the work of biophysical scientists. The Victorian Environment Assessment Council in its 2013 Yellingbo investigation[32] had this to say about the input of others –

'An enormous volunteer contribution has been dedicated to the preservation of this bird over more than 50 years. The Friends of the Helmeted Honeyeater, for example run an indigenous nursery to provide plants for revegetation and habitat improvement, and the total volunteer contribution has been estimated to be worth at least $80,000 per year'.

While the Victorian Government has been actively pursuing the conservation of the Helmeted Honeyeater since 1965, Menkhorst suggests that community interest and activity commenced in the early 1900s.[33]

Honeyeater

It is clear we need collaborations and careful scientific and policy interventions to improve environmental outcomes. State of the environment reporting is one of the levers intended to generating solutions. It is also clear that, given the range of protagonists, any report on the environment needs to speak to a wide audience.

The evolving reporting framework

Victorian *State of the Environment Reports* have over time (since SoE 1986) examined the biophysical *state* of the environment and the impacts of humanity on the environment. Environmental reporting has always collected data, described trends and recommended improvements in monitoring and research.

Early environmental reporting adhered to a template of *pressure, state, response* (PSR). As our understanding of complicated, subtle, shifting and intersecting environmental issues has become increasingly sophisticated the reporting template has evolved. Reporters have added *drivers* and

impacts to PSR, producing the Drivers Pressures State Impacts and Responses reporting model. This model has itself been re-evaluated and described as linear, and unresponsive to the inherent interconnections of the social with the environmental and economic in determining the triple bottom line which drives ecologically sustainable development.[34] Reporting which will be real and relevant will avoid a linear representation of the complex interplay of environmental issues.

This 2013 State of the Environment Report responds to the new reporting framework, *Science Policy People*, tabled in the Victorian Parliament in October 2010.[35] The SoE 2013 builds on the work we produced in our climate change risks and vulnerability, private land and biodiversity and water sensitive urban design foundation papers (2012-2013).[36]

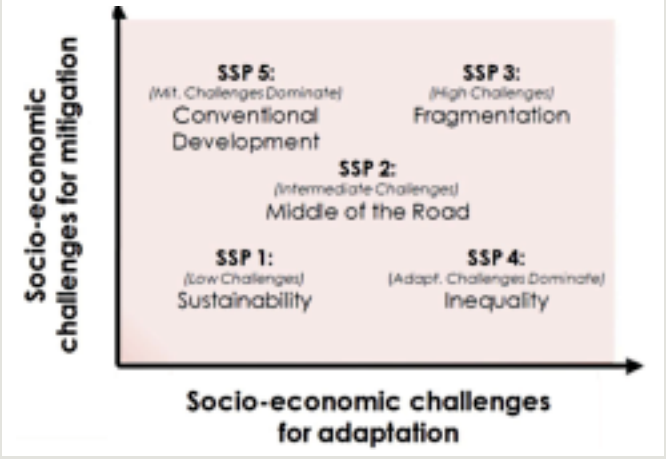
Changes are taking place in reporting across the environmental spectrum. The Intergovernmental Panel on Climate Change (IPCC), established by the United Nations Environment Programme and the World Meteorological Organisation in 1988 to provide the world with *a clear scientific view on the state of knowledge of climate change* and its potential environmental and socio-economic impacts, has also evolved its reporting framework.[37] The 5th IPCC Assessment Report Five (AR5) is being released progressively between September 2013 and October 2014.

Shared Socioeconomic reference Pathways (SSPs)

Unlike the emissions scenarios used for AR4, the RCPs do not provide information on underlying socioeconomic or policy conditions that are generating greenhouse gas emissions. For AR5, the research community is developing scenarios that can be used with the RCPs to create integrated assessments of climate change impacts. These scenarios will:

> **'supply quantitative and qualitative narrative descriptions of potential socioeconomic and ecosystem reference … the defining socio-economic conditions of these scenarios have been designated Shared Socioeconomic reference Pathways (SSPs)'[38]**

The SSP development process is expected to allow researchers to develop tailored scenarios that may include alternative socioeconomic driving forces, alternative technology development regimes, alternative realisations of Earth system science research, alternative stabilisation scenarios including traditional 'not exceeding' scenarios, 'overshoot' scenarios, and representations of regionally heterogeneous mitigation policies and measures, as well as local and regional socioeconomic trends and policies.[39]



This process is being led by the IPCC Working Group II, who are developing 5 Shared Socioeconomic reference Pathways (SSPs) that span a range of challenges for mitigation and adaptation (Figure O.1).

Figure O.3: 5 SSPs for which basic narratives were developed in 2011[40]

Variations in socioeconomic models are called narratives (or storylines) by the IPCC and they are expected to form a key plank of on-going investigation into the best way to address climate change. The 'Impacts, Adaptation and Vulnerabilities' part of AR5 is scheduled for release in March 2014 and it will report on new 'shared socioeconomic pathways' (SSPs).

Science communication

As the *framework* developed to guide the SoE 2013, this office joined a science communication community seeking more effective environmental reporting methods to both reflect and guide the work of a wide range of stakeholders.[42] Science communicators have been engaged in critical self-scrutiny in the past few years, striving to describe climate change impacts and adaptation strategies, biodiversity and the role and value of ecosystem services like clean air, fresh water, soils, and the cultural and recreational enjoyment the environment provides.[43]

The task is vast. Our *Foundation Papers* captured specific issues. Those papers emerged out of the scholarship and responded to and involved consultation with the community, scientists, local government and a broad spectrum of organisations and agencies. Public consultation efforts are explained in our report *Many Publics. Participation, Inventiveness and Change.* This report should be read as an adjunct to this larger work, as it outlines:

- the breadth of community commitment and leadership to doing better for the environment
- the public interest in reporting being accessible
- concerns about policy and organisational alignment and integration.

Not only is reporting on the state of the environment a deep and broad research endeavour, the task is also urgent. Organisations such as the World Bank,[44] OECD,[45] the UN,[46] TEEB for Business Coalition,[47] the World Business Council for Sustainable Development,[48] the World Economic Forum with its references to Sustainable Consumption and Creating a Low Carbon Economy,[49] and many authoritative others, have joined the IPCC to record concerns and promote immediate and aggressive remedial action. Increasingly reports and analysis reflect the need to undertake interdisciplinary work to more effectively communicate the deepening crisis we face as a function of climate change and biodiversity loss.[50] Australia's recent submission to the IPCC 2013 review stated the need to survey end users about the utility of reports and suggested those surveyed should include the research community, authors and government, but also observer groups and 'the wider society'.[51]

Reports and reporters are part of this ever expanding field and in this State of the Environment report we endeavour to capture and reflect this unfolding dialogue.

Science, Policy, People

As the triple pillars of environmental, social and economic considerations come into play to generate conditions conducive to ecologically sustainable development[52] environmental reporting is clearly infinitely more than the straight forward recitation of existing or accessible biophysical data.

Environmental reporting is increasing in importance. Its role is to actively encourage decision makers and the community to increase efforts to care for, protect and preserve the environment – not only because it has intrinsic value – but because it is fundamental to our *real* standard of living.

In the Commonwealth's 2011 *State of the Environment Report*[53] this is simply expressed –

Australians cannot afford to see themselves as separate from the environment.

Our overarching reporting objectives are that this SoE 2013 will reflect the ***science***, aid in the development of ***policy***, and speak to ***people*** at a time when our environmental indicators tell us we need to commit to and actively implement change – aggressively and as a matter of urgency.

SoE 2013 – *In summary*

Organising environmental data, knowledge and information[54] to meet statutory objectives[55] and accountabilities[56] and provide a cogent and compelling narrative in a State of the Environment Report is a complex task, compounded by the persistent observation that environmental monitoring is inadequate.[57]

External drivers such as climate change, population growth and economic growth[58] impose even greater complexity on the reporting task. Changes in data, demographics and development and jurisdictional imperatives increase the range of countervailing positions.

In the face of these challenges we have endeavoured to make this report accessible, readable and its information manageable, by producing it in two parts.[59]

Guide to the SoE 2013

The SoE 2013 contains two main parts and an epilogue.

Part A *Trends and Analysis*

Trends and Analysis of key indicators in the following categories to:

- Climate change and air quality[60]
- Biodiversity and land[61]
- Inland waters[62]
- Marine and coastal environments[63]
- Human settlements.

The reported Indicators inform us of the current condition and trends apparent for Victoria's environment, and also provide insight into the effectiveness of environmental management policies and activities.

Part B *Goals and Recommendations*

Goals for protecting and enhancing Victoria's ecosystems and our community's continued prosperity. The goals are:

- Resilient ecosystems
- Sustainable natural resources
- Sustainable energy
- Sustainable communities
- Understanding the environment

Recommendations for action are detailed across the goals in Part B. The recommendations are presented along with attributes for implementation to guide community discussion and the Victorian Government's consideration of the actions proposed.

Epilogue

The SoE 2013 concludes with an ***Epilogue,*** which considers how we might better measure well-being to ensure we capture the environmental, economic and social constituents of an equitable and prosperous society and build community resilience.

Leadership, the key

Compilation of environmental trend data is not just an exercise for the satisfaction of academics, scientists and agency staff. The public have a vital interest in the work. Our consultations across the state and in metropolitan settings illustrated this.*

The research and consultation this office has conducted (2009-2013) underscores the need for:

- Improved **dialogue** between policy makers and the research community
- **Alignment** across agencies and **integration** of policy
- **Leadership** from government.

These issues play out in any discussion of the trends in environmental quality in Part A and they are explicitly discussed in Part B. Figure 3 provides a summary view of the SoE 2013, its recommendations and the inextricable way in which they all work to preserve the ecosystem service and the health and prosperity of our community.

* See our public consultation report *Many Publics. Participation inventiveness and change* found at www.ces.vic.gov.au for an extensive outline of the work the community is engaged in in respect of environmental issues.

Figure O.4: SoE 2013 at a glance

Resilient Communities

INCENTIVES

RECOMMENDATION **4** biolinks development
RECOMMENDATION **11** sustainable farming incentives
RECOMMENDATION **14** material reclamation

TARGETS

RECOMMENDATION **2** ecosystem targets
RECOMMENDATION **6** environmental water targets

REVIEW AND REPORTING

RECOMMENDATION **8** planned burning outcomes
RECOMMENDATION **9** appropriate fire suppression
RECOMMENDATION **12** urban food production
RECOMMENDATION **30** environmental monitoring audit

INFORMATION PROVISION

RECOMMENDATION **16** LCA tools
RECOMMENDATION **20** urban development awareness
RECOMMENDATION **32** environmental data portal
RECOMMENDATION **33** environmental scenarios

METHODOLOGY

RECOMMENDATION **18** Blueprint for a Modern Energy System Plan

RESEARCH

RECOMMENDATION **28** research emissions impacts
RECOMMENDATION **34** benchmarking vulnerability and adaptive capacity

As we completed this SoE 2013, the IPCC commenced its release of AR5. A summary of findings is provided below. The impacts of climate change are a significant environmental concern and require considered, strategic leadership and community engagement.

Rural Women Leading Change, Bendigo Forum with Commissioner 2011

IPCC Working Group I – 5th Assessment Report Release

WORKING GROUP 1 REPORT

The first part of the IPCC 5th Assessment Report (AR5) is the Working Group 1 Report*: Climate Change 2013 The Physical Science Basis*. This was **released on Friday 27th September.**

It is available from: www.climatechange2013.org

WORKING GROUP 1 – KEY FINDINGS[64]

- Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. This evidence for human influence has grown since AR4. It is *extremely* likely that human influence has been the dominant cause of the observed warming since the mid-20th century.
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.
- **Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C** relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is likely to exceed 2°C for RCP6.0 and RCP8.5, and more likely than not to exceed 2°C for RCP4.5.
- Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. **Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped**. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2.
- **Limiting the warming caused by anthropogenic CO_2 emissions alone** … **will require cumulative CO_2 emissions from all anthropogenic sources to stay [*below 880 GtC*].** An amount of 531 … GtC, was already emitted by 2011.

All direct quotes except in [square brackets].

ABORIGINAL ACKNOWLEDGEMENT

Canoe Tree, Moodie Swamp

Recognition of Aboriginal people's prior occupation and continuing cultural connection

We start this Victorian State of the Environment Report (2013) with an acknowledgement.

Aboriginal people have occupied, enjoyed and understood Victorian landscapes in cultural and practical ways for millennia. Aboriginal people have practised sustainable environmental management in deeply cultural ways, and this relationship persists, even if altered due to colonial occupation.

The complexity of Aboriginal people's patterns of sustainable occupation may have been divided in ways which looked something like this:*

Figure AA.1: Aboriginal tribal boundaries (Tindale)

We now recognise this connection in other ways, including native title.

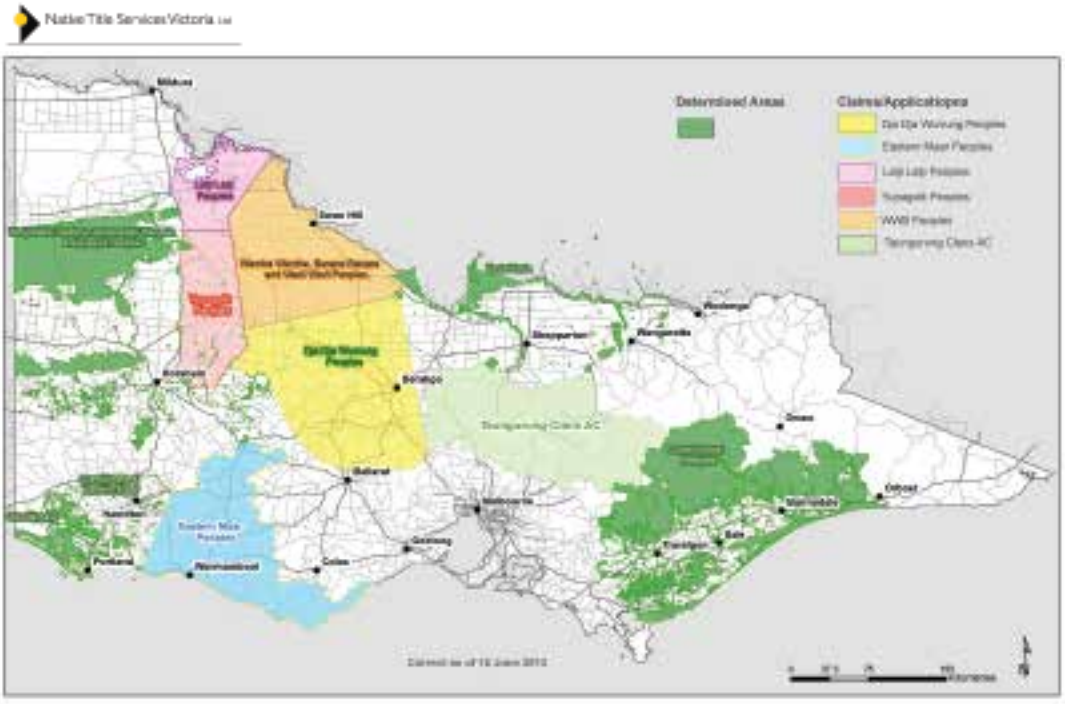


Figure AA.2: Native Title Claims/Determinations and Traditional Owner Settlement Act Applications in Victoria

* N.B. Tindale, 1974, *Aboriginal Tribes of Australia. Their Terrain, Environmental Controls, Distribution, Limits, and Proper Names*, Australian National University, Canberra. South East Australia Map – tribal boundaries. It should be noted that many Aboriginal people contest these boundaries and they cannot be used with confidence.

Aboriginal people shared their deep appreciation of the country. They told early Europeans about good country, water resources and biodiversity, medicinal plants, and, more prosaically, fishing places, river crossings and sheltering spots.

Aboriginal and western knowledge continue to meet and develop insights, together. Archaeologists,* drawing on long held narratives, now assure us that the western biophysical data we have collected generations later reflects Aboriginal people's knowledge, observations and oral traditions about matters as significant as sea level rise and retreat in Port Phillip Bay.

Among their considerable achievements Aboriginal people have conducted highly complex aquaculture.

Joseph Saunders demonstrates a traditional eel trap, Lake Condah

* Ian McNiven, 2011, *Aboriginal people's environmental understandings: Victoria*, paper prepared for the CfES see www.ces.vic.gov.au

Further, in contemporary contexts, Aboriginal women and men continue to concern themselves with old and new challenges: the age old issue of floods and, now, climate change.

Auntie Rochelle Patten, Yorta Yorta Elder, Barmah Forest National Park

PART A

Victoria:
STATE OF THE
ENVIRONMENT
2013

TRENDS AND ANALYSIS

INTRODUCTION PART A: TRENDS AND ANALYSIS

In *Part A: Trends and Analysis*, we report on environmental indicators that inform us of the current condition, and accompanying trends, of Victoria's natural environment. The indicators also provide insight into the effectiveness of environmental management policies and activities.

However, it should be noted that since the last State of the Environment report 2008, there have been a number of significant events that have affected Victoria's environment. These include the continuation and end of the Millennium Drought (1997 to 2009),[1] record breaking floods between September 2010 to February 2011,[2, 3] the devastating Black Saturday bushfires in February 2009,[6] and the occurrence of extreme heatwaves in early 2009 and the spring and summer of 2012–13.[8]

Such events have implications for a range of Victorian environments regardless of management. For example, drought conditions significantly reduced water availability for both terrestrial and aquatic ecosystems.

It is also important to note that environmental assessment is dependent on the availability, quality and comprehensiveness of data. This was found to be variable across the reporting themes, limiting the ability to determine environmental condition and trends for some indicators.

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Numurkah floods, 2012

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CHAPTER ONE CLIMATE CHANGE AND AIR QUALITY

A CLIMATE CHANGE

BACKGROUND

Climate change and its impact on Victoria is discussed in detail in Foundation Paper One, *Climate Change Victoria: The Science, Our People, and Our State of Play*.[1]

Climate change is considered to be the greatest environmental challenge facing Australia and Victoria. It has the potential to have significant natural, social and economic impacts both here and globally.

Solid scientific evidence supports the position that climate change is occurring now, and is caused by elevated concentrations of greenhouse gases in the atmosphere. Climate change in Australia has been reported by pre-eminent climate science scholars and reporters, CSIRO and the Australian Bureau of Meteorology.[2–5] This research shows that temperatures, sea levels and sea-surface temperatures are all rising in Australia.

Such changes will lead to significant ecosystem changes and biodiversity impacts, and will expose Victorians to increased droughts, fires, large storm events and coastal inundation (Figure A.1.1).

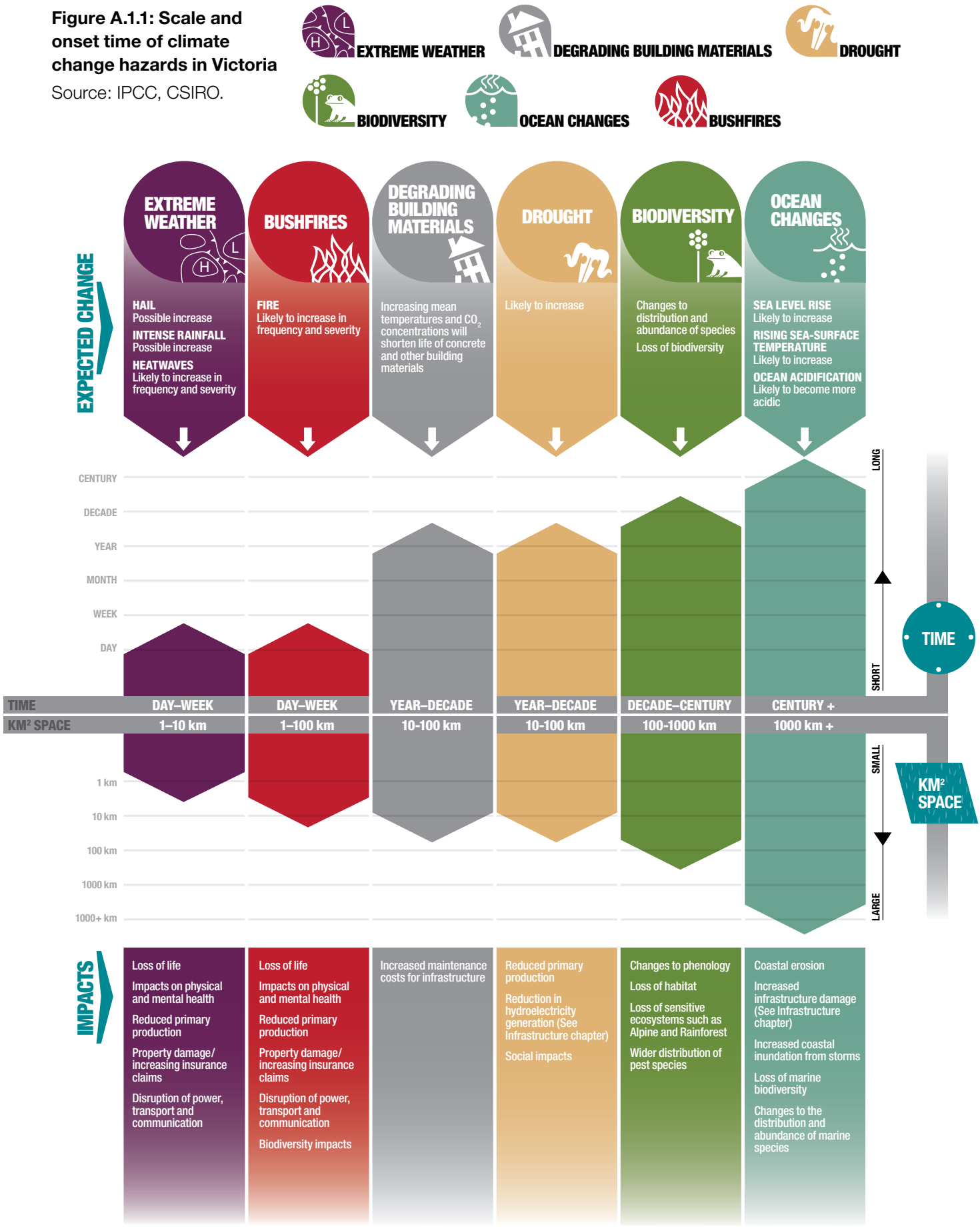
Some level of climate change is already unavoidable due to existing levels of greenhouse gases in the atmosphere.

To minimise the severity and impacts of climate change, emissions of greenhouse gases need to be reduced. Despite this, annual emissions are increasing both globally and in Victoria. Under current policies, the Organisation for Economic Co-operation and Development (OECD) estimates a rise in global greenhouse gas emissions of 50% by 2050.[6]

The opportunities to reduce greenhouse gas emissions and limit the severity of climate change are rapidly diminishing. However, action on climate change is proving to be a difficult global challenge. This is especially because climate change is hard to visualise; it happens slowly, almost imperceptibly; and impacts may have long lead times. However, strong action has to occur now if risks and their associated costs are to be avoided – the greater the warming, the greater the risk of irreversible climate change.

Figure A.1.1: Scale and onset time of climate change hazards in Victoria

Source: IPCC, CSIRO.



MAIN FINDINGS

Greenhouse gas emissions

- Victoria's greenhouse gas emissions continue to rise. In 2010–11, Victoria emitted a total of 118 million tonnes (Mt) CO_2-e of greenhouse gas, or 124 Mt CO_2-e when land use, land-use change and forestry are excluded. Between 1989–90 and 2010–11, total emissions increased by 12%, or 23% excluding land use, land-use change and forestry.
- Per capita greenhouse gas emissions decreased from 24 tonnes in 1989–90 to 21 tonnes in 2010–11. However, this decrease has been offset by population growth. Victoria's per capita emissions continue to place us among the world's highest polluters.
- Victoria is responsible for 21% of Australia's total net emissions.
- The stationary energy and transport sectors accounted for 68% and 14% of the total greenhouse gas emissions respectively. Agriculture was also a significant contributor, accounting for 11% of the total emissions.
- Emissions from the stationary energy sector increased by 42% between 1989–90 and 2010–11.
- Between 2000 and 2009, fires released 70 million tonnes of carbon dioxide, around 6% of the total emissions over the period. Large fires in 2007 released the equivalent of 20% of the total greenhouse gas emissions for that year.
- Passenger vehicles are the greatest contributor to greenhouse gas emissions in the transport sector. In 2008–09, passenger vehicles were responsible for 36% of all transport emissions in Victoria, 61% of all road-based transport emissions, and 96% of emissions from commuting.
- Passenger vehicle emissions increased by 21% between 1987–88 and 2008–09.
- In 2008–09, international air travel accounted for 21% of the total Victorian transport emissions. International air travel increased by 26% between 1987–88 and 2008–09.
- In 2010, Victoria's carbon stock for publicly managed forested land was estimated at between 680 and 775 Mt of carbon (or up to 2.8 billion tonnes of CO_2-equivalent). This represents roughly 25 years of Victoria's total annual greenhouse gas emissions.
- Carbon stocks in Victoria are vulnerable to climatic variation and the occurrence of bushfires.

Climate trends

- Average temperatures in Victoria have risen by approximately 0.8°C since the 1950s.
- The severity, duration and frequency of heatwaves have increased.
- Between 1997 and 2009, Victoria experienced a record-breaking 13-year drought, the longest recorded period of rainfall deficits on record.
- Over the past two decades, there has been a large decline in autumn rainfall, a small decline in winter and spring rainfall, a small increase in summer rainfall, and reduced frequency of very wet years.
- Victoria experienced its highest summer rainfall on record in 2010–11. The record rainfall led to major flooding that affected a third of Victoria.
- Since 1993, Victoria's sea level has been similar to global averages of 3 mm per year.
- Annual sea-surface temperatures in south-eastern Australia increased at a rate of 0.023°C per year, approximately four times the global ocean-warming average.

Climate change projections

- By 2030 warming in Victoria is likely to range from 0.6°C to 1.2°C on 1990 temperatures and by 2070 from 0.9°C to 3.8°C.
- Runoff is projected to decrease between 5% and 45% by 2030 and between 5% and 50% by 2070.
- Fire risk is forecast to increase substantially, with the number of very high or extreme fire danger days expected to increase by up to 25% by 2020 and up to 230% by 2050.
- By 2070 drought frequency is likely to increase by between 10% and 80% in the southern half of the State and by between 10% and 60% in the northern half.
- More frequent extreme weather events are predicted, with increasing damage from flooding, high winds and coastal storm surges and inundation.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
CC1 Trends in greenhouse gas emissions in Victoria	Between 1989–90 and 2010–11, total emissions increased by 12%, with stationary energy emissions increasing by 42%.		
	Per capita greenhouse gas emissions decreased from 24 to 21 tonnes between 1989–90 and 2010–11. However, this decrease was offset by population growth. With per capita emissions high compared to the global average, Victorians are among the world's largest greenhouse gas emitters.		
CC2 Victorian ecosystem contribution to global greenhouse gas balance and carbon storage	Victoria's forests store a considerable amount of carbon but are vulnerable to the occurrence of bushfires, which have temporarily decreased carbon storage in some areas. Carbon stocks are likely to be impacted by climate change with increased periods of drought and fire risk. Knowledge of Victoria's carbon stocks is improving but is mainly limited to forested public land.		
CC3 Climate trends in Victoria	Average temperatures in Victoria have risen by approximately 0.8°C since the 1950s and the severity, duration and frequency of heatwaves have increased. There has been a decline in autumn, winter and spring rainfall over the past two decades.		
CC4 Projected climate trends in Victoria	Victoria's future climate is projected to become hotter and drier with an increased risk of bushfire and drought, decreased availability of water resources, and more frequent extreme weather events. These will have severe environmental, social and economic consequences.	NA	NA
CC5 Sea-surface temperature and sea-level rise	Annual sea-surface temperatures in south-eastern Australia increased at a rate of 0.023°C per year, approximately four times the global ocean-warming average. Since 1993, Victoria's sea-level rise has been similar to global averages of 3 mm per year.		

Indicator Assessment Legend

Status

- Environmental condition is healthy across Victoria, **OR** pressure likely to have negligible impact on environmental condition/human health.
- Environmental condition is neither positive or negative and may be variable across Victoria, **OR** pressure likely to have limited impact on environmental condition/human health.
- Environmental condition is under significant stress, **OR** pressure likely to have significant impact on environmental condition/ human health.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

NA Assessments of status, trends and data quality are not appropriate for the indicator.

Indicator CC1: Trends in Greenhouse Gas Emissions in Victoria

Annual greenhouse gas emissions

There has been a dramatic growth in global greenhouse gas emissions since 1750, mainly through the combustion of fossil fuels and widespread land clearing. As concentrations of these gases have increased, global temperatures have risen, causing changes to weather conditions worldwide.

In Victoria, carbon dioxide is the most significant greenhouse gas, contributing over 80% of total emissions in 2009.[7] The majority of carbon dioxide emissions come from industry, transport and energy generation. Emissions of methane and nitrous oxide, mainly from land management and agriculture, also make significant contributions of 12% and 4% respectively. Other greenhouse gases include manufactured gases such as sulfur hexafluoride, chlorofluorocarbons (CFCs) and some of their replacements.[8, 9]

Australia's greenhouse gas emissions

Compared to the rest of the world, Australians (per capita) make a disproportionately high contribution to global warming. Although Australia only generates about 1.5% of the total global greenhouse gas emissions, our per capita emissions make us among the world's largest polluters. In 2012, Australia's emissions per capita were 25 tonnes of carbon dioxide equivalent (CO_2-e) per person, although this has declined by 24% since 1990.[10] This is nearly twice the OECD average and more than four times the world average.[11]

Victoria's greenhouse gas emissions

Victoria's greenhouse gas emissions are reported annually in the *Australian National Greenhouse Accounts*.[12] In 2010–11, Victoria emitted a total of 118 Mt CO_2-e of greenhouse gas, or 124 Mt CO_2-e when land use, land-use change and forestry (LULUCF) is excluded (Figure A.1.2).[13] Victoria is responsible for 21% of Australia's total net emissions.[12]

The stationary energy and transport sectors accounted for 68% and 14% of the total greenhouse gas emissions in Victoria respectively (Figure A.1.3). The stationary energy sector is heavily influenced by Victoria's reliance on coal-based energy industries. Agriculture was also a significant contributor, accounting for 11% of the total emissions.

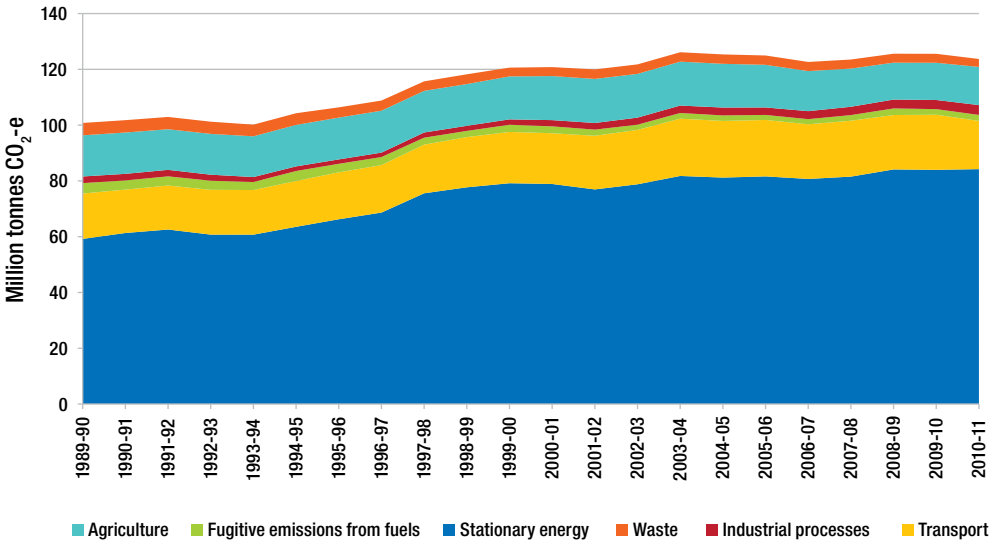
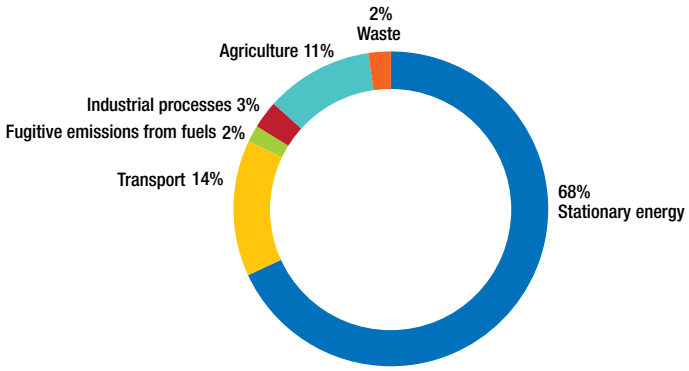


Figure A.1.2: Victorian greenhouse gas emissions by sector (excluding LULUCF), 1998–90 to 2010–11

Source: Australian Government Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Figure A.1.3: Sector contributions to Victorian greenhouse gas emissions (excluding LULUCF), 2010–11

Source: Australian Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.



Victoria's greenhouse gas emissions continue to rise. Between 1989–90 and 2010–11, total emissions increased by 12%, or 23% excluding LULUCF (Figure A.1.2).

The largest increases were 42% from the stationary energy sector, 48% from the industrial processes sector and 6% from the transport sector. Fugitive emissions from fuels, agriculture, waste and LULUCF emissions have all decreased since 1989–90 (Figure A.1.4).

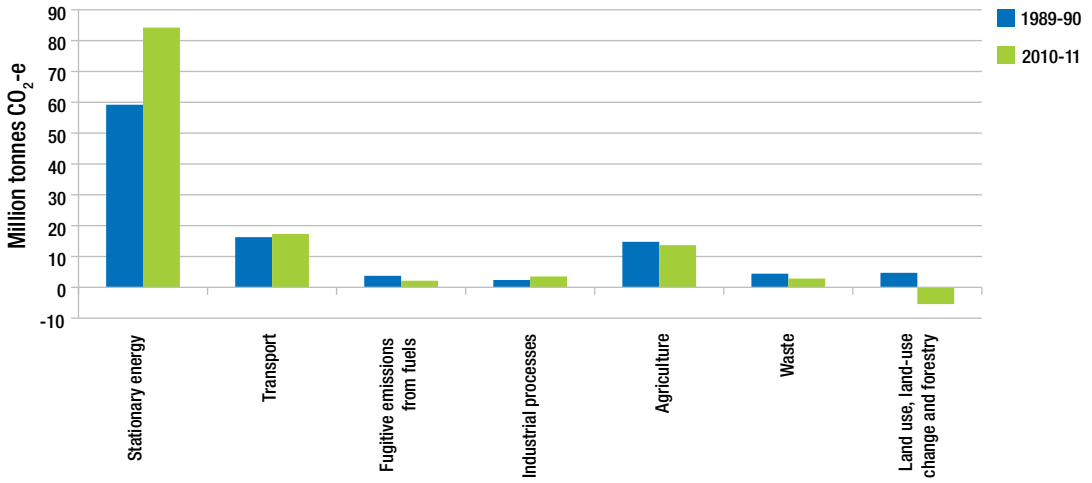


Figure A.1.4: Victorian greenhouse gas emissions by sector, 1989–90 and 2010–11

Source: Australian Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Notes: **'Stationary energy'** emissions from the production of electricity and other direct combustion of fossil fuels in industry; **'Transport'** emissions from air, road, rail and shipping transportation; **'Fugitive emissions from fuels'** emissions from the extraction and distribution of coal, oil and natural gas; **'Industrial processes'** direct emissions from the chemical and/or physical transformation of materials and the consumption of synthetic greenhouse gases; **'Agriculture'** emissions of methane and nitrous oxide from livestock, crops, agricultural and forest soils, and agricultural burning; **'Waste'** emissions from the disposal of solid waste to land, the treatment of domestic and industrial wastewater and the incineration of municipal and clinical waste; **'Land use, land-use change and forestry'** includes afforestation and reforestation (emissions and removals from forests established on previously cleared land since 1990), and deforestation (emissions and removals from the clearing of forest and replacement with other uses on land that was forest on 1 January 1990).

Despite the growth in total emissions, per capita greenhouse gas emissions have decreased from 24 tonnes in 1989–90 to 21 tonnes in 2010–11 (Figure A.1.5). However, this per capita decrease has been offset by population growth in Victoria.

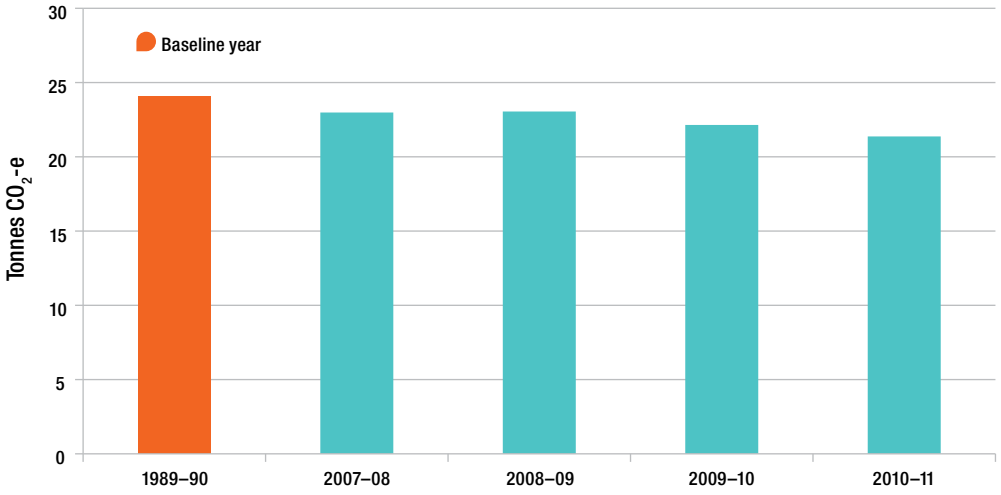


Figure A.1.5: Victorian per capita greenhouse gas emissions, 2010–11

Source: Australian Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Carbon dioxide emissions from fire

Fires are another source of greenhouse gas emissions in Victoria. It is estimated that nearly 70 million tonnes of carbon dioxide was released to the atmosphere as a result of fires between 2000 and 2009,[7] around 6% of the total emissions over the period.

Large fires can also be significant in terms of annual emissions – for example, fires in 2007 were equivalent to 20% of the total greenhouse gas emissions for that year.

For impacts of fires on carbon stocks see Indicator CC2: Victorian Ecosystem Contribution to Global Greenhouse Gas Balance and Carbon Storage.

Transport emissions

Passenger vehicles are the greatest contributor to greenhouse gas emissions in the transport sector. In 2008–09, passenger vehicles were responsible for 36% of all transport emissions in Victoria (Figure A.1.6). In terms of road-based transport, passenger vehicles contributed 61% of total transport emissions and 96% of total emissions from commuting (Figures A.1.7 and A.1.8). Passenger vehicle emissions increased by 21% between 1987–88 and 2008–09.[14]

Other significant trends in transport emissions include the following.[14]

- Buses and light rail only contribute 3% of commuting emissions in Victoria.
- Trucks and light commercial vehicles contributed 37% of road-based emissions and 21% of total travel emissions in 2008–09. Emissions from trucks and light commercial vehicles increased by 48% between 1987–88 and 2008–09.
- In 2008–09 international air travel accounted for 21% of the total transport emissions.
- Domestic air travel emissions increased by 34% between 1987–88 and 2008–09, with international air travel emissions growing by 26% over the same period.

Figure A.1.6: Greenhouse gas emissions from all transport in Victoria

Source: A. Pekol, *Victorian Transport Facts 2011.*[14]

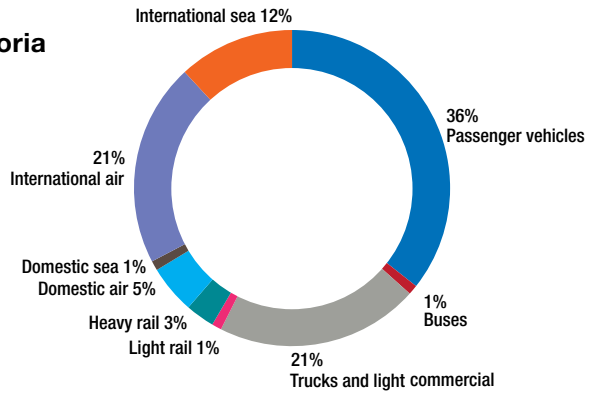


Figure A.1.7: Greenhouse gas emissions from road-based transport in Victoria

Source: A. Pekol, *Victorian Transport Facts 2011.*[14]

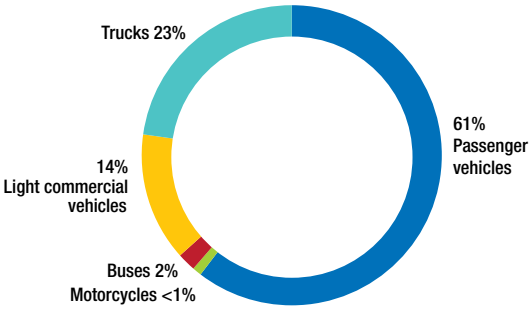
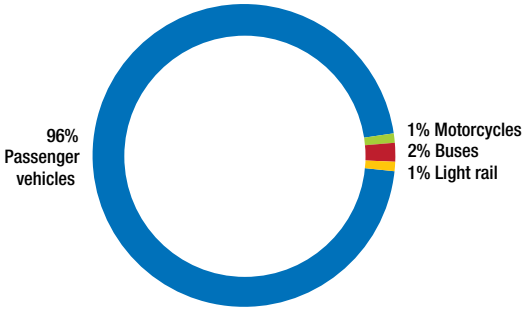


Figure A.1.8: Greenhouse gas emissions by commuting type in Victoria

Source: A. Pekol, *Victorian Transport Facts 2011.*[14]



Indicator CC2: Victorian Ecosystem Contribution to Global Greenhouse Gas Balance and Carbon Storage[15]

Forest ecosystems play an important role in the global carbon cycle and global greenhouse gas balance by storing carbon in both trees and soil.

Carbon storage is dependent on a range of factors that are impacted by climate change, such as rainfall, soil moisture, nutrient availability, and disturbances such as bushfire.

Land-use change (permanent clearing) and forest harvesting also affect carbon storage.

Victoria's forests store a considerable amount of carbon. In 2010, Victoria's carbon stock for publicly managed forested land was estimated at between 680 and 775 million tonnes of carbon (or up to 2.8 billion tonnes of carbon dioxide equivalent). This represents approximately 25 years of Victoria's total annual greenhouse gas emissions (Figure A.1.9).

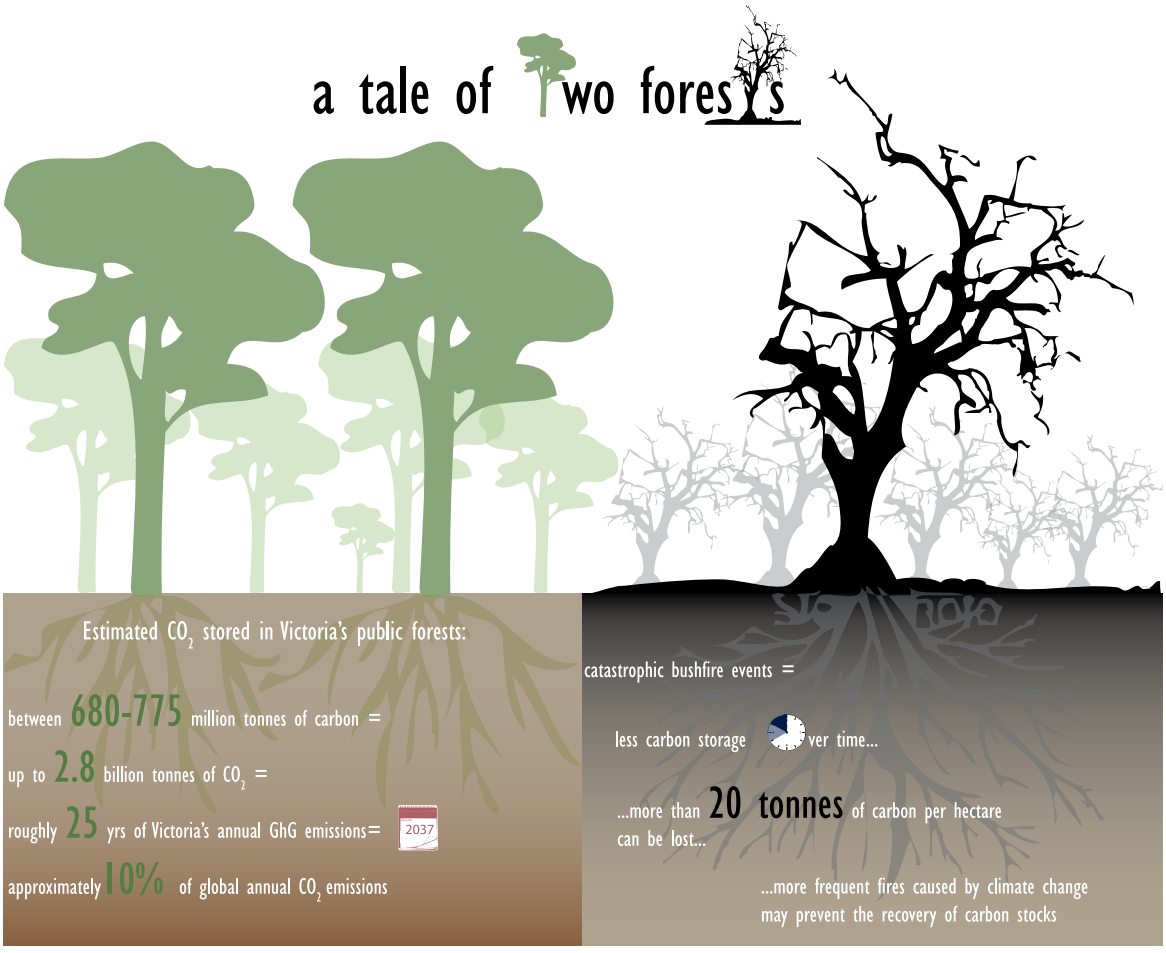


Figure A.1.9: Impacts of bushfire on carbon storage in Victorian forests

Source: Infographic based on DEPI information.

Figure A.1.10 shows the changes in the modelled total above-ground carbon stock for Victoria's public land estate between 1970 and 2010. A strong west to east and north to south trend is evident. This largely follows the rainfall gradient. In addition, the impact of recent fires appears across the Central Highlands and Alps, which have relatively low carbon stocks compared to the largely unburnt areas of the state in East Gippsland and the Strzelecki Ranges.

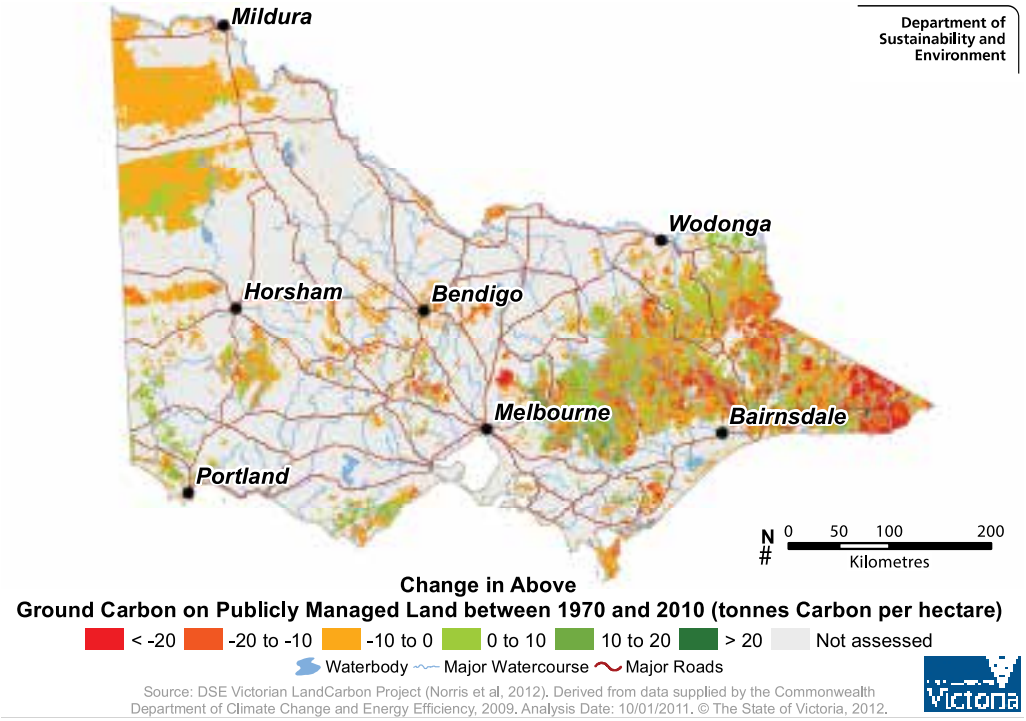


Figure A.1.10: Change in above-ground carbon on publicly managed land between 1970 and 2010 (tonnes carbon per hectare)
Source: DEPI.

Impact of fire on carbon stocks

Figure A.1.11 shows the area affected by the 2009 Black Saturday bushfires. The effect of the fires on carbon storage is shown by the change in carbon stocks between 2008 and 2010. Results show that catastrophic bushfire events can have considerable impacts on carbon stocks, with a change of more than 20 tonnes of carbon per hectare in some areas.

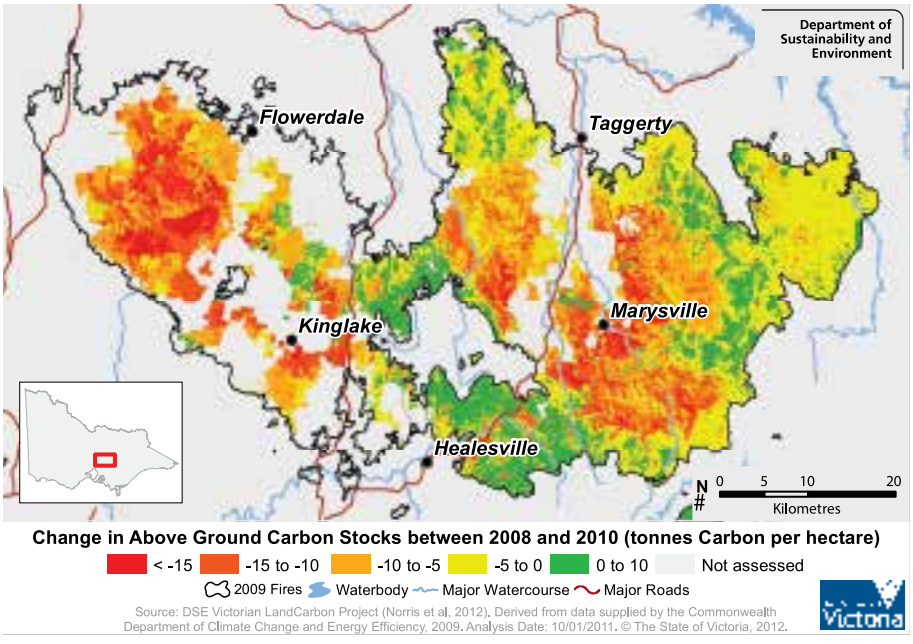


Figure A.1.11: Change in above-ground carbon stocks between 2008 and 2010 (tonnes of carbon per hectare)
Source: DEPI.

While the post-fire recovery of forests will increase carbon stocks, the projected increase in the occurrence and severity of fire as a result of climate change is of particular concern.

It is unlikely that Victoria's forests can remain resilient to the impacts of increased fire frequency.

Exceeding ecological fire tolerances is likely to result in forests being altered in terms of structure, dominant species and function – potentially storing less carbon over time.

Carbon stocks in Victoria are vulnerable to climatic variation and the occurrence of bushfires. This has important implications for the management of Victoria's carbon stocks with the ability of forests to take up carbon vital for the mitigation of climate change.

Indicator CC3: Climate Trends in Victoria

Victoria's climate is influenced by a range of factors, including atmospheric conditions (the Southern Oscillation) and changes in sea-surface temperatures (El Niño and La Niña cycles). These drivers of climate lead to large natural year-to-year variations in temperature and rainfall. However, long-term climate change caused by increasing greenhouse gas emissions is occurring at global scales and is cumulative over many years.

Climate change is now reported widely and the global warming trend is unequivocal. In south-eastern Australia, research has determined both the Millennium Drought (1996–2010) and the record-breaking rainfall in the summer of 2010–11 were found to be at least partly linked to climate change.[4]

Climate change is discussed in detail in Foundation Paper One, *Climate Change Victoria: The Science, Our People, and Our State of Play*.[1]

Observed surface temperature

Victoria's climate has been getting warmer since the 1950s (Figures A.1.12 to A.1.15).

There has been an increase in both the frequency and severity of hot temperatures and a decrease in cold temperatures. Average temperatures in Victoria have risen by approximately 0.80°C since the 1950s.[16] Annual maximum temperatures rose by 0.85°C from 1910 to 2010, slightly greater than the Australian average of around 0.75°C. Victorian minimum temperatures have increased by approximately 0.90°C between 1910 and 2010.[7]

Heatwaves are the most significant natural hazard in Australia in terms of loss of life. In January 2009, Melbourne experienced three consecutive days at or above 43°C. There were 980 heat-related deaths during this heatwave, which preceded the Black Saturday bushfires.

Over the period 1971–2008, the severity, duration and frequency of heatwaves have increased. In Melbourne, the long-term average number of days per year above 35°C was 9.9, but between 2000 and 2009, the average number rose to 12.6 days. This increase is quicker than climate model projections.[16]

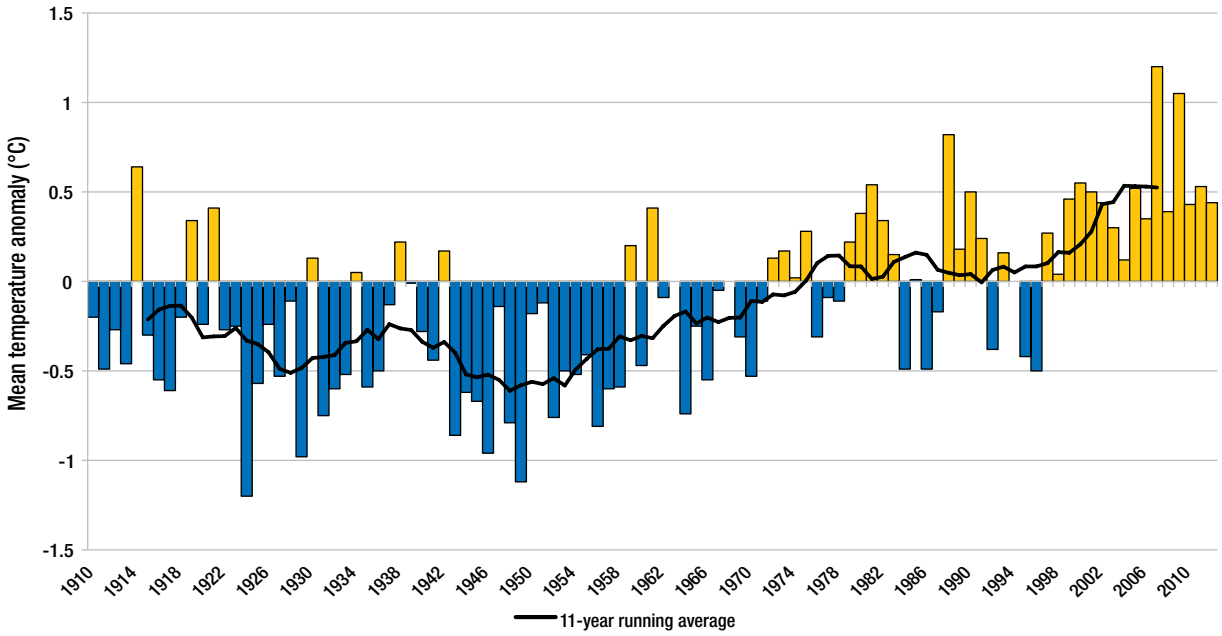


Figure A.1.12: Victorian mean temperature anomaly, 1910 to 2012

Source: BoM.

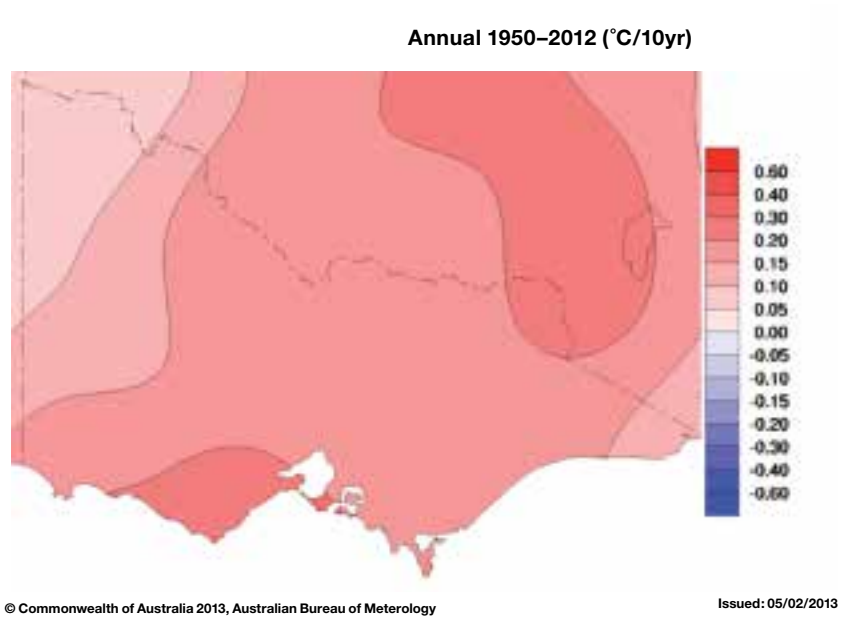


Figure A.1.13: Trend in Victorian mean temperature, 1950 to 2012

Source: BoM.

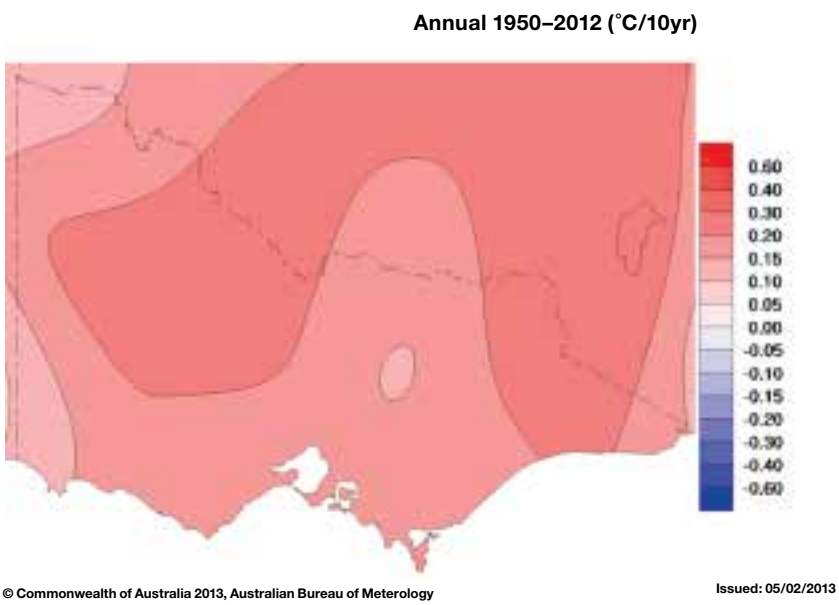


Figure A.1.14: Trend in Victorian maximum temperature, 1950 to 2012

Source: BoM.

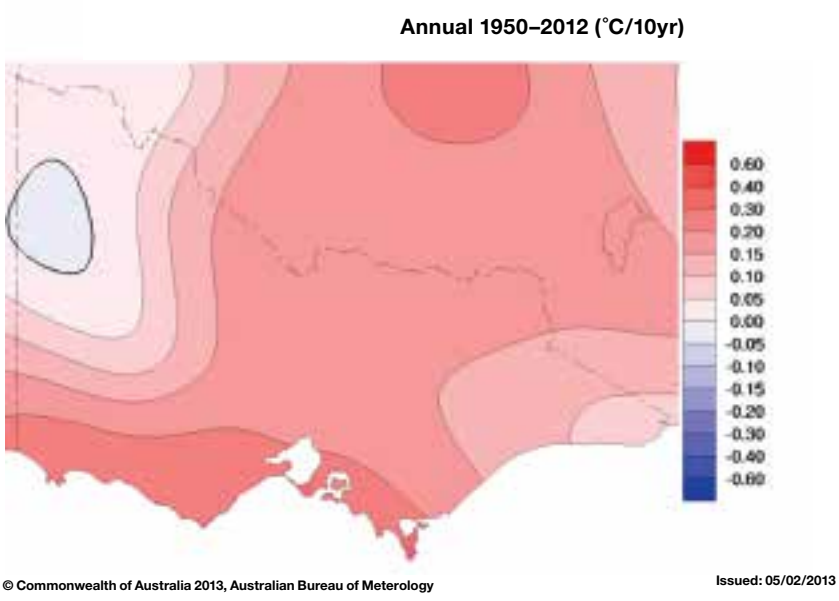


Figure A.1.15: Trend in Victorian minimum temperature, 1950 to 2012

Source: BoM.

Observed average rainfall

Annual rainfall in Victoria experienced large variations over the past century with no long-term trend (Figures A.1.16 to A.1.18). However, over the past two decades there has been a large decline in autumn rainfall, a small decline in winter and spring rainfall, a small increase in summer rainfall, and reduced frequency of very wet years.[7, 16]

Between 1997 and 2009, Victoria experienced a record-breaking 13-year drought – the longest recorded period of rainfall deficits on record. During this period, the annual inflow into Melbourne's dams dropped by almost 40%, and total water storage was down to 17% in 2009. In the Wimmera Southern Mallee region, drought conditions resulted in an 80% reduction in grain production and a 40% reduction in livestock production.[16]

Despite the drought ending in 2010 with two above-average rainfall years (2010 was the fifth-wettest year on record), ongoing declines in autumn rainfall persist, leaving large areas of Victoria with below-average rainfall.

Victoria experienced its highest summer rainfall on record in 2010–11. Record levels of rainfall were recorded across most of the state, with western, central and north-eastern Victoria particularly affected.

The high rainfall was the result of a combination of weather phenomena, including one of the strongest La Niña events ever observed and record high sea-surface temperatures to the north of Australia, which are associated with high rainfall in Victoria[7] The record rainfall led to major flooding that affected a third of Victoria.

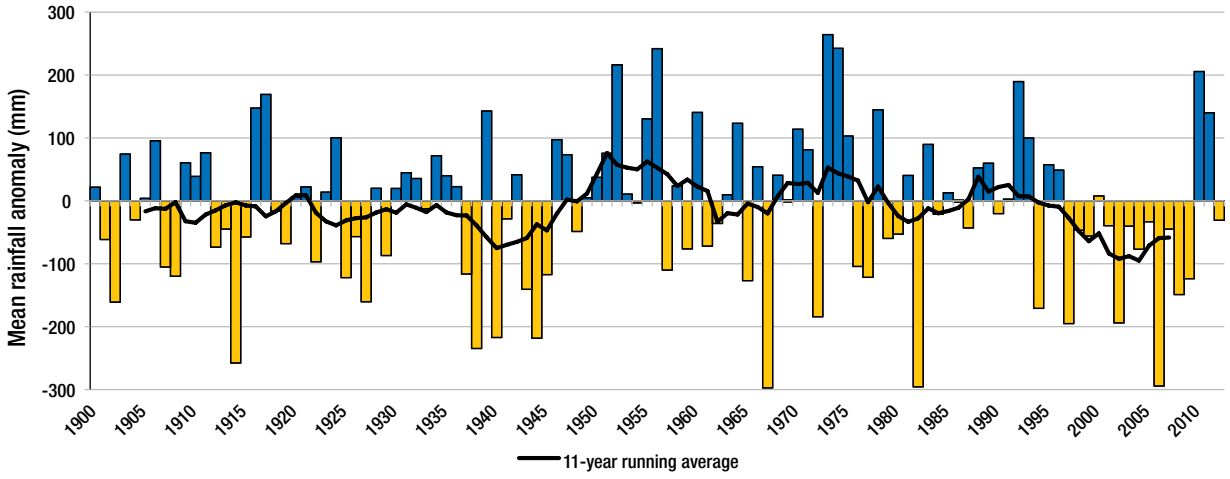


Figure A.1.16: Victorian annual rainfall anomaly, 1900 to 2012

Source: BoM.

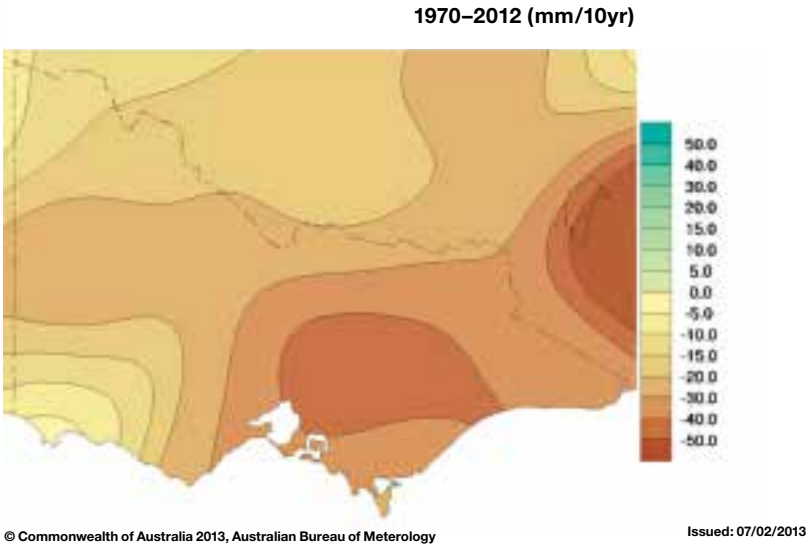


Figure A.1.17: Trend in Victorian annual total rainfall, 1970 to 2012

Source: BoM.

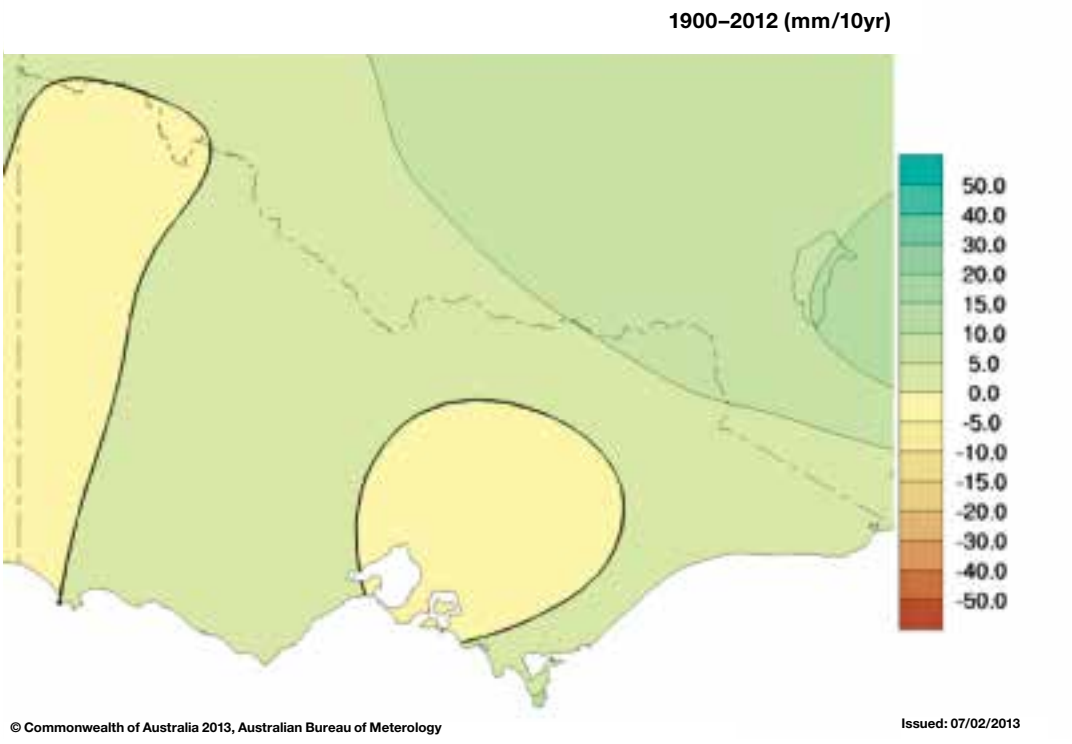


Figure A.1.18: Trend in Victorian annual total rainfall, 1900 to 2012
Source: BoM.

Snow cover

Snow cover in alpine areas is critical to Victoria's ecosystem resilience, water supply, biodiversity and recreation. It is also an important indicator of climate change extent and impacts.

The snow season over south-east Australia has shortened in recent decades, most likely due to higher temperatures in early spring, causing faster melting of snow on the ground and possibly less snowfall.[9] Between 1962 and 2001, the Australian Alps warmed by 0.2°C per decade with snow depth (measured at Spencers Creek in NSW) decreasing by 40% over roughly the same period.[17, 18]

In a recent study, Victorian snow measurements from 1954 to 2011 (taken from Rocky Valley Dam) showed a decrease in maximum snow depths and an earlier end to the snow season.[2] These changes were due to higher maximum temperatures and reduced snowfall from June to August.

CSIRO temperature and precipitation projections indicate that the length of the snow season will be reduced in the future with lower maximum snow depths.[2] The average snow-covered area of north-east Victoria is also likely to decline. Although natural year-to-year variability is projected, the number of good snow seasons is expected to decline while the number of poor seasons is likely to increase.*

* J. Bhend et al., *Climate Change Impacts on Snow in Victoria, 2012*, 2012, The Centre for Australian Weather and Climate Research.

Indicator CC4: Projected Climate Trends in Victoria

The range of climate projections in Australia was examined in detail by CSIRO in the 2007 analysis *Climate Change in Australia*.[9] The outcomes for Victoria were discussed in detail in the previous State of Environment report in 2008. Main findings include:

- By 2030 warming in Victoria is likely to range from 0.6°C to 1.2°C on 1990 temperatures and by 2070 from 0.9°C to 3.8°C.
- The 2030 rise is largely locked in by the current level of emissions, with the 2070 projections dependent on rates of global growth and measures put in place to reduce greenhouse gas emissions.
- Runoff into most of our waterways is projected to decrease between 5% and 45% by 2030 and between 5% and 50% by 2070.
- Fire risk is forecast to increase substantially in Victoria, with the number of very high or extreme fire danger days across south-eastern Australia expected to increase by up to 25% by 2020 and up to 230% by 2050.
- By 2070 drought frequency is likely to increase by between 10% and 80% in the southern half of the state and by between 10% and 60% in the northern half.
- More frequent extreme weather events are predicted, with increasing damage from flooding, high winds and coastal storm surges and inundation; a current 1 in 100 year extreme storm surge could occur around every five years by 2070. Projected sea-level rises will further exacerbate these problems.
- An updated analysis of the implications of global climate change projections for Australia, using the most recent modelled data, is currently being undertaken by CSIRO and will be available to the public in 2014.

Future Climate Zones in South-East Australia

The effects of changing patterns of rainfall and temperature were assessed in Foundation Paper One, *Climate Change Victoria: The Science, Our People, and Our State of Play*. This analysis used global model data to estimate potential southward movement of climate zones in south-east Australia by 2050 compared to the 1975–2004 baseline climate.

Based on a 'business as usual' scenario (IPCC A1FI),[19] some of the key outcomes were:

- decrease in the area covered by temperate climate from 55% to between 32 and 37% in 2050
- increased area of desert climate in south-east Australia from 5% to between 11 and 24% of the analysed area in 2050
- the emergence of a persistently drier climate in the western districts
- rising temperatures across Victoria leading to hotter summers.

Modelled outcomes were also examined under a lower emissions scenario (SRES B1).[19]

In this case, the most severe changes were often avoided in southern Victoria but substantial changes in climate were still seen in the north-west.

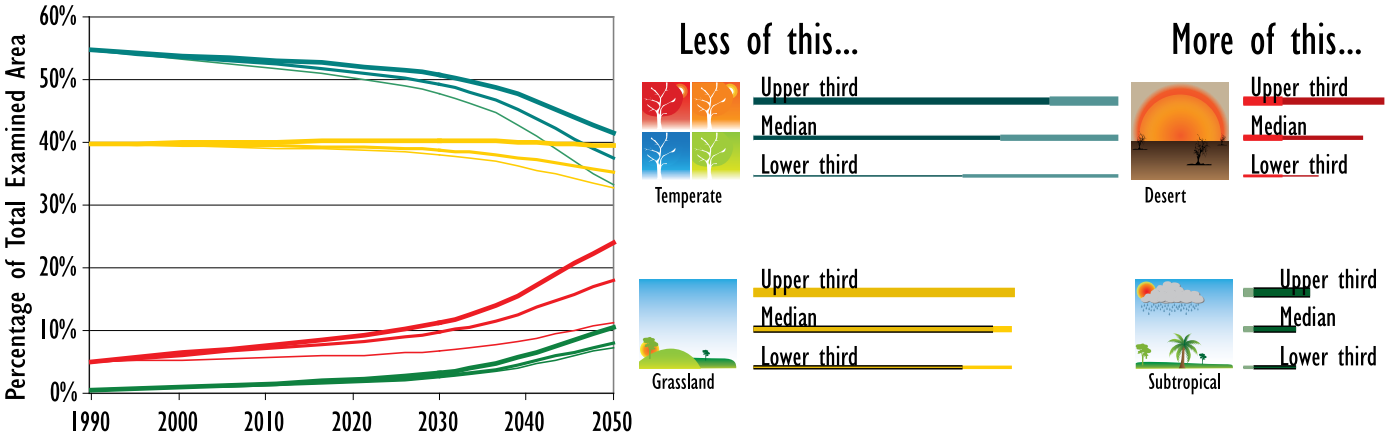


Figure A.1.19: Projected change in area covered by Subtropical, Temperate, Grassland and Desert climate zones in south-east Australia in 2030 and 2050 compared to 1990 under an unabated use of fossil fuels scenario (A1FI)

Note: The plots summarise the output of 23 global climate change models and show the median change across all models and the range of the middle 33% of changes.

Source BoM.

Indicator CC5: Sea-Surface Temperature and Sea-Level Rise

Sea-surface temperature

Victorian waters are getting warmer, with annual sea-surface temperatures increasing by around 0.8°C since 1910 (Figure A.1.20).

Southern Australia has experienced some of the fastest increases in ocean temperatures globally.

This rise in temperature is mainly due to the southern extension of the East Australian Current (Figure A.1.21). Changes in climactic conditions have strengthened the current by 20% in the last 50 years, increasing its southward penetration by 350 km.[20] The current brings warmer and saltier waters from north-east Australia down the east coast and its strengthening has caused warming at a rate of 0.023°C per year, approximately four times the global ocean-warming average.[21]

The changes in current strength and rising sea temperatures are likely to have severe consequences for marine ecosystems in Victoria.

In 2010, sea-surface temperatures in the Australian region were the highest on record, with nine of the months during 2011 ranked in the top 10 warmest months on record. Ocean temperatures around Australia were warmer during 2010–11 than for any previously identified La Niña event. This outcome was probably caused by the long-term warming trend of the past century.[5]

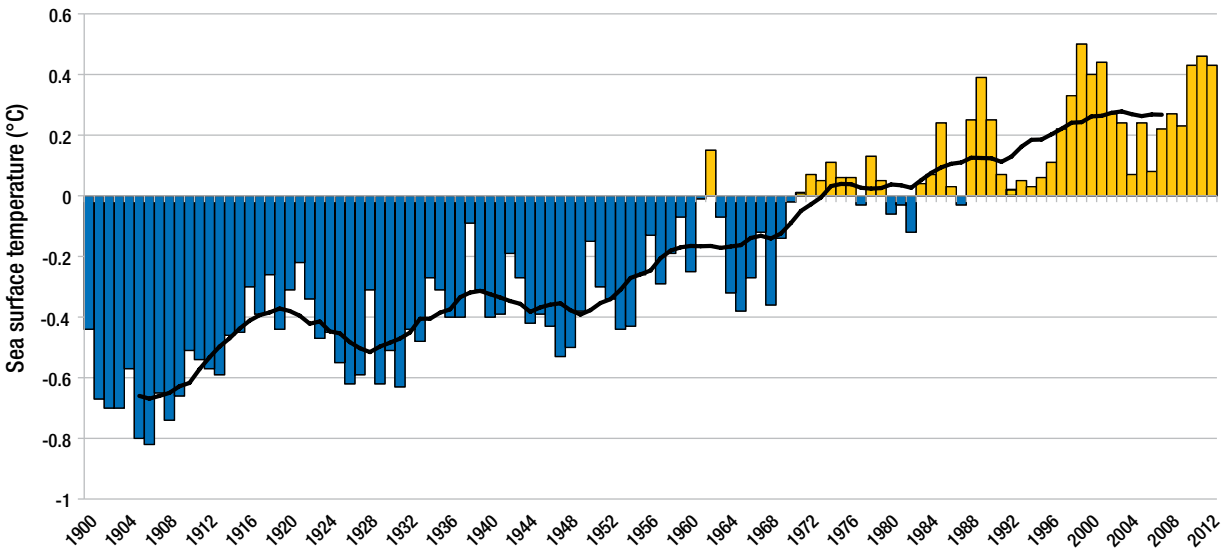


Figure A.1.20: Annual sea-surface temperature anomaly, southern region 1900–2012
Source: BoM.

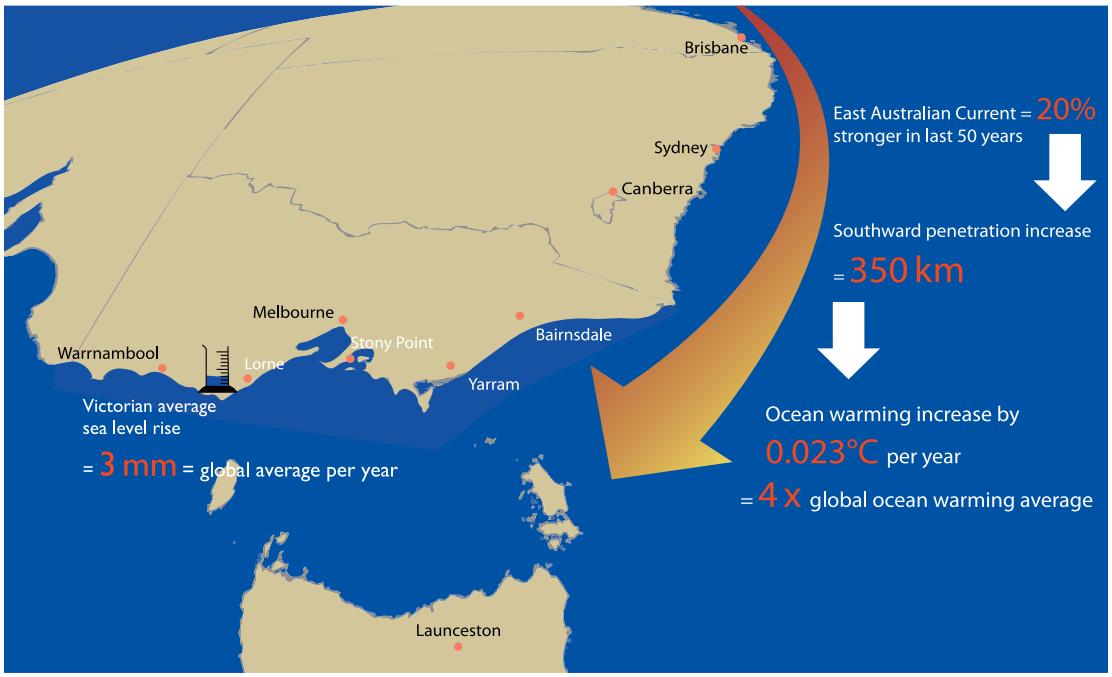


Figure A.1.21: Changes to the East Australian Current [20, 21, 22]

Observed sea level

Sea-level rise is the result of thermal expansion of ocean water in response to global warming and increases in ocean mass from the melting of glaciers (with smaller contributions from the polar ice sheets).

Global rates of sea-level rise are not uniform and vary from year to year, and by region. This is because of differences in conditions such as ocean currents and prevailing winds.

Global average mean sea level rose 210 mm (± 30 mm) between 1880 and 2011 (1880 is the earliest year for which robust estimates are available). Sea-level rise was faster between 1993 and 2011 than during the 20th century as a whole. Global average sea level rose at a rate of 3 mm per year between 1993 and 2011, compared to 1.7 mm per year during the 20th century as a whole, placing it at the high end of current projections.[5]

Victorian sea-level recording stations Lorne and Stony Point have shown an annual rise of 2.7 mm and 2.6 mm respectively since 1993.[23] Averaged annual sea-level rise across all Victorian waters is considered to be similar to the global average of 3 mm over the same period (Figure A.1.21).[5] Sea-level rise in Australia is highly variable, with the north and north-west regions showing a rise of 7 to 11 mm per year, two to three times the global average.

B AIR QUALITY

BACKGROUND

Good air quality is essential for human health and the environment. Air quality is primarily of concern in areas with high concentrations of population, transport and industrial activities. Such areas can experience localised air-quality problems, which have the potential to cause adverse health impacts. The common air pollutants – ozone, particles, nitrogen dioxide, carbon monoxide and sulfur dioxide – are associated with a range of health effects.

Currently, the main sources of air pollution in Victoria are industry, wood heaters, windblown dust, bushfires, planned burning activities such as fuel reduction burns, and motor vehicles (especially diesel exhaust).

Climate change will compound existing threats, with higher temperatures likely to increase the risk of more frequent and severe fires and dust storms, as well as an increase in summer smog formation.

EPA Victoria monitors air quality at 14 sites across Victoria (Figure A.1.22), with 12 in metropolitan Melbourne (11 long-term and one short-term), one in Geelong and one in the Latrobe Valley. EPA Victoria also receives data from industry-operated stations such as the Alcoa site at Point Henry.

Figure A.1.22: EPA Victoria air-quality monitoring sites in Melbourne and Geelong

Source: EPA Victoria.

MAIN FINDINGS

- Victoria has good air quality by international standards, although areas of poor air quality exist.
- Current air pollution levels can cause adverse health impacts.
- Levels of some gaseous pollutants, especially carbon monoxide and nitrogen oxides (emitted by cars and trucks), have significantly decreased in Melbourne since 1996.
- Levels of particle pollution (PM_{10} and $PM_{2.5}$ and visibility reduction) have been relatively stable since 1996, except for very high levels during fire and dust events.
- Bushfires and dust storms linked to prolonged below-average rainfall are the main causes of poor air quality across Victoria.
- Particle pollution is the most significant air-quality issue in Victoria.
- Levels of fine particles and ozone do not always meet the objectives set out in Victoria's ambient air-quality policy.
- Odour is a significant issue in Victoria, with around 4,000 complaints made to the Environment Protection Authority Victoria (EPA) each year.
- Climate change is likely to increase the frequency and severity of bushfires and drought leading to greater smoke and dust impacts on Victoria's air quality. Planned burning measures to reduce the severity of bushfires is also likely to increase smoke impacts in many areas. In addition, higher temperatures are likely to increase summer smog formation.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
AQ1 Status and trends in levels of air pollutants	Victoria's air quality has improved significantly over the past decades and remains good by international standards. Fires and dust storms continue to be responsible for the most severe air pollution events. However, some localised problems occur from the accumulation of urban pollution sources, including wood heaters, transport exhaust and industrial pollution. While air quality monitoring is good in Melbourne, regional monitoring is limited.		Melbourne Regional Victoria
AQ2 Emissions of major air pollutants by sector	Future air-quality projections show a net reduction in total vehicle exhaust emissions due to better vehicle exhaust controls. In contrast, road dust is expected to increase in line with traffic growth. Industrial emissions will remain relatively stable over time, although some increases are predicted due to growth in economic activity. Emissions linked to domestic and business activity are expected to grow in line with population growth.	NA	NA
AQ3 Health impacts of air pollution	Although no recent comprehensive data are available for Victoria, previous studies suggest that there are relationships between human health and air pollution. Current air pollution levels are known to impact on the health of sensitive people.		

Indicator Assessment Legend

Status

- Pressure likely to have negligible impact on environmental condition and/or human health.
- Pressure likely to have limited impact on environmental condition and/or human health.
- Pressure likely to have significant impact on environmental condition and/or human health.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

Deteriorating | Improving | Stable | Unclear

NA Assessments of status, trends and data quality are not appropriate for the indicator.

Current knowledge

Melbourne

Air quality in Melbourne has improved significantly since the 1970s and remains relatively good by international standards. This has occurred despite the pressures from a growing population and increased economic activity. Air-quality improvements are the result of Victoria's regulation of pollution sources, particularly in relation to industry, vehicle exhaust and backyard burning.

For example, gaseous motor vehicle exhaust pollutants such as carbon monoxide have significantly reduced over the last decade. In addition, particle pollution levels have remained relatively stable, except for periods of severe impact due to major fire and dust events.

Melbourne's air quality is considered to be relatively good for a major metropolitan centre.[24] Despite this, air pollution problems still exist in Melbourne because of localised sources such as industry and high-density traffic. For example, the EPA has found that Brooklyn in Melbourne's west has experienced ongoing air-quality problems (see Case Study: Air Quality Monitoring in Brooklyn, Melbourne).[24]

EPA Victoria has also undertaken air toxics monitoring at residential sites in Tullamarine beside the old Tullamarine landfill, and at residential sites surrounding the Dandenong South industrial precinct. The majority of the air toxics were detected at low levels or not at all.

Case Study: Air Quality Monitoring in Brooklyn, Melbourne[25, 26]

In late 2009, EPA commenced an air-quality monitoring program in Brooklyn, a suburb 10 km west of the Melbourne city centre. The area had been subject to high levels of particle pollution with the suspected cause being the Brooklyn Industrial Estate.

Particle pollution can have significant health impacts, particularly for young children, the elderly, and people with respiratory (such as asthma, bronchitis and emphysema) and heart conditions. Main health impacts include:

- increased allergic reactions and asthma attacks in people with these pre-existing conditions
- increased breathing-related problems in people with respiratory conditions
- increased symptoms of existing heart problems
- in severe cases, hospitalisation.

Monitoring results show that particle pollution (PM_{10} – particles smaller than 10 micrometres in size) in Brooklyn is much higher than other regions of Melbourne and Geelong (Figure A.1.23). Between November 2009 and April 2013, the PM_{10} air-quality objective was exceeded on 95 days, including on 38 days between November 2009 to October 2010.

Annual exceedences in Brooklyn are significantly higher than the Ambient Air Quality National Environment Protection Measure for particles, which states levels should not exceed the PM_{10} air-quality standard on more than five days a year.

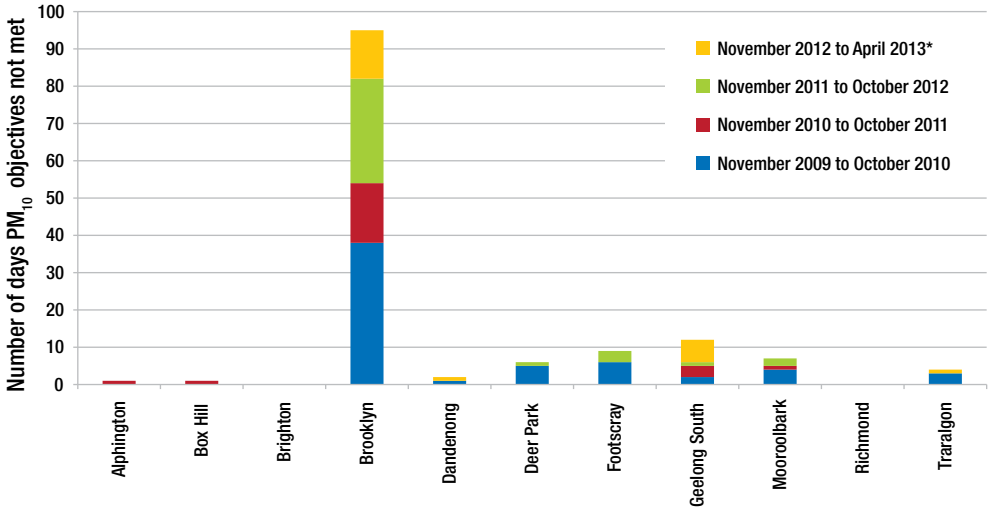


Figure A.1.23: Number of days PM_{10} objectives not met, Victorian air-quality monitoring stations

Source: EPA Victoria.

*Note: *Only six months of monitoring data available for 2012–13, from November to April.*

Poor air quality in Brooklyn generally occurred on weekdays, particularly mornings, during dry periods with strong and persistent northerly winds.

In addition, the $PM_{2.5}$ reporting standard was not exceeded, showing that larger particles are causing the poor air quality. The major source of larger particles was windblown dust, derived from clay, soil, silt, sand, crushed building material, unpaved roads and other similar material. No other harmful particles were found.

These findings confirm that activities within the Brooklyn Industrial Precinct are the source of the ongoing air pollution, including from large trucks travelling along unsealed roads in the industrial estate. About 30% of the PM_{10} measured during days with high particle levels is attributable to dust from roads in the estate.

The Victorian EPA is continuing to monitor air quality in Brooklyn. The monitoring enables the EPA to respond to community concerns and work with local industries and government to improve dust management practices in the area.

Regional Victoria

Knowledge of regional air quality is limited to short-term measurements (typically 12 months) taken in a limited number of Victorian towns (including Bairnsdale, Ballarat, Bendigo, Bright, Mildura, Morwell East, Shepparton, Wangaratta and Warrnambool), and evidence from targeted emission studies. While regional air quality is generally better than in Melbourne, problems do occur, including:[24, 27]

- poor air quality during dust storms, bushfires and planned burning activities, including agricultural burning
- odour and dust, which can be serious problems, especially near local industries such as agriculture, mining and intensive animal production
- smoke from the use of wood heaters in winter
- elevated sulfur dioxide levels in areas around power stations, refineries and smelters.

Future issues

The EPA has identified the following issues for future air quality in Victoria.[27]

- The key pollutants of concern in the future are expected to be particles ($PM_{2.5}$ and PM_{10}) and ozone (O_3). These pollutants are likely to continue to breach current air quality standards.
- Emissions from many unregulated sources are expected to increase or, at best, remain unchanged. These sources include wood heaters, small petrol engines (used for garden maintenance, generators, etc.), and small to medium industries.
- Bushfires, dust storms and planned burns are likely to cause major air-quality impacts. These will vary from year to year depending on weather conditions.

Indicator AQ1: Status and Trends in Levels of Air Pollutants

Particle pollution (PM_{10} and $PM_{2.5}$)

Particle pollution is the most significant air-quality issue in Victoria, with high levels associated with respiratory and cardiovascular illness. The specific effect of a particle on health depends on its size, composition and concentration. Particles are associated with increased respiratory symptoms, aggravation of asthma, increased mortality and hospital admissions for heart and lung diseases.

The most common measures of particles are PM_{10} (particles smaller than 0.010 mm) and $PM_{2.5}$ (particles smaller than 0.0025 mm). Particles smaller than 2.5 micrometres are considered to have more significant health impacts due to their deeper penetration into the lungs.

Particle pollution is usually the community's main indicator of air quality, often evident as a haze that reduces visibility. Particle pollution can result from both anthropogenic sources (industry, motor vehicles – particularly diesel, wood heaters) and natural sources (dust storms, bushfires, sea salt).

Climate change is likely to increase the occurrence of particle pollution with conditions leading to dust storms and more prevalent fires.

PM_{10}

PM_{10} has been measured on a daily basis since 1995 in Melbourne and since late 2002 in Geelong and the Latrobe Valley. Annual average PM_{10} levels (Figure A.1.24) have remained relatively unchanged over the monitoring period and show no clear trend. Although the data suggest a higher particle load in Geelong, results have been influenced by a local dust source and may not accurately represent the Geelong region. Average PM_{10} results are generally a little higher in Melbourne than in the Latrobe Valley.

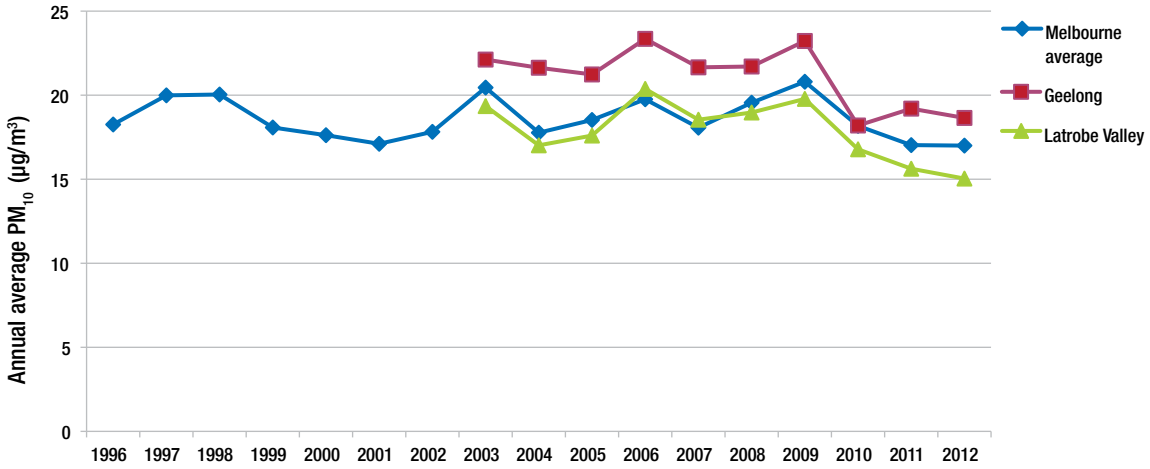


Figure A.1.24: Annual average PM_{10} 1996–2012

Source: EPA Victoria.

In most years of monitoring, the National Environment Protection Measure (NEPM) 24-hour average standard (50 µg/m^3) was exceeded because of dust storms caused by prolonged below-average rainfall and, to a lesser extent, fire events (Figure A.1.25).

These events strongly influence the concentration of airborne particles. In severe events, winds can transport soil particles and smoke many hundreds of kilometres, affecting air quality across large areas of the state.

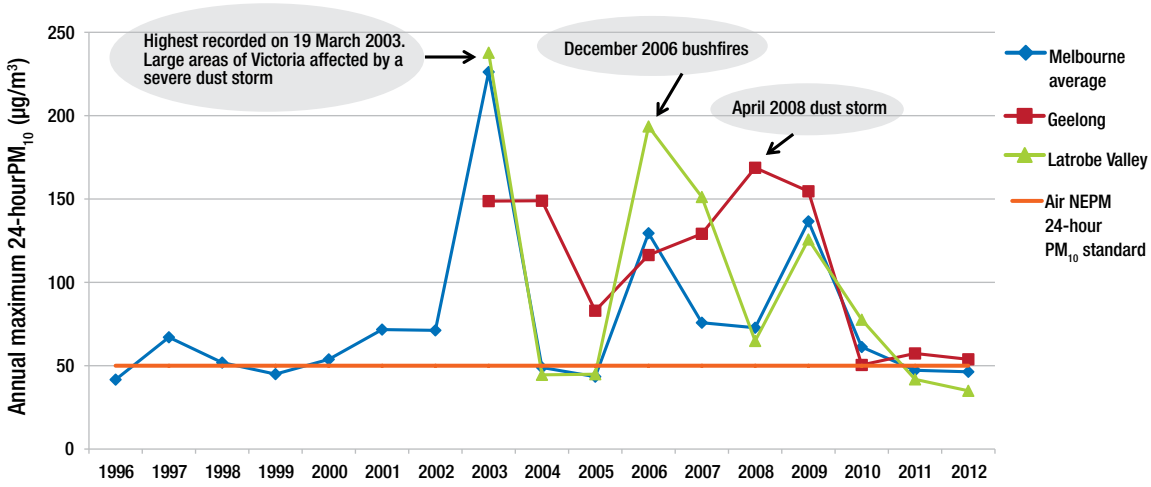


Figure A.1.25: Annual maximum 24-hour average PM_{10} 1996–2012

Source: EPA Victoria.

$PM_{2.5}$

There is currently no national standard for $PM_{2.5}$ particles. However, the NEPM specifies advisory reporting standards for $PM_{2.5}$ levels not to exceed a concentration of 25 µg/m^3 per day, or an average of 8 µg/m^3 per year. EPA Victoria assesses $PM_{2.5}$ at two suburban locations in Melbourne (Alphington and Footscray).

The annual data from 1996 to 2012 suggest no long-term trend in $PM_{2.5}$ (Figure A.1.26). The Melbourne average $PM_{2.5}$ level (derived from the two monitoring locations) only exceeded the annual advisory reporting standard in years with major bushfires.

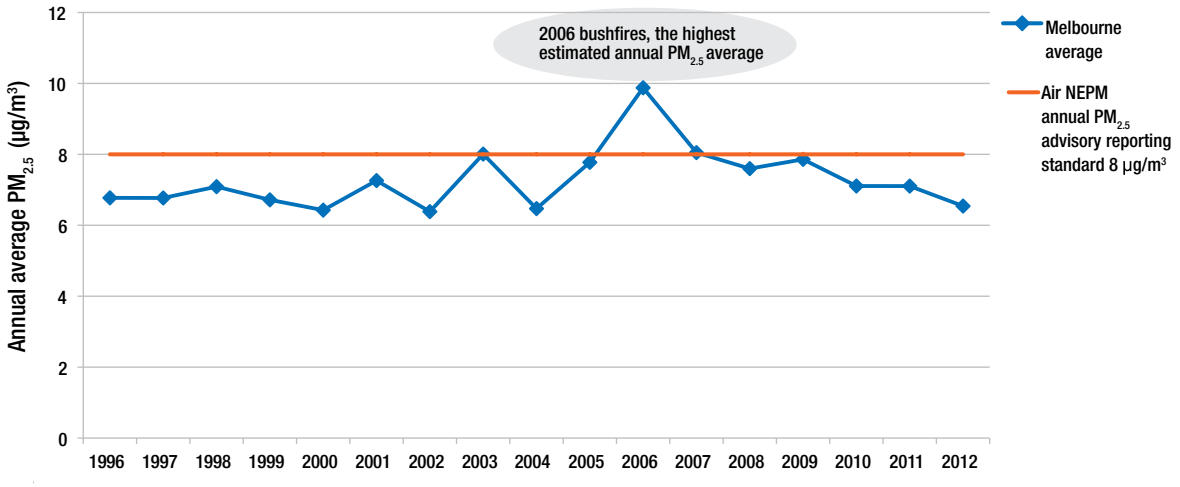


Figure A.1.26: Annual average $PM_{2.5}$ 1996–2012

Source: EPA Victoria.

Note: $PM_{2.5}$ levels are assessed at two suburban locations in Melbourne (Alphington and Footscray). These datasets have been combined to provide an estimate of the Melbourne average.

The daily advisory standard was exceeded for most years of monitoring (Figure A.1.27). In recent times, bushfires have been the main cause of high $PM_{2.5}$ levels in Melbourne, with some planned burning activities also resulting in $PM_{2.5}$ levels above the advisory standards. Other causes of high $PM_{2.5}$ include wood heaters and the accumulation of urban pollution on calm autumn and winter days. The highest Melbourne 24-hour average $PM_{2.5}$ level was 141 µg/m^3, recorded on 20 December 2006, a day of severe bushfire smoke.

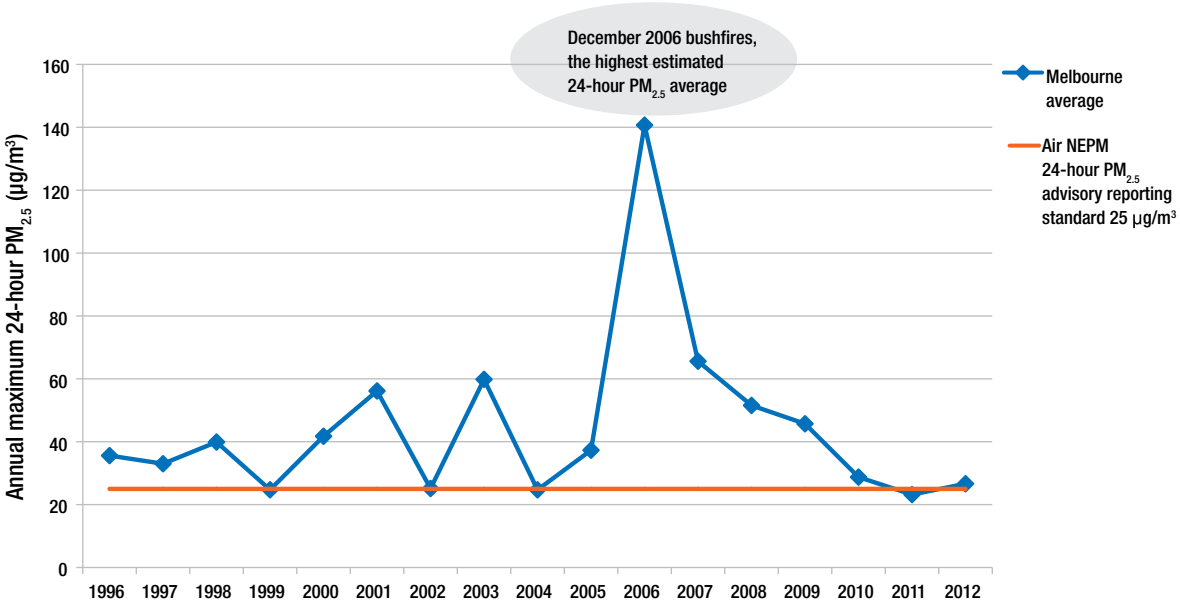


Figure A.1.27: Annual maximum 24-hour average $PM_{2.5}$ 1996–2012

Source: EPA Victoria.

Note: $PM_{2.5}$ levels are assessed at two suburban locations in Melbourne (Alphington and Footscray). These datasets have been combined to provide an estimate of the Melbourne average.

Visibility

Fine particles reduce how far we can see through the air. The Victorian State Environment Protection Policy (SEPP) for ambient air quality includes a visibility objective of 20 km in dry air – that means it should be possible on a fine day to see a contrasting object against a background at a distance of 20 km. This Victorian air-quality objective is more stringent than any of the national standards for airborne particles.

Visibility is expressed using an Airborne Particle Index (API), the lower the visibility, the higher the API. No significant trends over time were found in the annual average API levels (Figure A.1.28). However, the data does suggest that the Latrobe Valley experiences more fine particles than Melbourne. This is likely to be caused by air pollutants from wood heaters and planned burns, which can easily accumulate in the Latrobe Valley under light wind conditions.

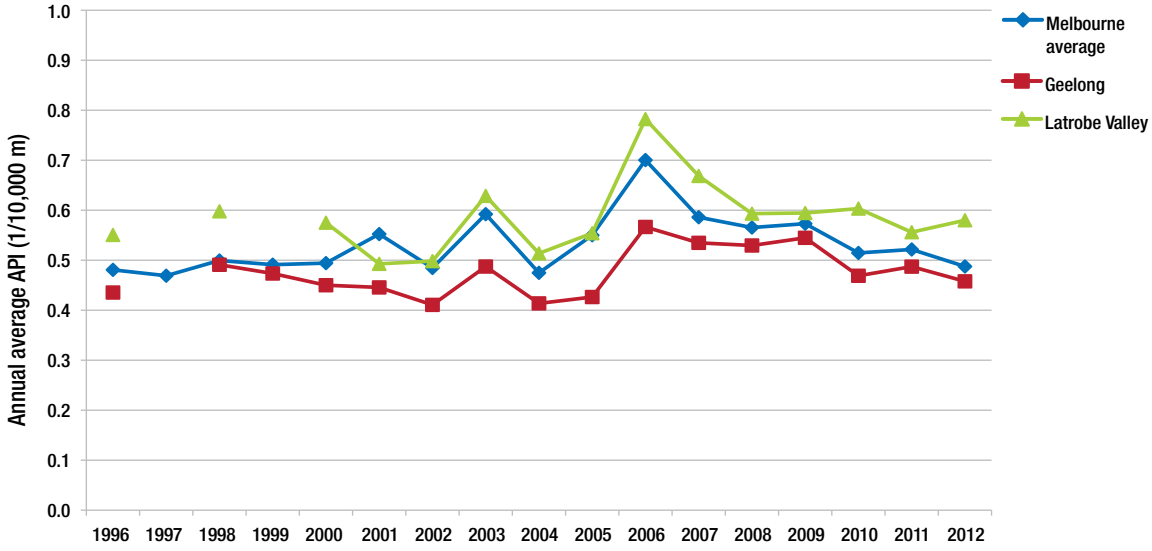


Figure A.1.28: Annual average Airborne Particle Index (API) 1996–2012 (1/10,000 m)

Source: EPA Victoria.

The annual maximum 1-hour API shows that the visibility objective is breached almost every year (Figure A.1.29). Bushfires are the main cause of poor visibility, with planned burns, winter smog and dust storms also impacting on visibility.

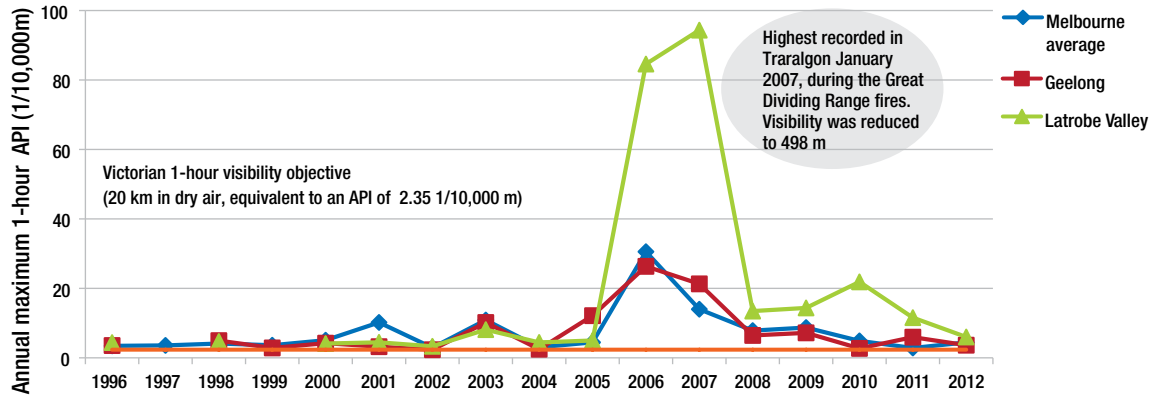


Figure A.1.29: Annual maximum 1-hour Airborne Particle Index (API) 1996–2012 (1/10,000 m)

Source: EPA Victoria.

Ambient ozone levels (summer smog)

Summer smog may appear on hot afternoons between November and March, mostly around Melbourne and Geelong. It is usually seen on the horizon as a white or grey haze. Summer smog is caused by reactions between various air pollutants. Ozone is the most significant component of the resulting mixture and provides an indication of summer smog levels.

Ozone is not directly emitted into the air. It is formed when volatile organic compounds (from industry, vehicles and vegetation) and oxides of nitrogen (from industry, vehicles and natural gas use) react in sunlight. These reactions only produce significant amounts of ozone on warm, sunny days with light or recirculating winds. Ozone can also form downwind of bushfires when the chemicals in smoke react in the presence of sunlight.

Human exposure to high concentrations of ozone can result in decreased lung function, increases in asthma attacks, and increases in hospital admissions for people with heart and lung conditions.

Although ozone levels occasionally breach the air-quality standards in Victoria, levels have remained fairly stable with no discernible trend since 1996 (Figure A.1.30). The highest levels of ozone in Victoria have been linked to bushfires, such as those occurring in 2006–07.

In the future, the higher temperatures predicted as a result of climate change are likely to lead to a greater potential for ozone formation.

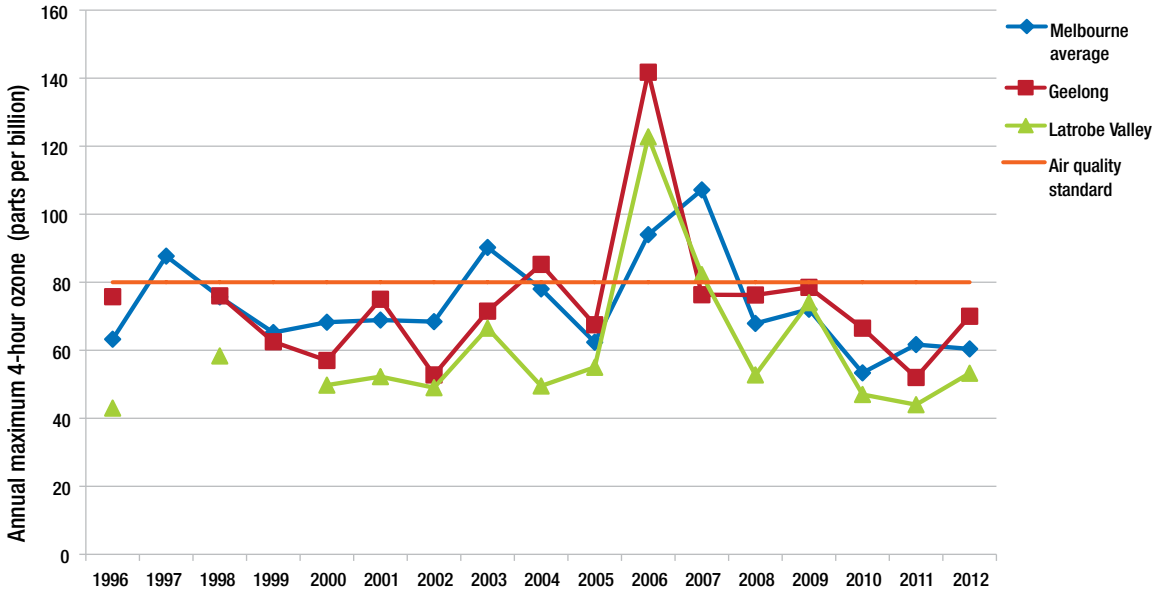


Figure A.1.30: Annual maximum 4-hour ozone (O_3) 1996–2012 (parts per billion)

Source: EPA Victoria.

Carbon monoxide and nitrogen dioxide

Carbon monoxide (CO) and nitrogen dioxide (NO_2) are produced from petrol engine exhaust. NO_2 is also produced by the burning of fuels such as natural gas and diesel. Both are harmful to human health, especially for children, the elderly and those with asthma.

Carbon monoxide and nitrogen dioxide levels have been decreasing in Melbourne since 1996 – remaining below air-quality standards. This is mainly because of progressive improvements in motor vehicle emissions. Controls on tailpipe emissions from cars and trucks have outweighed the growth in traffic over this time.

Since 2002, average carbon monoxide levels in Geelong have increased, and are now similar to those in Melbourne. This increase may be caused by factors other than motor vehicles, or may simply reflect an increase in urban density.

Average levels of nitrogen dioxide are higher in Melbourne than in Geelong and the Latrobe Valley, mainly due to the greater population and traffic density. There are no clear trends in nitrogen dioxide levels in Victoria, with increased levels usually occurring as a result of bushfires.

Average levels of nitrogen dioxide in Geelong and Latrobe Valley are lower than in Melbourne, and show no clear trend. Slightly higher levels can occur during major bushfires.

Sulfur dioxide

Most sulfur dioxide (SO_2) emissions are from coal-fired power stations and metal smelting industries. This gas can irritate the lungs, and is particularly harmful for people with asthma.

Levels of sulfur dioxide are extremely low in most areas of Melbourne and Geelong, remaining well below air-quality standards. This can be attributed to the very low sulfur content of the fuels used in Melbourne and Geelong for both heating and transport. Much higher levels of sulfur dioxide are measured near industrial sites, although results are still below air-quality standards.

Lead

Due to the removal of lead from petrol, lead levels have decreased to such an extent that ongoing monitoring is no longer undertaken in Victoria.

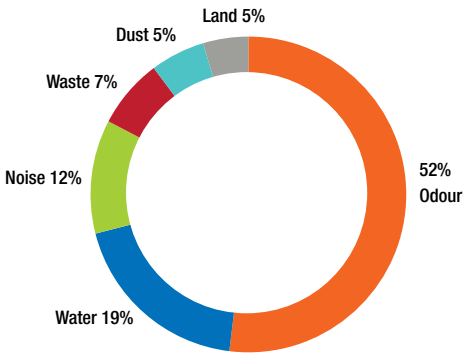
Amenity: dust, noise and odour

Odour, dust and noise can impact on the wellbeing of Victorians. Between 2000 and 2010, nearly 86,500 complaints were made to EPA Victoria regarding environmental conditions (Figure A.1.31). Odour was responsible for 52% of complaints made, with noise and dust responsible for 12% and 5% respectively.

Odour is clearly a significant issue in Victoria, with around 4,000 complaints made each year. Odour issues are not limited to high population areas, with some regional towns also affected by wastewater treatment plants and intensive animal industries. Anecdotal evidence suggests that residential encroachment on industry (including landfills, farms, composting operations and manufacturing) has made the problem worse in some locations.

Figure A.1.31: Complaints to EPA Victoria, 2000 to 2010

Source: EPA Victoria.



Indicator AQ2: Emissions of Major Air Pollutants by Sector

The sources and amounts of pollutants emitted into the atmosphere are influenced by many factors, including population, economic activity, prosperity, mobility and personal behaviour.

The Victorian Environment Protection Authority is currently producing a 2011 air pollutant inventory. The main findings from the previous inventory in 2006 were reported in the 2008 State of the Environment report. Main findings included the following.

- Motor vehicles contribute most of the carbon monoxide and oxides of nitrogen, except in the Latrobe Valley, where most oxides of nitrogen come from industry.
- Large industry contributes most of the sulfur dioxide and significant amounts of oxides of nitrogen.
- Windblown dust contributes most of the particle emissions, bushfires are also important sources in some areas.
- Bushfires also contribute large amounts of particles, as well as carbon monoxide.
- Biological sources contribute most of the volatile organic compounds.

For sources of greenhouse gases see Indicator CC.1: Trends in Greenhouse Gas Emissions in Victoria.

The Victorian Environment Protection Authority has also released projections for future air quality in Victoria.[27] Key findings include the following.

- Total vehicle exhaust emissions are decreasing because of the introduction of better vehicle exhaust controls. The trend towards improved exhausts is happening faster than the growth in vehicle traffic, resulting in a net reduction in total exhaust emissions from cars and trucks over time. In contrast, road dust, caused by the movement of vehicles on roads during dry weather, is expected to increase in line with traffic growth.
- Industrial emissions are relatively stable over time. Some growth in industrial emissions can be expected due to general economic growth. However, in most cases, these emissions take place high above the ground (from tall stacks), and therefore have minimal impact at ground level.
- Emissions linked to domestic and business activity are expected to grow in line with population growth. In most cases these emissions are not well regulated (see Part B Goal 4.5).

Indicator AQ3: Health Impacts of Air Pollution

No long-term studies that document the association between mortality and air pollution exposure have been carried out in Australia. However, short-term studies suggest that there are similar relationships between health and air pollution in Australia to those observed in Europe and North America.[28] These studies have observed significant associations between high concentrations of PM_{10}, NO_2 and CO and daily cardiorespiratory mortality.

Studies in Melbourne (carried out in the 1990s) indicated that air pollution contributed to approximately 300 deaths and 1,000 hospital admissions per year.[29, 30] The impacts of air pollution on human health is dependent on a range of factors, including exposure level and the age and background health status of individuals.

For example, across all Australian cities, air pollution has been significantly associated with cardiovascular disease hospital admissions in people over the age of 65.[31]

In recognition of this, national standards are moving towards the position that there is no safe concentration for sensitive people, especially for particles (PM_{10} and $PM_{2.5}$).[32]

Data gaps

While air-quality monitoring is generally good across Melbourne, statewide data is lacking. Only two sites are currently monitored in regional Victoria, one in Geelong and one in Traralgon in the Latrobe Valley.

For a comprehensive assessment of air quality in Victoria, wider monitoring coverage is required. Information is also lacking on the impacts of air pollution on human health in Victoria.

Koala

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CHAPTER **TWO** BIODIVERSITY AND LAND

BACKGROUND

This chapter assesses the status of Victoria's land and terrestrial biodiversity. Aquatic biodiversity is discussed in the Inland Waters and Marine and Coastal Environments sections. The management of Victoria's land and biodiversity on private land is discussed in Foundation Paper Two: *Land and Biodiversity Victoria: The Science, Our Private Land Holders, Incentives and Connectivity*.[1] The impacts of climate change on land and biodiversity is discussed in Foundation Paper One: *Climate Change Victoria: The Science, Our People, and Our State of Play*.[2]

Healthy land and biodiversity are essential for all Victorians. They provide vital services such as clean air and water, control of pests and fertile soil, and help to regulate our climate. These are necessary to support the production of water resources, food, fibre and timber. Healthy ecosystems are also important for our own health and wellbeing, providing places for cultural, spiritual and recreational activities.

Degradation of land and biodiversity resources impact on the services they provide. Biodiversity loss or decline can have significant consequences for natural processes such as pollination and nutrient cycling, decrease the availability of habitat, and impact on predator–prey relationships. In severe cases, biodiversity loss can lead to significant alterations in ecosystem type and the functions ecosystems provide. It is important to maintain and, where necessary, improve the biodiversity and health of Victoria's ecosystems to ensure the continued provision of the services on which all Victorians depend.

The degradation of terrestrial ecosystems has far reaching consequences for many Victorian environments. Terrestrial ecosystems are intimately connected to aquatic ecosystems, including the marine environment.

Poor terrestrial health has implications for the condition of rivers, lakes, wetlands, estuaries and coastal waters (see Part A: 3 Inland Waters and Part A: 4 Marine and Coastal Environments).

Pressures on Victorian land and biodiversity

The historic clearing of native vegetation in much of Victoria has resulted in the widespread loss of habitat and the decline of many species. Victoria is the most cleared state in Australia with nearly two-thirds of Victoria's landscape now modified for agriculture and urban purposes. This, combined with ongoing pressures from further clearing, habitat fragmentation, altered hydrology, inappropriate land-use and fire regimes, and invasive species, puts enormous stress on land and biodiversity across Victoria.

Despite the efforts of governments, non-government organisations, communities and individuals over many decades, the health of our species and ecosystems continues to decline.[3] The highest number of threatened species in any one region in Australia occurs in north-western Victoria.

Although many land and biodiversity concerns are focused on extensively cleared private land, the management of Victoria's relatively intact public land remains a significant problem. The condition of land and biodiversity on public land is variable because of ongoing impacts from previous land use and current pressures. Consequently, improved management of land and biodiversity is required on both public and private land.

Historic broad-scale clearing of native vegetation has also changed Victorian landscape functions in ways that are now presenting major challenges to land managers. Accelerated erosion, acidification, and salinity, as well as the loss of soil nutrients and organic content, are problems facing land managers.

Climate change

Climate change is predicted to compound existing pressures on Victoria's biodiversity and ecosystems.[2] Projections of significant shifts in local climates and increases in drought, bushfires and storms, will impact on Victoria's natural ecosystems and primary production industries alike.

Climate change is likely to threaten species with limited capacity to migrate, such as those restricted to particular habitats and fragmented landscapes, or those that tolerate only narrow ranges of temperature and rainfall. Ecosystems such as rainforest, wetlands, alpine areas and coastal and marine habitats have been identified as being at greatest risk in Victoria. Climate change will exacerbate current environmental pressures, and therefore the capacity of natural ecosystems to adapt to climate change will be improved if existing threats are addressed.

In addition to impacts on natural ecosystems, climate change also threatens agriculture and forestry through impacts on land health, water availability, agricultural yields, and increased damage from bushfires and storms.

Future land-use patterns and the location of primary industries in Victoria may have to alter in order to adapt to climate change. Changes to the distribution of primary production will have significant socioeconomic implications for Victorian communities.

A BIODIVERSITY

MAIN FINDINGS

Conservation of Victorian ecosystems and species

- While conservation areas provide protection by excluding damaging land uses and activities, they are still at risk from a range of pressures. Invasive species, inappropriate fire regimes, pathogens and diseases can all threaten ecosystem health and require ongoing intervention to minimise impacts.
- Climate change will threaten conservation areas, especially where changes to temperature and rainfall, and the occurrence of fire, exceed the tolerances of ecosystems.
- In 2010, there were 2,945 parks and reserves in Victoria covering approximately 4 million hectares, around 18% of the state. The area of parks and reserves increased by more than 160,000 hectares between 2005 and 2010. The large majority of Victoria's conservation reserves are very small, isolated and/or fragmented.
- In 2010, 15 out of Victoria's 28 bioregions had less than 20% of their area within parks, and eight of these had less than 10%. Only seven bioregions had conservation levels of 50% or higher.
- The majority of Victoria's Ecological Vegetation Classes have less than 50% of their total area protected in parks, with six having less than 25% of their area in the parks system. The most under-represented Ecological Vegetation Divisions include Basalt Grassland and Inland Plains Woodland (4% of total area), Foothills Forest and Western Plains Woodland (18% of total area) and Forby Forest (21% of total area).
- The majority of rare and threatened flora and fauna species have been recorded in the Victorian parks system.
- In 2010, all 37 Victorian flora and fauna communities listed as threatened under the *Flora and Fauna Guarantee Act 1998* were represented in parks. However, most were represented in only one, or less than five parks.
- With some 62% of Victoria's land under private ownership, significant conservation effort is required outside of public land reserves to protect native ecosystems and species.
- Between 2008 and 2012, the area of land under private conservation agreements increased from 212,000 to 242,000 hectares, an increase of some 30,000 hectares.
- Despite the rise in conservation agreements on private land, the area is still very small compared to that on public land.

Threatened species

- Expert advice indicates that there is an overall decline in threatened species and populations because of habitat loss and fragmentation, and ongoing degradation of remaining habitat.

Fauna

- A total of 294 vertebrate fauna species across all habitats were listed on the *Advisory List of Threatened Vertebrate Fauna in Victoria, 2013.* This included nine extinct fauna species, 15 species extinct in Victoria, and one extinct in the wild. A further 50 species were listed as critically endangered, 57 endangered, 84 vulnerable and 64 near threatened. Data was found to be deficient for 14 species.
- All vertebrate groups have a considerable proportion of their extant species listed as threatened, including 22% of terrestrial mammals, 19% of birds, 30% of reptiles, 43% of amphibians and 55% of freshwater fish.
- Between 2007 and 2013, Victoria's threatened vertebrate species (all habitats) continued to decline. The conservation status of 33 species worsened over the period and 13 species were added to the Advisory List of threatened species because of decreasing populations. The number of critically endangered species increased by 13, endangered by five, and vulnerable by 12. Some species are showing signs of recovery, with eight improving their conservation status and three removed from the list as a result of species population increases.
- For terrestrial species, the status of 18 vertebrate species declined between 2007 and 2013, and seven were added to the list because of decreasing populations. Only five species improved their threatened status. The period also saw the extinction in the wild of the Eastern Barred Bandicoot (*Perameles gunnii* un-named subspecies), which was critically endangered in 2007.
- There remains a large number of species whose population trend is inconclusive, unclear or variable.

Flora

- The most recent Advisory List for plants was released in 2005. Consequently, it is not possible to determine changes in the status of plant species since 2005. Expert opinion indicates that the overall trend is one of decline.
- In 2005, 51 species of flora had become extinct from Victoria, with a further 778 species listed as vulnerable or endangered, 838 species as rare, and 305 were poorly known.

Invertebrates

- As at 2009, one invertebrate species had become extinct and another five species extinct in Victoria. A further 127 species were listed as critically endangered, endangered, or vulnerable, seven species listed as near threatened, and 38 were poorly known.
- There is little information on invertebrates in Victoria and for most of Australia. Consequently, data on conservation status is limited and the current number of threatened species likely to be vastly under-reported.

Threatening processes

- The most commonly identified threatening processes to Victorian species are habitat loss (109 species), weed invasion (108 species), grazing (99 species) and inappropriate fire regimes (63 species).

Knowledge

- Victoria's conservation planning efforts and conservation needs are still hampered by the lack of integrated and well-designed monitoring. Knowledge of the status of invertebrates, lichens and fungi remains poor.

Extent and condition of Victoria's native vegetation

- Historic land clearing has resulted in the loss of approximately half of Victoria's native vegetation, causing a serious and ongoing loss of habitat for Victoria's native species. The majority of this has been on private land, where only 20% of native vegetation cover remains, compared to 80% of the original vegetation on public land.
- The most significant losses of vegetation in Victoria have occurred in native grasslands, grassy woodlands and box ironbark forests.
- Less than a quarter of native vegetation cover remains in the Victorian Volcanic Plain, Victorian Riverina, Warrnambool Plain and Wimmera.
- Currently, the major source of native vegetation loss is the chronic degradation of habitat condition, mainly in fragmented landscapes.
- Substantial native vegetation (over 1 million hectares) is found on roadside reserves in many of Victoria's most cleared landscapes. These provide important habitat and wildlife corridors across fragmented landscapes.
- Vegetation quality is generally stable on public land and in largely intact landscapes, but likely to be declining on private land and in fragmented landscapes.
- Victoria's extended drought and increase in large fires is likely to have significantly impacted on vegetation quality.
- Between 2006–07 and 2011–12, the annual total area of State forest harvested ranged between 7,900 and 11,600 hectares or between 0.3% to 0.4% of the total State forest area.
- Fire salvage operations increased between 2007–08 and 2010–11 in response to the occurrence of fires over the period, fire salvaging can be detrimental to biodiversity by removing important habitat. The harvesting of unburnt forest is also an issue in areas where significant fires have occurred because they provide an important refuge for displaced fauna.

Pest plants and animals

- Pest plant and animal species (invasive species) continue to establish in Victoria and pose a major threat to biodiversity, ecosystem health and primary production.
- Pest plants are considered one of the major factors in the loss of biodiversity.
- Predation by pests is a threatening process for at least 47 species of threatened fauna in Victoria.
- Coordinated ongoing management can have positive outcomes for biodiversity. Fox management programs have increased populations of Southern Brown Bandicoots (*Isoodon obesulus*) and Long-nosed Potoroos (*Potorous tridactylus*) in treatment areas.
- Statewide information on the number of introduced species has not been updated since the 2008 Victorian State of the Environment report. Consequently, it is not possible to determine changes in the number of pest plants and animals since 2008
- Comprehensive data on the extent of pest plant and animal management is not available for Victoria, particularly for private land. However, some data is available for specific management programs on public land. Between 2008 and 2011, some 1.5 million hectares of public land was treated for pest animals, the majority for foxes. Another 282,000 hectares was treated for weeds.

Fire impacts

Planned burning

- Between 2001–02 and 2012–13, 1.7 million hectares of native vegetation was burnt by planned fires in Victoria. The total area burnt represents over a fifth of the total area of public land, and is equivalent to nearly half of the total area burnt by bushfires over the period.
- Some 85% of planned burns were carried out for fire suppression purposes (fuel reduction).
- The Gippsland region accounted for 37% of the total planned burn area between 2001–02 and 2012–13, with the North East region accounting for 28%. The Orbost and Mallee districts accounted for 16% and 15% of the total area burnt over the period respectively.
- The annual area of planned burning for fuel reduction purposes has been increasing, with annual burns of 120,000 hectares or higher since 2006–07. The annual area of planned burning for ecological purposes has also increased significantly since 2008–09.
- The Victorian Government has been progressively increasing the annual planned burning target. Prior to 2010–11, the annual target was 130,000 hectares. This increased to 200,000 hectares in 2010–11, 225,000 hectares in 2011–12 and 250,000 hectares in 2012–13.
- The increase in planned burning has been in response to recommendations from various inquiries into large bushfires since 2002.

Bushfires (unplanned burning)

- Victoria has experienced three extensive bushfire seasons in less than a decade – 2002–03 (1.3 million hectares), 2006–07 (1.2 million hectares) and 2009 (430,000 hectares).
- This period saw prolonged drought and higher temperatures across Victoria, which increased the frequency and severity of large bushfires. This is consistent with predictions that climate change will increase the occurrence and risk of bushfires in the future.
- Victorian regions most impacted by bushfires were the North East and Gippsland, which accounted for nearly 80% of the area burnt between 2001–02 and 2012–13.
- The 2009 bushfires have been another significant event for Victoria's biodiversity. The once healthy population of the endangered Leadbeater's Possum on the Lake Mountain plateau was decimated by the fires, with only a few individual animals known to have survived the fire.
- Adding to fire impacts is the detrimental impacts of salvage logging. The removal of dead trees and the important habitat they provide can lead to ongoing impacts on biodiversity greater than the impact of the fire alone.

Fire regimes

- In 2012, 40% of native vegetation was estimated to be below minimum tolerable fire intervals (TFI), with 3% above the maximum TFI. Only 18% of native vegetation assessed was found to be within the required TFI to maintain vegetation communities. TFI could not be calculated for 39% of native vegetation due to the lack of fire history.
- For the 32 Ecological Vegetation Divisions (EVD) assessed, only eight had 25% or more of their assessable area within TFI, none had over 50% of their area within TFI. Fourteen EVDs had less than 10% of their assessable area within TFI.
- Over the next decade, large areas of Victoria will remain below minimum TFI irrespective of the level of planned burning and future fire events. This places species with life cycles dependent on particular fire intervals at increased risk.
- The increase in large-scale bushfire events means that early growth stages are now over-represented in Victoria's vegetation growth stages. Of the assessed native vegetation, 35% were found to be in early growth stages compared to only 25% in mature or over mature stages. This has severe implications for biodiversity, especially fauna that require older growth stages.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
LB1 Conservation of Victorian ecosystems and species	Conservation areas are increasing both on public and private land. However, many bioregions and vegetation communities remain under-represented in parks and reserves.		
LB2 Threatened species in Victoria	Between 2007 and 2013, the conservation status of many threatened vertebrate species continued to decline, with far fewer species showing improvement. The status of flora species has not been updated since the previous State of the Environment report, however, expert opinion indicates a general decline. Information on invertebrate species is improving but remains limited.		
LB3 Extent and condition of Victoria's native vegetation	The extent and condition of native vegetation continues to decline in Victoria particularly through the chronic degradation of habitat condition, mainly in fragmented landscapes. Although assessments of vegetation extent and condition are improving, it is difficult to accurately determine statewide trends because of methodology changes.		
LB4 Pest plants and animals	Pest plant and animal species continue to establish and pose a major threat to biodiversity, ecosystem health and primary production. Data on pest plants and animals and their management is poor.		
LB5 Impact of fire on Victorian ecosystems	Victoria has experienced an increase in large fires over the last decade. Planned burning has also increased. Most vegetation in Victoria is now outside of its tolerable fire intervals.		

Indicator Assessment Legend

Status

- Environmental condition is healthy across Victoria, **OR** comprehensive protection of natural ecosystems and biodiversity.
- Environmental condition is neither positive or negative and may be variable across Victoria, **OR** moderate protection of natural ecosystems and biodiversity.
- Environmental condition is under significant stress, **OR** inadequate protection of natural ecosystems and biodiversity.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

NA Assessments of status, trends and data quality are not appropriate for the indicator.

Indicator LB1: Conservation of Victorian Ecosystems and Species

Conservation on public land

Conservation areas are vital for the protection of Victoria's remaining natural ecosystems and the biodiversity they support. Parks and reserves include many threatened communities and species, and Victoria's largest and least disturbed ecosystems. These areas also protect remnant vegetation within urban and agricultural environments.

While conservation areas provide protection by excluding damaging land uses and activities, they are still at risk from a range of pressures. Invasive species, inappropriate fire regimes, pathogens and diseases can all threaten ecosystem health and require ongoing intervention to minimise impacts.

Climate change will also threaten conservation areas, especially where changes to temperature and rainfall, and the occurrence of fire, exceed the tolerances of ecosystems.

In 2010, there were 2,945 parks and reserves in Victoria protecting approximately 4 million hectares, around 18% of the state (see Indicator LB6: Land Use). The area of parks and reserves increased by more than 160,000 hectares between 2005 and 2010. This included additions of River Red Gum parks in northern Victoria, with four new National Parks: Barmah, Gunbower, Lower Goulburn River and Warby–Ovens, and the Cobboboonee National Park in Victoria's west.

Approximately 10% of Victoria's parks and reserves account for some 90% of the total area protected in the parks and reserves system. Consequently, the large majority of Victoria's conservation reserves are very small, isolated and/or fragmented.

In addition to parks and reserves, around a quarter of Victoria's State forest (753,000 hectares) are classed as Special Protection Zones. These areas are managed for conservation and are excluded from timber harvesting (see Indicator LB3: Extent and Condition of Victoria's Native Vegetation).

Conservation of bioregions

There are 28 bioregions in Victoria, each one representing unique ecological characteristics and the biodiversity they contain. Many of Victoria's bioregions have been heavily cleared, with four of Australia's five most cleared bioregions occurring in Victoria. In 2010, 15 out of Victoria's 28 bioregions had less than 20% of their area within parks, and eight of these had less than 10% (Figure A.2.1). Only seven bioregions had conservation levels of 50% or higher. Bioregions with high proportions of vegetated public land generally have a higher proportion protected in parks.

The majority of bioregions are under-protected. This, in part, reflects the high proportion of private land in these bioregions, the extent of vegetation loss and the consequent difficulties in reserve establishment. However, some bioregions such as the Strzelecki Ranges, Wimmera, Central Victoria Uplands and Goldfields, have significant areas of vegetated public land not in the reserve system.[4]

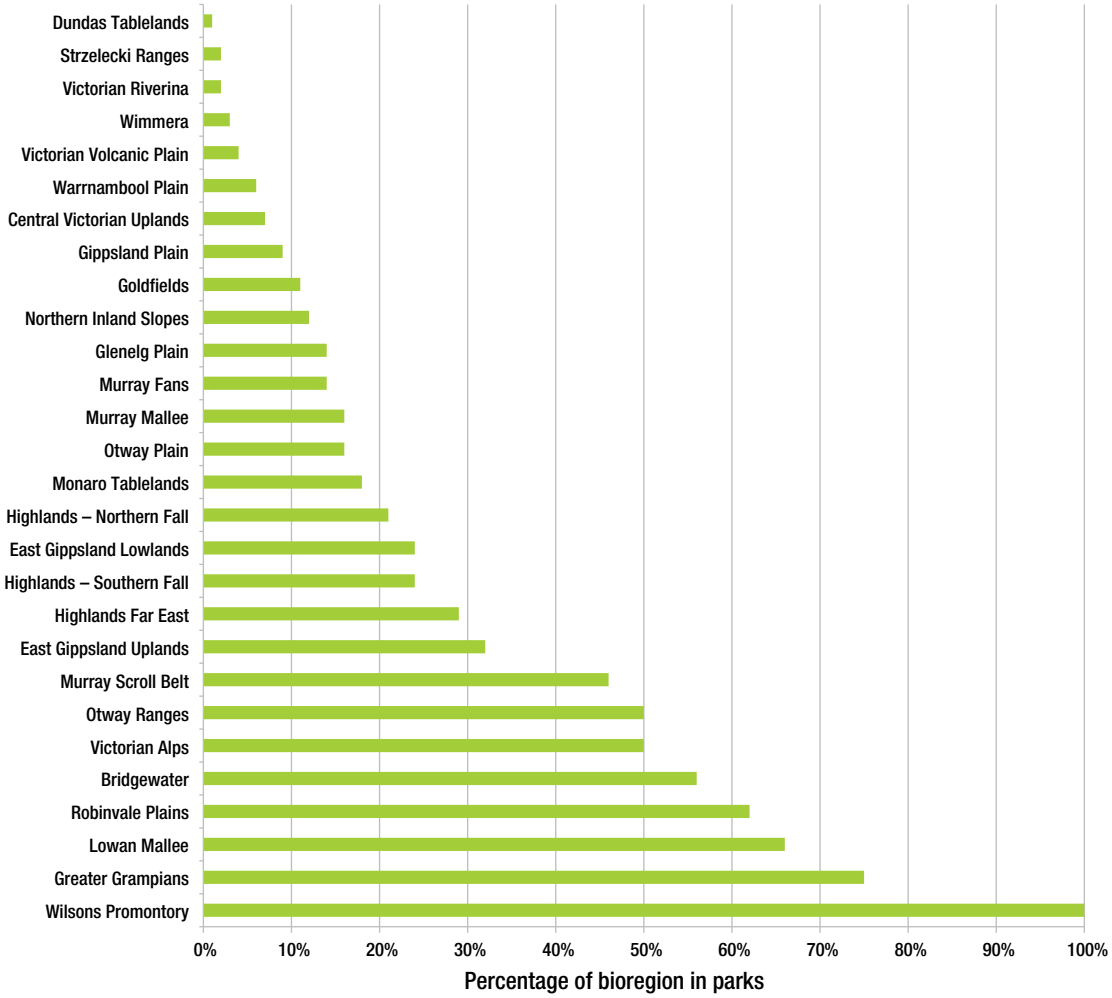


Figure A.2.1: Proportion of Victoria's terrestrial bioregions protected in parks and reserves, 2010

Source: Parks Victoria.

Conservation of flora and fauna

Figure A.2.2 shows percentage of selected Ecological Vegetation Divisions (EVDs) protected in parks.*

All EVDs occur in Victoria's parks network to some extent. Eleven EVDs have 50% or more of their total area within the parks system. Hummock-grass Mallee (86% of total area), Alpine Treeless (77% of total area), High Altitude Wetland (72% of total area) are all particularly well represented. The majority of EVDs have less than 50% of their total area protected in parks, with six having less than 25% of their area in the parks system. The most under-represented EVDs include Basalt Grassland and Inland Plains Woodland (4% of total area), Foothills Forest and Western Plains Woodland (18% of total area) and Forby Forest (21% of total area).

* Native vegetation in Victoria has been classified according to Ecological Vegetation Classes (EVCs). EVCs are classifications described through a combination of floristics, life forms and ecological characteristics and are associated with particular environmental attributes such as soil, rainfall and topography. There are approximately 300 EVCs statewide. Ecological Vegetation Divisions are aggregations of similar EVCs.

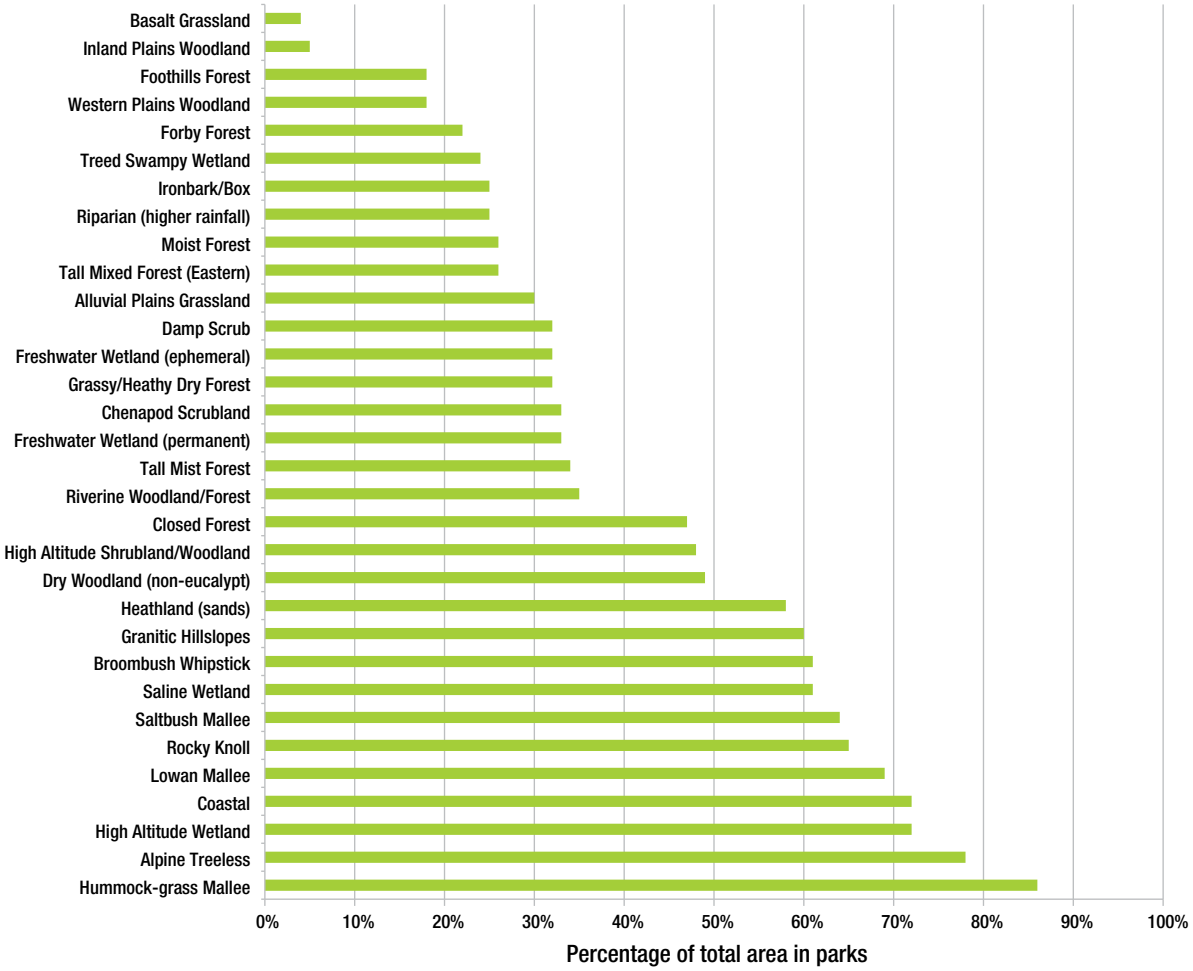


Figure A.2.2: Percentage of Ecological Vegetation Divisions protected in parks, 2010

Source: Parks Victoria.

The number of rare and threatened species found in parks and reserves are shown in Figure A.2.3. Species include those protected under the *Flora and Fauna Guarantee Act 1998* (FFG Act), the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and those that are allocated a Victorian conservation status but not under legislative protection.

The majority of rare and threatened flora and fauna species have been recorded in the Victorian parks system. However, their presence in the parks system alone does not guarantee ongoing survival. Populations of rare and threatened species will only increase if pressures such as invasive species are managed.

Figure A.2.3: Rare and threatened species recorded in Victorian parks and reserves, 2010

Source: Parks Victoria.

	Total species listed in Victoria	Species recorded in parks and reserves
Flora		
Total rare and threatened flora species	**1,758**	1,570 (89%)
FFG Act listed flora species	**308**	260 (84%)
EPBC Act listed flora species	**134**	119 (89%)
Victorian Conservation Status – flora	**1,745**	1,561 (89%)
Fauna		
Total rare and threatened fauna species	**306**	280 (92%)
FFG Act listed fauna species	**210**	193 (92%)
EPBC Act listed fauna species	**74**	69 (93%)
Victorian Conservation Status fauna	**283**	266 (94%)

In 2010, 37 communities of flora and fauna (31 flora and six fauna) were listed as threatened under the FFG Act.

All 37 communities are represented in parks. However, most are represented in only one, or less than five parks (Figure A.2.4). For many communities this is due to their restricted distribution. However, that many threatened communities are limited to one or few parks, highlights the high risk posed by localised impacts such as fire. Communities more broadly represented across the parks network are better able to withstand such impacts.

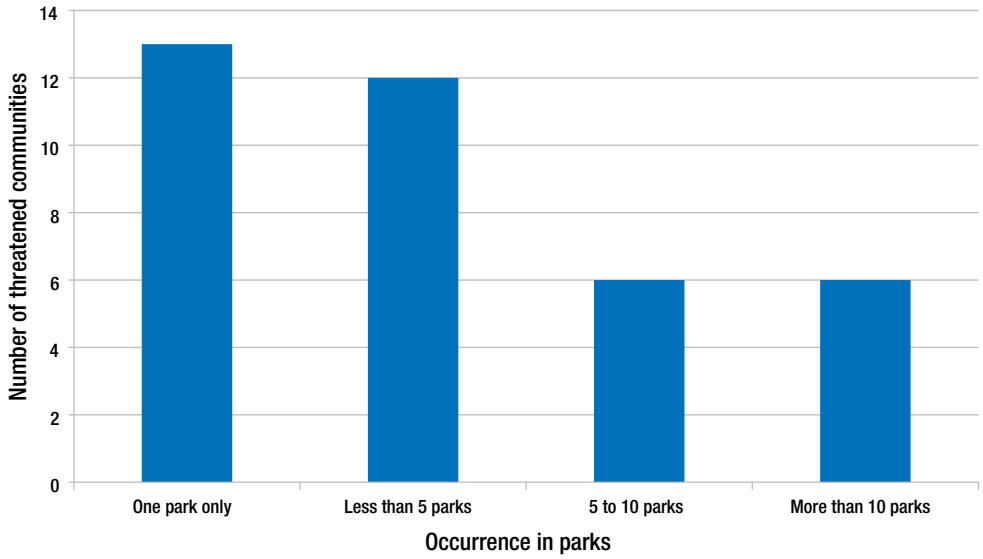


Figure A.2.4: Occurrence of threatened communities listed under the *Flora and Fauna Guarantee Act 1998*, 2010

Source: Parks Victoria.

Conservation on private land

With some 62% of Victoria's land under private ownership, significant conservation effort is required outside of public land reserves to protect native ecosystems and species.

Although only 20% of native vegetation remains on private land, it provides habitat for at least 30% of Victoria's threatened species populations.[4]

Conservation on private land comes from a variety of voluntary conservation mechanisms These range from permanent protection binding on the title of the land (Trust for Nature conservation covenants), fixed-term management agreements linked to financial incentives and specific agreed management actions (BushTender and related market-based schemes) to non-binding agreements (Land for Wildlife). There is also a range of grants and rebate schemes available to encourage biodiversity conservation on private land.

Between 2008 and 2012, the area of land under private conservation agreements increased from 212,000 to 242,000 hectares, an increase of some 30,000 hectares (Figure A.2.5). The largest increases were for Trust for Nature, which increased by 13,000 hectares, and BushTender, which increased by 11,500 hectares. Land for Wildlife agreements are responsible for the majority of land under private conservation, with nearly 70% of the total area in 2012.

Despite the rise in conservation agreements on private land, the area is still very small compared to that on public land. Given that nearly two-thirds of Victoria is private land, it is clear that opportunities for conservation needs to be increased across the state.

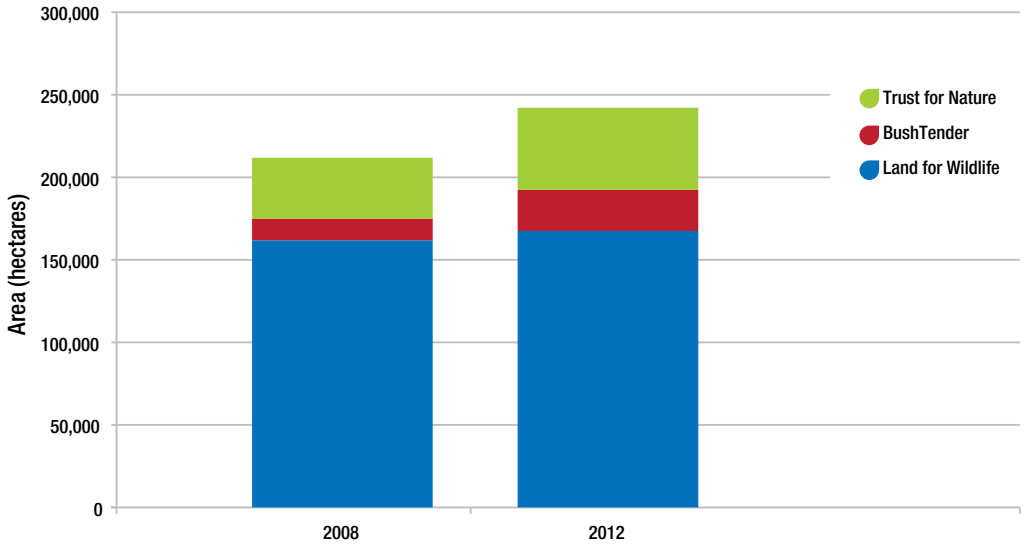


Figure A.2.5: Area of private land conservation agreements in Victoria, 2008 and 2012

Source: DEPI and Trust for Nature 2012.[5]

Indicator LB2: Threatened Species in Victoria

Number of threatened species in Victoria

Although the classification of threatened species highlights those species at risk, it is often of limited value in determining changes in environmental condition. This is because a species may be affected by a combination of pressures, or by subtle drivers that do not impact on the wider ecosystem.

The Department of Environment and Primary Industries (DEPI) maintains threatened species Advisory Lists which document a species' threat status.[6–11] The lists are based on information and advice obtained from a range of experts. They are periodically reviewed by DEPI. There are no legal requirements or consequences that flow from the inclusion of a species in an Advisory List. However, the lists are commonly used in planning processes such as the development of management plans and strategies, local government planning schemes and in setting priorities for actions to conserve biodiversity.

Victorian threatened species are also listed under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These provide legal protection for species listed.

DEPI's Advisory Lists are used here in preference to the FFG Act which reflects the rate of public nominations, rather than changes in either knowledge or actual status. However, in using the Advisory Lists the following should be noted and results interpreted with caution:

- Conservation status for a species is assessed for all of Victoria, it does not reflect regional variations in population status, nor the status of species in other Australian States.
- The number of threatened species may reflect improved knowledge, rather than changes in the number of species actually at risk.
- Changes in the rules used to assign categories or in the taxonomy of plant and animal groups may strongly influence the results.
- Not all taxa are reviewed regularly.

Vertebrate fauna

All fauna

A total of 294 vertebrate fauna species across all habitats (terrestrial, freshwater and marine) were listed on the *Advisory List of Threatened Vertebrate Fauna in Victoria, 2013*.[11] This included nine extinct fauna species, 15 species extinct in Victoria, and one extinct in the wild. A further 50 species were listed as critically endangered, 57 endangered, 84 vulnerable, and 64 near threatened. Data was found to be deficient for 14 species (Figure A.2.6).

All vertebrate groups have a considerable proportion of their extant species listed as threatened (includes regionally extinct, critically endangered, endangered and vulnerable categories), including 22% of terrestrial mammals, 19% of birds, 30% of reptiles, 43% of amphibians, and 55% of freshwater fish.[12] This shows that many natural ecosystems and the biodiversity they support are under pressure in Victoria.

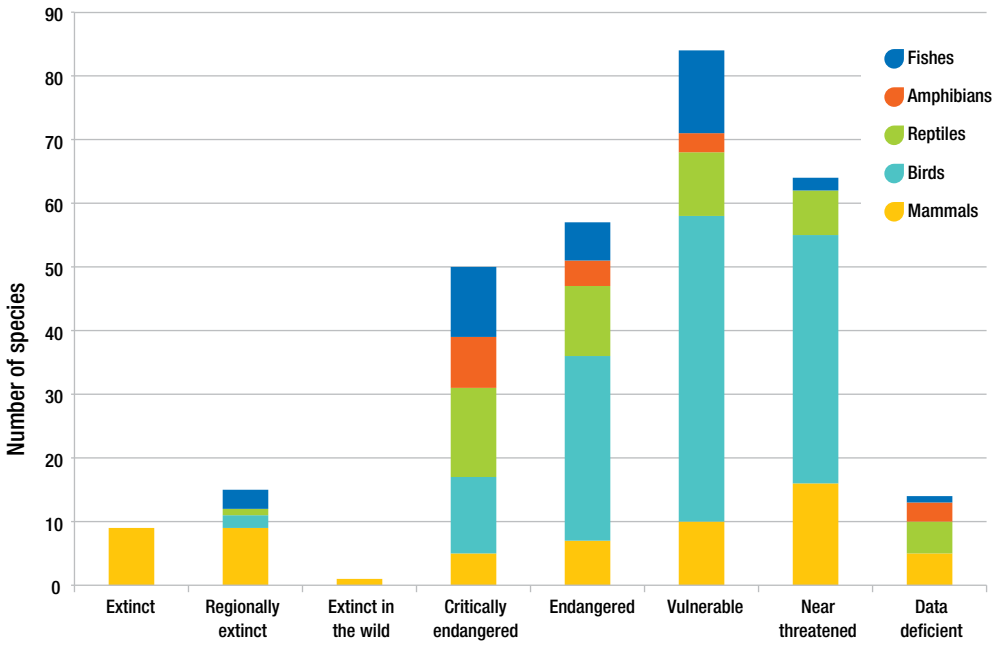


Figure A.2.6: Number of Victorian vertebrate species listed on the *Advisory List of Threatened Vertebrate Fauna in Victoria, 2013*

Source: DEPI.

Change 2007 to 2013

Between 2007 and 2013, Victoria's threatened vertebrate species continued to decline.[9, 13] The conservation status of 33 species declined over the period and 13 species were added to the Advisory List because of decreasing populations. The number of critically endangered species increased by 13, endangered by five, and vulnerable by 12 (Figure A.2.7). The period also saw the extinction in the wild of the Eastern Barred Bandicoot (*Perameles gunnii* un-named subspecies), which was critically endangered in 2007.

Some species are showing signs of recovery over the period with, eight improving their conservation status and three removed from the list as a result of population increases. There was no change in status for 237 species.

There remains a large number of species whose population trend is inconclusive, unclear or variable. These species require ongoing monitoring. Considerable re-establishment of habitat and restoration of environmental flows will be required to significantly improve the conservation status of many species and regional ecosystems.

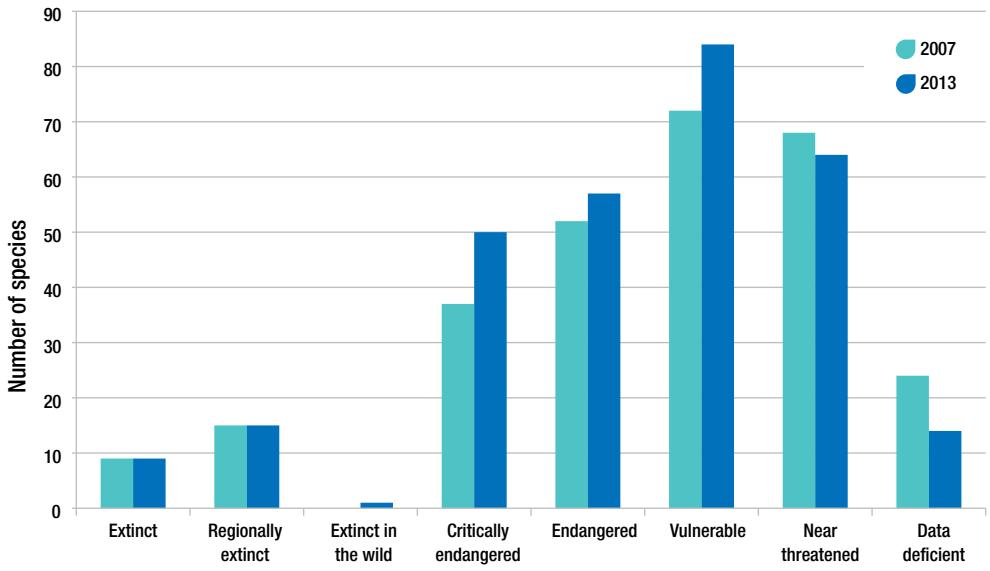


Figure A.2.7: Change in status of Victorian terrestrial vertebrate species, 2007 to 2013

Source: DEPI.

Terrestrial fauna

For terrestrial vertebrate fauna, nine species had become extinct, 12 species extinct in Victoria, and one extinct in the wild. A further 24 species were listed as critically endangered, 31 endangered, 38 vulnerable, and 44 near threatened. Data was found to be deficient for six species (Figure A.2.8).

Among the threatened terrestrial fauna species are Victoria's mammal emblem, the Leadbeater's Possum (*Gymnobelideus leadbeateri*) and bird emblem, the Helmeted Honeyeater (*Lichenostomus melanops cassidix*).

Terrestrial vertebrate fauna accounted for all but three species in the extinct categories, and approximately 50% of threatened species (critically endangered, endangered and vulnerable). This demonstrates the significant impact of habitat loss from historic land clearing on terrestrial species, as well as ongoing pressures from a range of impacts such as invasive species.

Between 2007 and 2013, the status of 18 terrestrial vertebrate species declined and seven were added to the Advisory List because of decreasing populations. Only five species improved their threatened status. These results indicate a further decline in terrestrial biodiversity.

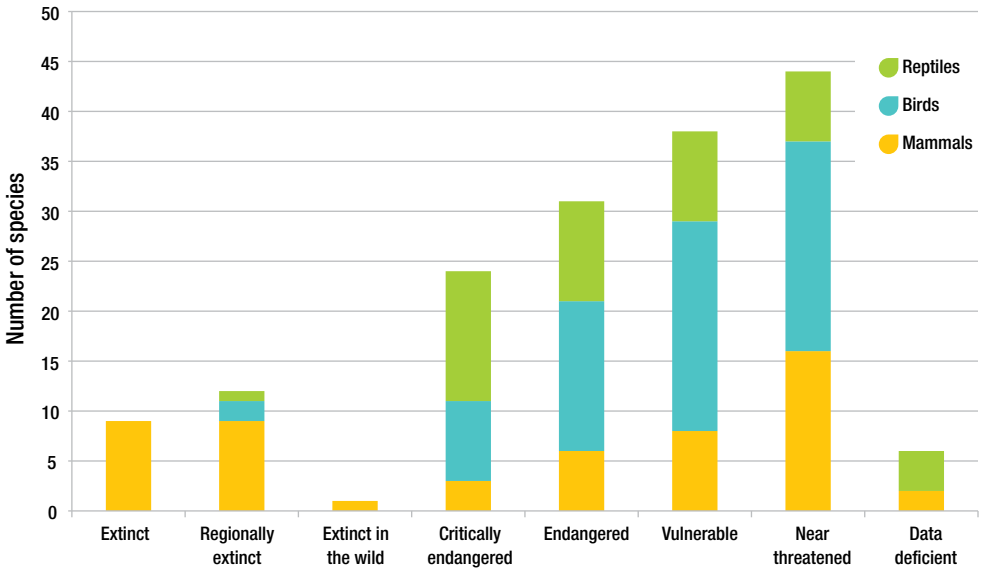


Figure A.2.8: Number of Victorian terrestrial vertebrate species listed on the *Advisory List of Threatened Vertebrate Fauna in Victoria, 2013*

Source: DEPI.

Flora

The most recent Advisory List for plants was released in 2005.[8] Consequently, it is not possible to determine changes in the status of plant species since 2005. Expert opinion indicates that the overall trend is one of decline due to the effects of past habitat clearance and fragmentation, and ongoing degradation of remaining habitat.[12] The exception is intact landscapes where large, contiguous areas of remnant native vegetation occur. Some gains have been made through targeted recovery efforts and other management activities.

For vascular plants, 2005 data showed that 49 species had become extinct from Victoria, with a further 745 species listed as vulnerable or endangered, 804 species as rare, and 228 were poorly known (Figure A.2.9). For lesser known groups of non-vascular flora – bryophytes, lichens and fungi – two species are known to have become extinct from Victoria, 33 were listed as endangered or vulnerable, 34 were rare, and 77 were listed as poorly known.

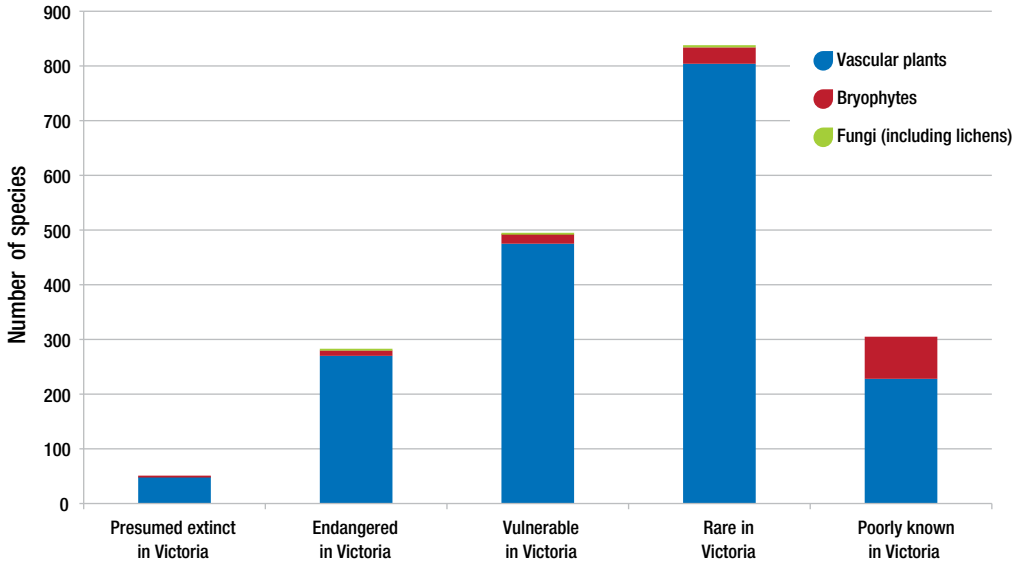


Figure A.2.9: Number of Victorian plant species listed on the *Advisory List of Rare and Threatened Plants in Victoria, 2005*

Source: DEPI.

Invertebrates

Currently, only one Advisory List of invertebrate species has been released.[10] As at 2009, one invertebrate species had become extinct in Australia and another five species extinct in Victoria. A further 127 species were listed as critically endangered, endangered or vulnerable, seven species listed as near threatened, and 38 were poorly known (Figure A.2.10).

There is little information on invertebrates in Victoria and for most of Australia.[14] This is mainly due to the lack of research and monitoring on invertebrate species. Even the total number of invertebrate species is unknown in Victoria. Consequently, data on conservation status is limited and the current number of threatened species likely to be vastly under-reported.

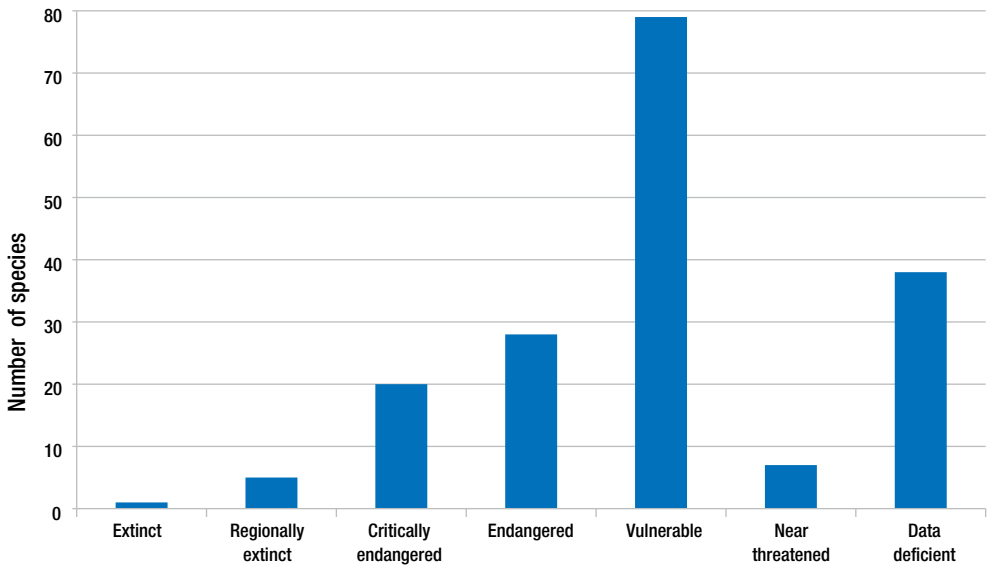


Figure A.2.10: Number of Victorian invertebrate species listed on the *Advisory List of Threatened Invertebrate Fauna in Victoria, 2009*

Source: DEPI.

Impact of threatening processes on native species

A range of threatening processes impact on Victoria's native species, both threatened and non-threatened. These processes range from effects of past clearing, fragmentation and modification of habitat, the impacts of pest plants and animals, the alteration of hydrological regimes and the increasing threat of climate change.

The most commonly identified threatening processes to Victorian species are habitat loss (109 species), weed invasion (108 species), grazing (99 species), and inappropriate fire regimes (63 species) (Figure A.2.11).

However, the relative impact of particular threatening processes varies between flora and fauna, for example, weed invasion and grazing threaten mostly for plant species. Other significant threatening processes include human disturbance, decline in water quality, predation by invasive species and habitat fragmentation. Climate change has now been included as a threatening process and is likely to apply to more species as impacts become evident and better understood.

It should be noted that the number of species impacted does not necessarily determine the severity of threatening process impacts. Some threatening processes have significant impacts on specific species or groups of species, the loss of which can severely degrade ecosystem health. For example, disease is identified as an immediate threat for only a small number of threatened species but the spread of Cinnamon fungus (*Phytophthora cinnamomi*) has wide-ranging impacts on forest health by causing dieback disease in Eucalyptus trees.

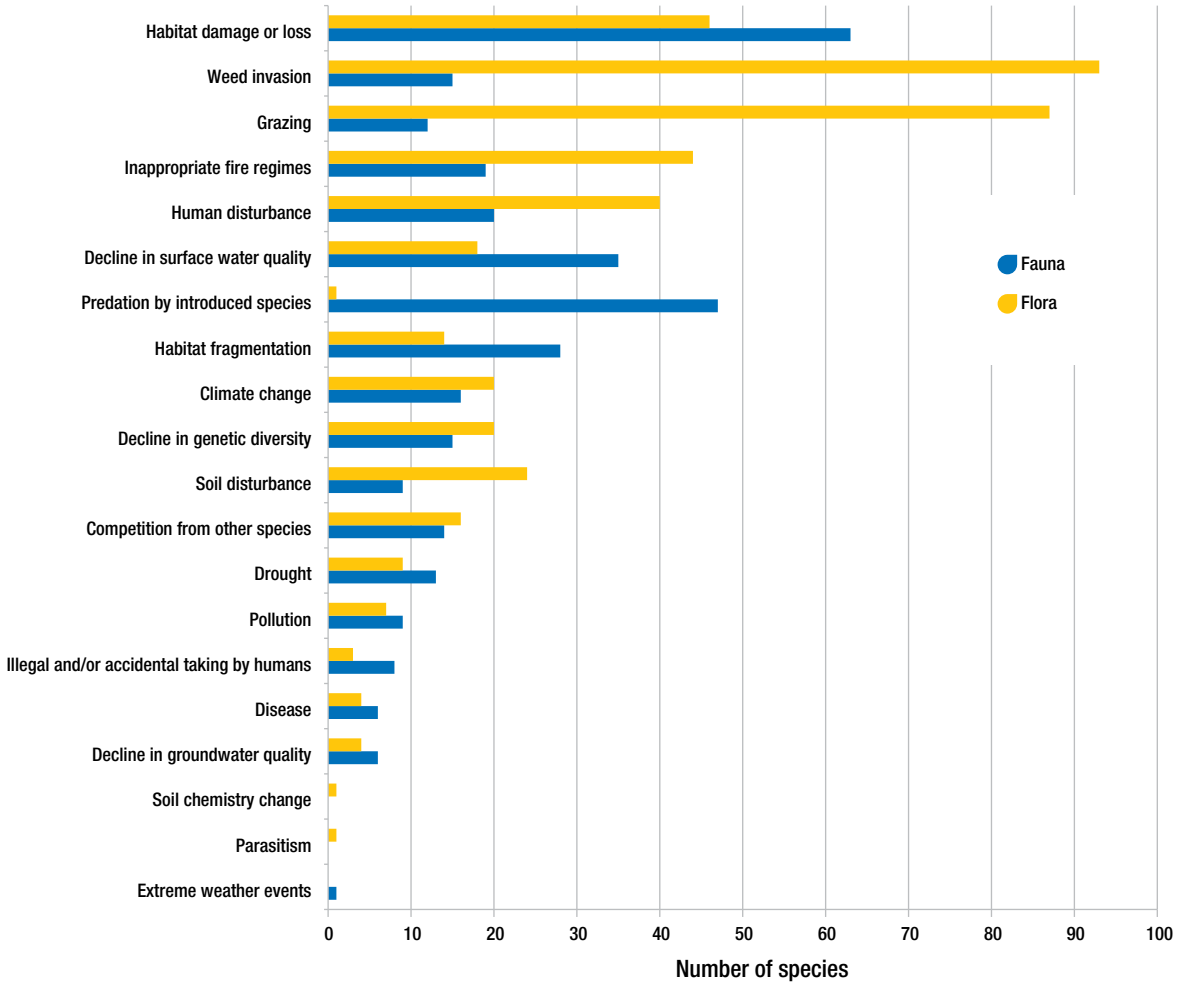


Figure A.2.11: Number of threatened flora and fauna species affected by threatening processes as listed in the Actions for Biodiversity Conservation database

Source: DEPI.

Note: Data is derived from the Actions for Biodiversity Conservation (ABC) Information System. Data is for DSE Advisory List species under active management – does not include 2013 vertebrate fauna list. Data is for a total of 259 species. Only threats identified as currently operating and of moderate, major or catastrophic impact are included.

Indicator LB3: Extent and Condition of Victoria's Native Vegetation

Native vegetation provides many ecosystem services such as provision of habitat, protection of biodiversity, protection of soil health and water quality, and sequestration of carbon. Consequently, declining extent and quality of native vegetation has profound ecosystem health implications. The loss of vegetation is considered to be the main threat to biodiversity in Victoria.

Historic land clearing has resulted in the loss of approximately half of Victoria's native vegetation, causing a serious and ongoing loss of habitat for Victoria's native species. The majority of this has been on private land where only 20% of native vegetation cover remains, compared to 80% of the original vegetation on public land. Areas most suitable for agriculture and urban development have lost the most native vegetation, especially the Victorian Volcanic Plain, west of Melbourne, and the Riverina in northern Victoria, which each retain less than 25% of their original native vegetation cover.

The extensive historic clearing of Victoria has produced a legacy of highly fragmented native vegetation throughout the agricultural areas of the state. Fragmented landscapes prevent the movement of species, limiting opportunities for mating and dispersal, and potentially creating genetic isolation. Fragmentation can also exacerbate the impacts of land use change and climate change by restricting opportunities for fauna to migrate or adapt. Although clearing has been significantly reduced, Victoria's native vegetation is under continuing pressure from intensification of agricultural production and urban expansion.

Native vegetation remnants are often small, isolated and subject to disturbance and degradation arising from human activities. However, this vegetation is vital for Victoria's biodiversity. Native vegetation in fragmented landscapes supports the majority of the state's biodiversity, with around 40% of vertebrate species virtually restricted to fragmented landscapes. A further 45% rely on fragmented landscapes across a major part of their distribution in Victoria. Only about 15% of land vertebrates are mainly restricted to largely intact landscapes.[15] In addition, about 60% of the remaining vegetation on private land are threatened vegetation types, and support 30% of Victoria's threatened species populations.[16]

Native vegetation in landscapes dominated by public land (such as National Parks and State forests) has not been extensively cleared and is more intact than native vegetation on private land. In these largely intact landscapes, natural disturbances such as fire, drought or flood, as well as timber harvesting, have produced a complex range of different vegetation types and age structures. Such vegetation communities are more likely to be highly resilient and of good quality.

In fragmented landscapes, native vegetation remnants are vulnerable to natural disturbance events such as drought, fire and flood, as well as pressures arising from agriculture and residential activities.

This results in vegetation declining, or at risk of decline, in extent, quality and regenerative capacity. Declining vegetation quality is now a key driver of vegetation loss in many parts of Victoria, although clearing remains the main cause of loss for native grasslands.

Native timber harvesting

Native timber harvesting in Victoria is carried out in State forests. Although timber harvesting is more benign than historic broad-scale vegetation clearing and land degradation, it does affect the vegetation structure and species composition of Victoria's forests and woodlands. This has implications for biodiversity and habitat availability. For example, the harvesting of mature trees impacts on species such as possums and owls, which nest in tree hollows, the availability of which is strongly influenced by tree age. The length of harvest rotation, which is usually shorter than the normal lifespan of the trees, further disrupts forest vegetation structure and natural succession.

In addition, firewood collection in some woodland ecosystems, such as Box Ironbark and Red Gum forests, has significantly reduced the amount of coarse woody debris, reducing habitat for a range of ground-dwelling and hollow-dwelling species.

Extent of native vegetation

The current extent of native vegetation in Victoria is approximately 10.9 million hectares (Figure A.2.12). Although private land covers approximately two-thirds of Victoria, it retains only 20% of its original vegetation.

Public land retains over 80% of its original vegetation cover and now accounts for the majority (approximately two-thirds) of Victoria's native vegetation.

Improvements in the detection of native vegetation from satellite data have meant that the current estimate of native vegetation extent is greater than that reported in the previous Victorian State of the Environment (10.3 million hectares). However, the vast majority of this increase represents improved data and not actual increases in vegetation extent.

Substantial native vegetation (over 1 million hectares) is found on roadside reserves (used and unused) in many of Victoria's most cleared landscapes (see Indicator LB6: Land use). In three large bioregions (Victorian Riverina, Victorian Volcanic Plains and the Wimmera), for example, more than 15% of public land native vegetation is on road reserves.[15] Road reserves provide important habitat and wildlife corridors across fragmented landscapes. In many cases, road reserves provide the best or only examples of native vegetation in heavily cleared landscapes.

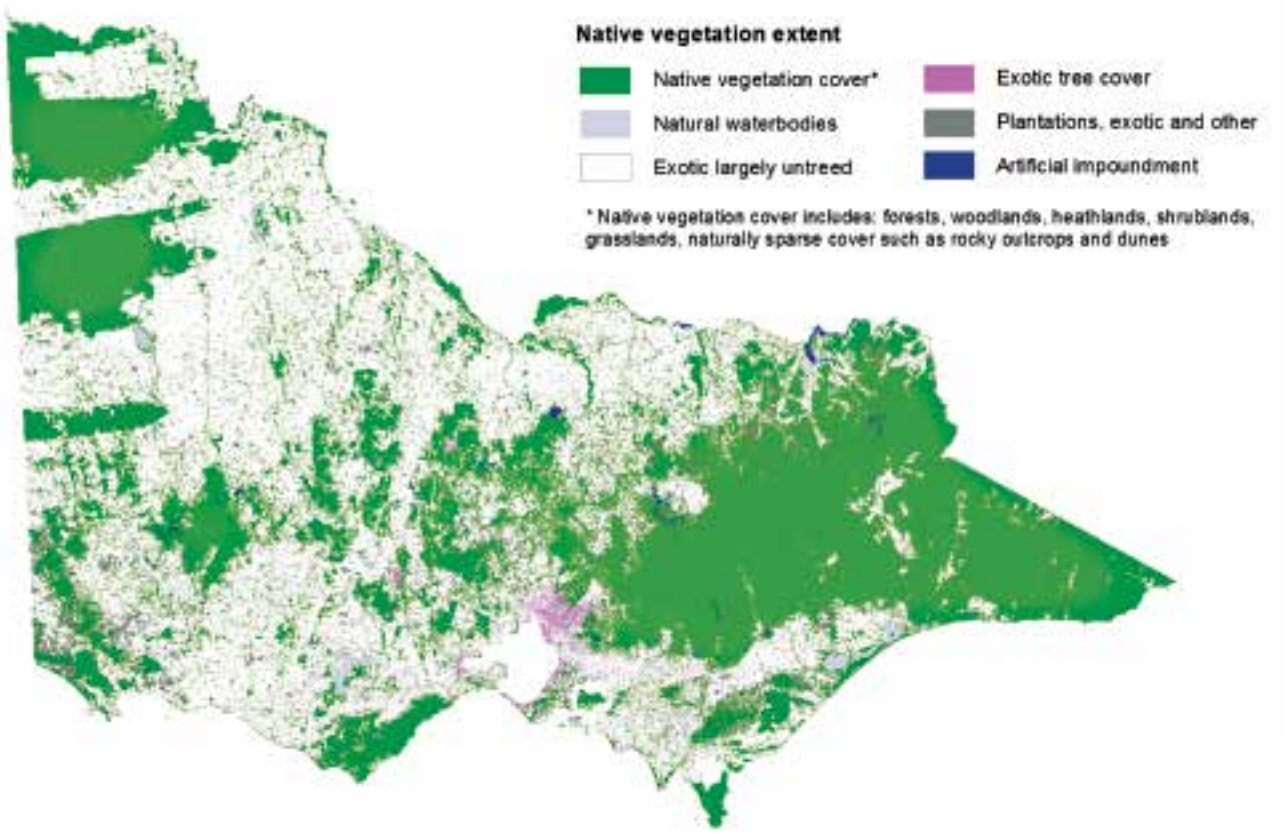


Figure A.2.12: Native vegetation extent in Victoria, as at 2010

Source: DEPI.

Depletion of native vegetation

Since European settlement, some 52% of Victoria's native vegetation has been cleared. The most significant losses of vegetation in Victoria have occurred in native grasslands, grassy woodlands and box ironbark forests.[15] The most cleared Ecological Vegetation Classes (EVCs)* occur in areas most suitable for agriculture. Less than 20% of the original extent of Plains Grasslands and Chenopod Shrublands, and Plains Woodlands or Forests remain (Figure A.2.13). Ongoing losses, particularly of grasslands, continue from illegal clearing and decline in condition. In contrast, montane and subalpine ecosystems, rainforests and rocky outcrops or escarpment scrublands retain over 90% of their original extent. Some EVC groups, such as Mallee and Riverine Grassy Woodlands or Forests, occur in areas that are both suitable for agriculture (which have largely been cleared) and areas not suitable due to soil type or flooding (which have largely retained vegetation).

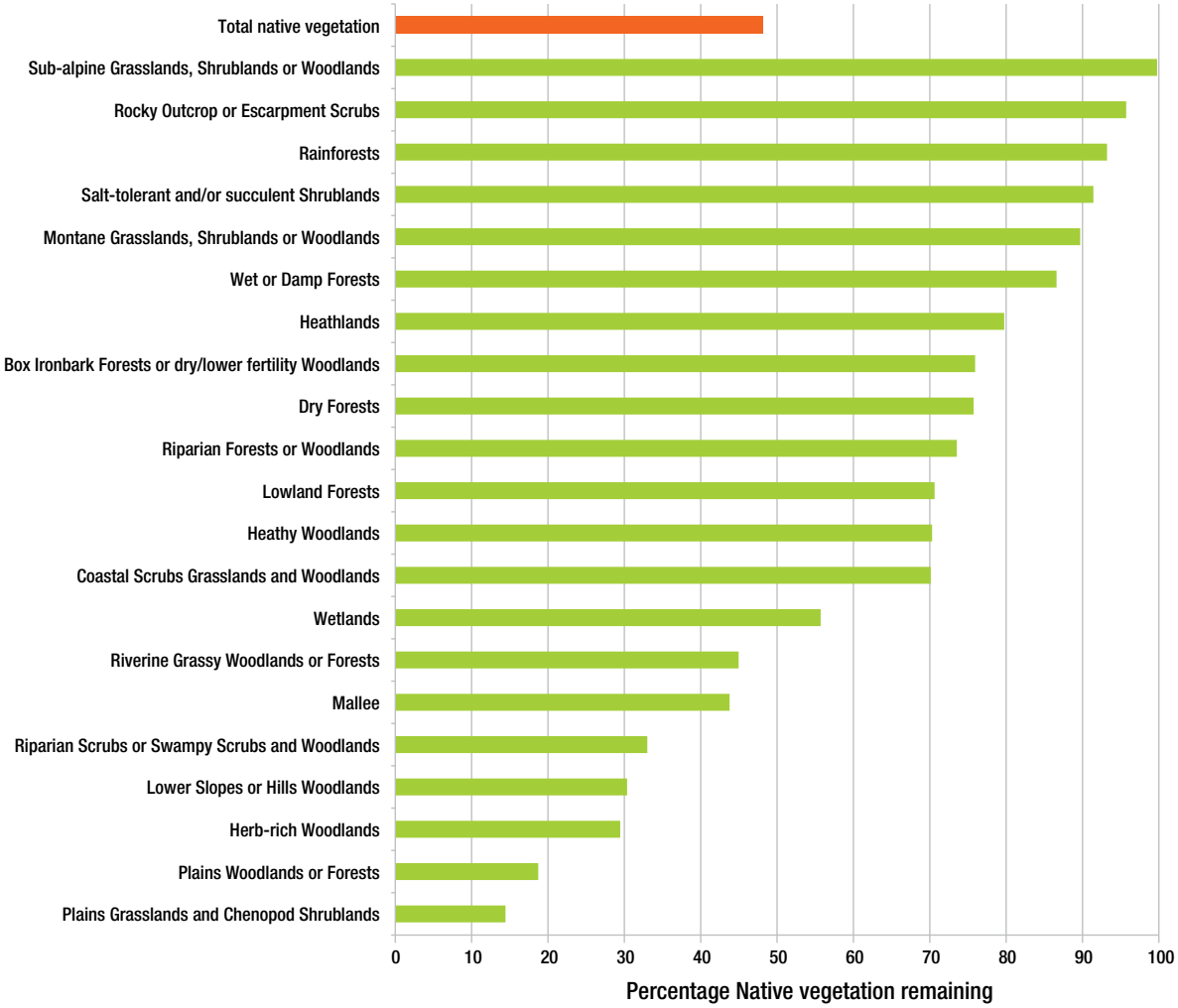


Figure A.2.13: Change in extent of ecological vegetation class broad groupings in Victoria, 1750 to 2012

Source: DEPI.

* Ecological Vegetation Classes (EVCs) are a native vegetation classification described through a combination of floristics, life forms and ecological characteristics and are associated with particular environmental attributes such as soil, rainfall and topography.

Depletion of native vegetation in Victorian bioregions

The loss of native vegetation has varied across Victorian bioregions. Relatively flat, agriculturally productive bioregions in western Victoria have been most heavily cleared, with less than a quarter of native vegetation remaining in the Victorian Volcanic Plain, Victorian Riverina, Warrnambool Plain and Wimmera, while less than one-third of the Gippsland Plain, Dundas Tablelands and Murray Mallee retain native vegetation (Figure A.2.14). In contrast, of the 12 bioregions with greater than 80% of their native vegetation remaining, nine are in mountainous regions of the state, and three occur in the desert (Lowan Mallee) and floodplain (Murray Scroll Belt, Robinvale Plains) of the north-west of the state. Generally the most heavily cleared bioregions have proportionately lost the highest number of species.[17]

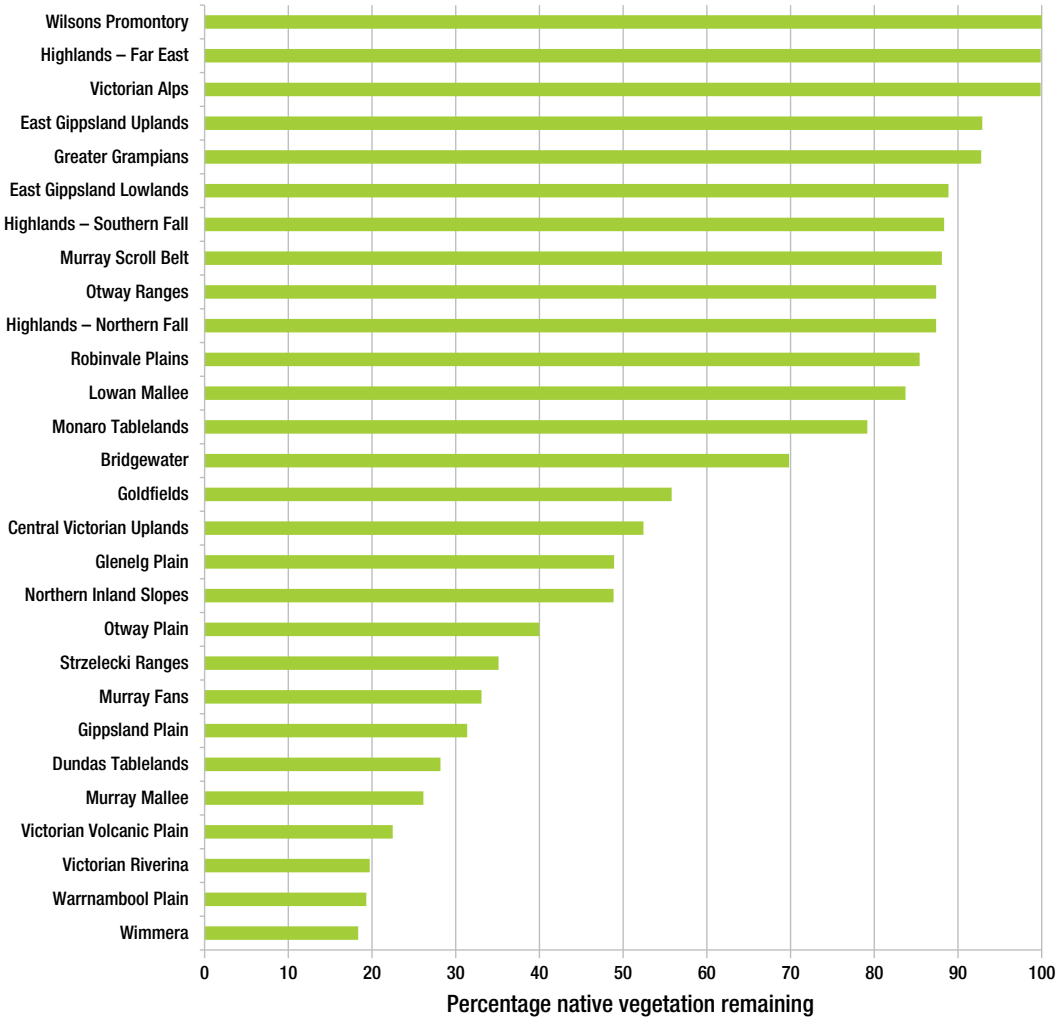


Figure A.2.14: Change in extent of native vegetation by Victorian bioregion, 1750 to 2012

Source: DEPI.

Annual vegetation loss

There has been no update on the clearance of native vegetation since 2008, when it was estimated that Victoria lost 4,000 hectares of native vegetation per year on private land.[17] The majority of native vegetation lost was from endangered native grasslands, of which only 5% remain in Victoria, with less than 1% in good condition.[18]

While the clearing of native grasslands remains of concern, particularly in urban and peri-urban areas with high population growth to the west of Melbourne, it is no longer the largest source of native vegetation change in Victoria. The major source of native vegetation loss is the chronic degradation of habitat condition, mainly in fragmented landscapes.[17] This is compounded by the decrease in rainfall and increased temperatures associated with climate change.

Expert opinion suggests that the extent of native vegetation is most likely to be continuing to decline on private land and in fragmented landscapes, and most likely to be stable in largely intact landscapes. Much of the actively cleared vegetation loss will have occurred through 'allowed actions' such as bushfire protection. Revegetation through investment programs partially mitigates the overall decline in vegetation extent. Overall, however, losses in native vegetation extent from clearance on private land are likely to have exceeded gains from revegetation and natural regeneration.[12, 15]

Quality, condition and fragmentation of native vegetation

Vegetation quality is modelled at a landscape scale across Victoria. Assessments are based on biophysical components of the site (site condition), and the size of a patch of remnant native vegetation and its proximity to adjacent patches of remnant native vegetation (landscape context). Changes in either component can drive changes in vegetation quality.

The bioregions most suitable for urban development and agriculture have not only suffered the greatest loss of vegetation, but the quality of the remaining vegetation is among the lowest in the state (Figure A.2.15 and Figure A.2.16). Furthermore, these regions are characterised by high levels of vegetation fragmentation and low connectivity, which further limits the ecological functionality of these landscapes.[4] Broad-scale clearing has led to the fragmentation of approximately two-thirds of native vegetation in Victoria.

Generally, native vegetation on private land is in poorer condition than that on public land.

Furthermore, native vegetation on public land tends to be better connected structurally than vegetation on private land, mostly because the larger patches of native vegetation are on public land.[15]

In some parts of Victoria, specifically the well-vegetated and mountainous eastern highlands and the Mallee country in the north-west, ecosystems, vegetation condition and quality are considered to be high. Bioregions with the highest levels of low and medium quality vegetation include Dundas Tablelands, Warrnambool Plain, Victorian Volcanic Plain, Strzelecki Ranges, Wimmera, Victorian Riverina, Gippsland Plain and Bridgewater.

It is not possible to compare current vegetation quality data with that reported in the last State of the Environment report due to methodology changes. However, expert opinion suggests the following trends:[12]

- Vegetation quality is generally stable on public land and in largely intact landscapes, but likely to be declining on private land and in fragmented landscapes.
- Improved management through investment programs partially reduces the overall decline in vegetation condition. However, this accounts for only a small proportion of native vegetation on private land.
- Victoria's extended drought is likely to have significantly impacted on vegetation quality, with widespread mature tree death observed in areas of foothills forests.
- Large bushfires in the last decade have also impacted on vegetation quality.

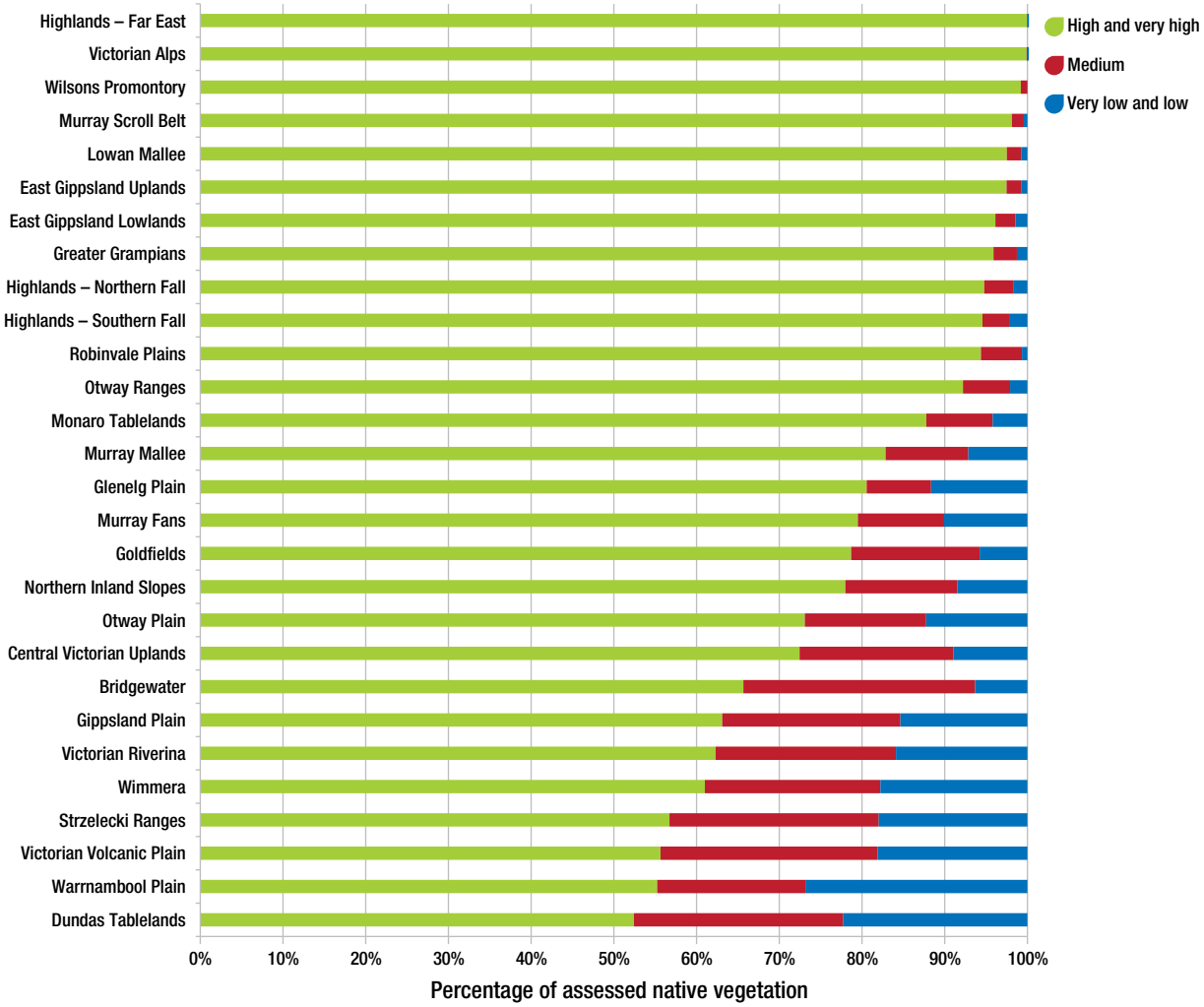


Figure A.2.15: Condition of native vegetation (modelled) by Victorian bioregion, as at 2010

Source: DEPI.

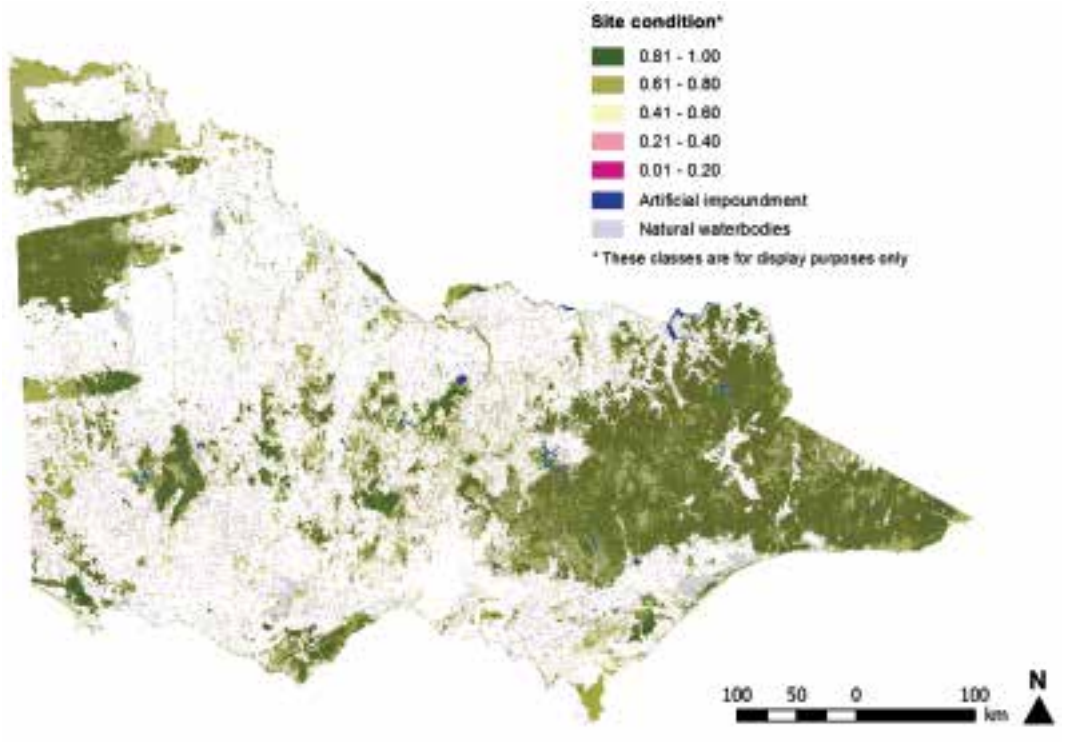


Figure A.2.16: Modelled condition of native vegetation, as at 2010

Source: DEPI.

Native forest timber harvesting

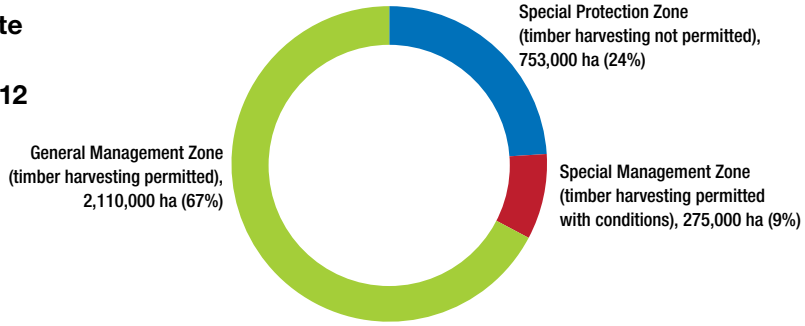
The harvesting of native forest on public land is mainly restricted to State forest, which comprises 3.14 million hectares, approximately 40% of public land and 14% of Victoria (See Indicator LB6: Land Use). Apart from the supply of timber resources, State forest is managed for a variety of purposes, including the conservation of flora and fauna, protection of water catchments, protection of heritage values, and the provision of recreational and educational opportunities.

Forest management zones are used to determine the types of activities that can take place in State forests. In 2012, timber harvesting was permitted in over three-quarters of the State forest area (Figure A.2.17). This includes General Management Zones (2,110,000 hectares, 67% of State forest), and Special Management Zones (275,000 hectares, 9% of State forest) which allow harvesting in accordance with specified conditions. Less than a quarter of Victoria's State forest (753,000 hectares) is covered by Special Protection Zones that are exempt from timber harvesting.

It should be noted that for areas in which timber harvesting is permitted, not all forests are suitable for forestry operations. For example, it is estimated that between 30–40% of forest in General Management Zones is not suitable for harvesting because of timber production exclusions such as excessive slope and proximity to waterways.

Figure A.2.17: Area and percentage of State forest by Forest Management Zone, 2012

Source: DEPI.



Area of native forest harvested

Between 2006–07 and 2011–12, the annual total area of State forest harvested (including fire salvage harvesting) ranged between 7,900 and 11,600 hectares (Figure A.2.18), around 0.3% to 0.4% of the total State forest area and less than 1% of the area available for timber harvesting. The majority of State forest harvested for timber lies within Ash, Red Gum and mixed species forests.

A range of silvicultural systems are used to harvest different forest types, depending on the regeneration requirements of the forest, particularly the availability of suitable seed in the surrounding forest. Victorian silvicultural systems include clearfelling, clearfell with seedtree retention, thinning and single-tree selection. These systems determine the area harvested, for example single-tree selection is less intensive but utilises larger areas. Typically, a quarter or less of the annual harvested area is clearfell, which is the most intensive of the harvesting systems. Clearfelling mainly occurs in Ash forests, whereas single-tree selection method is used for Red Gum forests and mixed species forests.

The sustainability of timber harvesting in Victoria was reviewed in 2001 and timber yields were found to be unsustainable. As a result, the industry was significantly restructured and the sustainable harvest level was substantially reduced. Consequently, the volume of sawlogs harvested from native forest has decreased to meet the reduced, sustainable harvest levels. Since 2005, harvest levels have been within sustainable harvest levels.

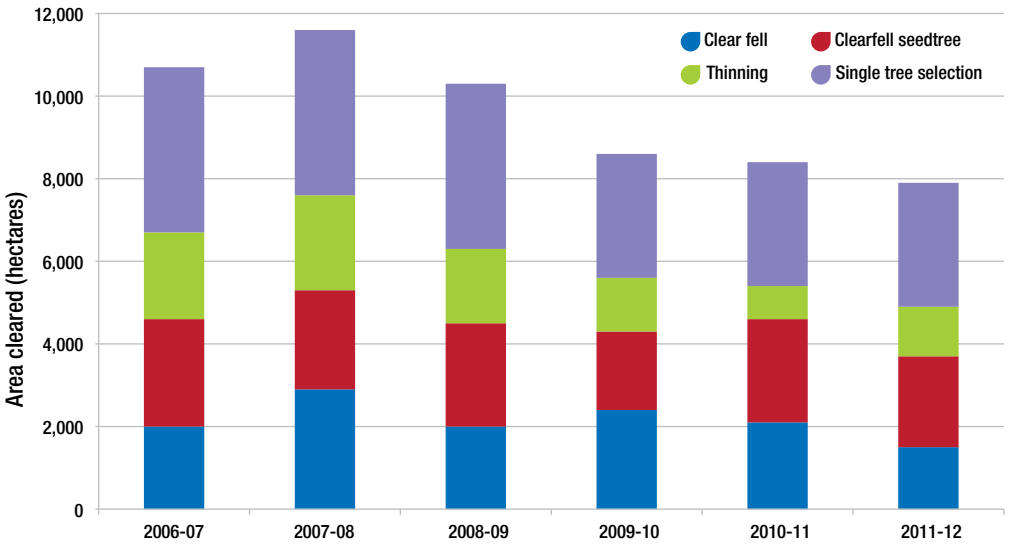


Figure A.2.18: Area of native timber harvest by silvicultural system (including fire salvage harvesting), Victorian State forest, 2006–07 to 2011–12

Source: DEPI.

Note: The silvicultural system used determines the total area harvested; for example, single-tree selection and thinning are less intensive but utilise larger areas. Data does not include area of forest harvested for domestic firewood production.

Fire salvage harvesting

Between 2006–07 and 2011–12, approximately 7,000 hectares of fire salvage harvesting was undertaken in response to the large bushfires in 2006–07 and 2009 (Figure A.2.19). Nearly a third of the salvage harvesting undertaken was through clearfelling. Although fire salvage harvesting was carried out for only 0.4% of the total area burnt by bushfires over the period, salvaging can be detrimental to biodiversity, particularly for mature forest areas. Large trees killed by fire events provide nesting sites for marsupials and birds, and decaying logs are habitats for a range of animals. Consequently, the removal of dead trees by salvage logging can lead to ongoing impacts on biodiversity greater than the impact of the fire alone (See Indicator LB5: Impact of Fire on Victorian Ecosystems).[19, 20]

The harvesting of unburnt forest is also an issue where significant fires have occurred because they provide an important refuge for fauna. Logging of these unburnt areas reduces the availability of habitat for those species displaced by fires. This is particularly an issue where areas designated for harvesting have been set prior to large fire events. Such areas can greatly increase in importance for the protection of biodiversity.

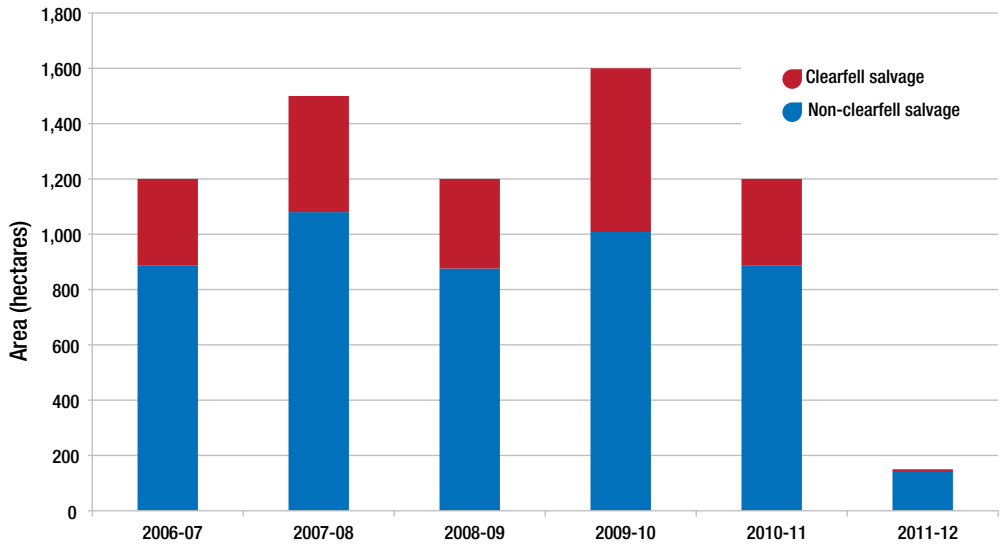


Figure A.2.19: Area of fire salvage harvesting by silvicultural system, Victorian State forest, 2006–07 to 2011–12

Source: DEPI.

Indicator LB4: Pest Plants and Animals

Pest plant and animal species (invasive species) continue to establish in Victoria and pose a major threat to biodiversity, ecosystem health, primary production and landscape aesthetics.

Although this report is mainly concerned with the impacts of invasive species on biodiversity, it must be acknowledged that pest plants and animals are an important and costly issue across all Victorian landscapes and tenures. In 2009 the annual cost to the Victorian economy was estimated to be over $900 million alone.[1] This primarily represents lost production and management costs, as the cost of invasive species to native biodiversity is largely incalculable. Between 2007–08 to 2011–12, the Victorian Government spent $139 million on pest species management on private land alone. The high costs associated with the control of pest species reduce the resources available for other environmental management activities.

Because the eradication of widely established pest species is not feasible, the goal of pest management is to reduce pest numbers to levels where they have no significant impact. This goal requires ongoing and coordinated management. The challenge is to monitor and control established species and, where possible, detect and eradicate new potentially invasive plants and animals before they establish.

Coordinated ongoing management can have positive outcomes for biodiversity. For example, some populations of Southern Brown Bandicoots (*Isoodon obesulus*) and Long-nosed Potoroos (*Potorous tridactylus*) are showing signs of a positive response to the reduction in foxes achieved under the Southern Ark program.[21]

Pest plants and animals are not restricted to exotic species (i.e. those not indigenous to Victoria); over-abundant native animals such as kangaroos and koalas can impact on ecosystem health. Some native species, particularly plants, can also become pests if they become established outside of their natural range.

Climate change may extend the range of many pest plants and animals in Victoria, and may facilitate the introduction and spread of new species (see Foundation Paper One: *Climate Change Victoria: The Science, Our People, and Our State of Play*.)[2]

Pest plants

Plant invasions are considered one of the major factors in the loss of biodiversity through the displacement of native species and the reduction of food and habitat (see Indicator LB2: Threatened Species in Victoria). In addition to threatening native flora and fauna, environmental weeds have other impacts on ecosystem function, including changing hydrological cycles, increased soil erosion, alteration of soil chemistry and nutrient cycling patterns, alteration of geomorphic processes (e.g. dune configuration), and alteration of stream flow and flooding characteristics (e.g. willow invasion of streams).

Pest plants include environmental weeds that threaten natural ecosystems and biodiversity, or agricultural weeds that threaten crops, horticulture, pasture production and may be toxic to livestock.

Weeds have invaded all Victorian landscapes and are a concern across all land tenures, affecting forest, coasts, bushland, farms and urban environments. Twenty of the 32 Australian Weeds of National Significance are known to be present in Victoria.

Pest animals

Pest animals threaten biodiversity through habitat modification, predation of native fauna, and competition for food and habitat. The main pest animal species in Victoria include foxes, rabbits, feral cats and wild dogs. Predation by foxes, cats and dogs is a known threatening process for at least 47 species of threatened fauna in Victoria.

Pest animals can have significant environmental impacts due to soil disturbance from burrowing, grazing and the action of hard hooves (e.g. deer, goats). These promote erosion and can lead to water quality declines. Feral pigs occupying forests and marshes can damage wetlands and habitat of ground-nesting birds. Land disturbance by pigs also facilitates weed invasion. Pest animals can also spread disease and parasites.

Rabbits pose a particular threat to native vegetation, as they prevent regeneration by removing seedlings. Loss of native vegetation by rabbit grazing places pressure on native herbivores and the presence of rabbits can sustain fox and feral cat populations. These predators, in turn, place further pressure on native prey species.

Number of introduced plant and animal species

Statewide information on the number and distribution of introduced species has not been updated since the 2008 Victorian State of the Environment report. Consequently, it is not possible to determine changes in the number of pest plants and animals since 2008. Main findings from the previous State of the Environment report include:[4]

- In 2008, exotic plant species represented approximately 30% of Victoria's flora, with over 1,280 species considered naturalised in Victoria. This increased from 878 naturalised species in 1984. It is estimated that an average of 7.3 new plant species establish in Victoria per year, and that this rate increases each year.
- Weeds affect all Victorian landscapes. Approximately 90% of the native bushland in Melbourne is badly affected by weeds, with more than 50% severely degraded by weeds.
- Almost 80% of recently recorded plant naturalisations in Victoria are of garden origin.
- The area occupied by naturalised plant species increases annually. Some of Victoria's most significant weed species are likely to become more widespread with climate change and land-use change.
- Most pest animals occur and are managed on local scales, and statewide trends in pest species are not monitored. While foxes and rabbits are widespread throughout Victoria, wild dogs and feral pigs are absent or unknown over large areas of Victoria.

Extent of active management

Comprehensive data on the extent of pest plant and animal management is not available for Victoria, particularly for private land. However, some data is available for specific landscape scale management programs on public land. These programs are generally aimed at protecting biodiversity values, such as threatened species, and therefore often target a range of pest plant or animal threats. For example, between 2008 and 2011, some 1.5 million hectares of public land was treated for pest animals through these landscape scale programs, the majority for foxes and 282,000 hectares for weeds. Other pest animals subject to management include rabbits, cats, pigs and goats.

Pest plants and animals on public land are also managed on a local scale through targeted programs for particular pest species. These programs include ongoing maintenance programs, opportunistic control programs and emergency incursion response.

Case Study: Pest Plant and Animal Management in Victorian Parks and Reserves

Source: Parks Victoria.

Pest species are a significant problem in Victoria's parks and reserves. The protection of parks from invasive species represents the largest program of natural values management activity undertaken by Parks Victoria (by area and expenditure).

In 2010, over 1.1 million hectares were treated to control pest animals in Victoria's parks and reserves, including some 800,000 hectares for Red Fox, 200,000 hectares for European Rabbits, and 20,000 hectares for feral cats (Figure A.2.20). In addition, 115,000 hectares were treated for weeds.

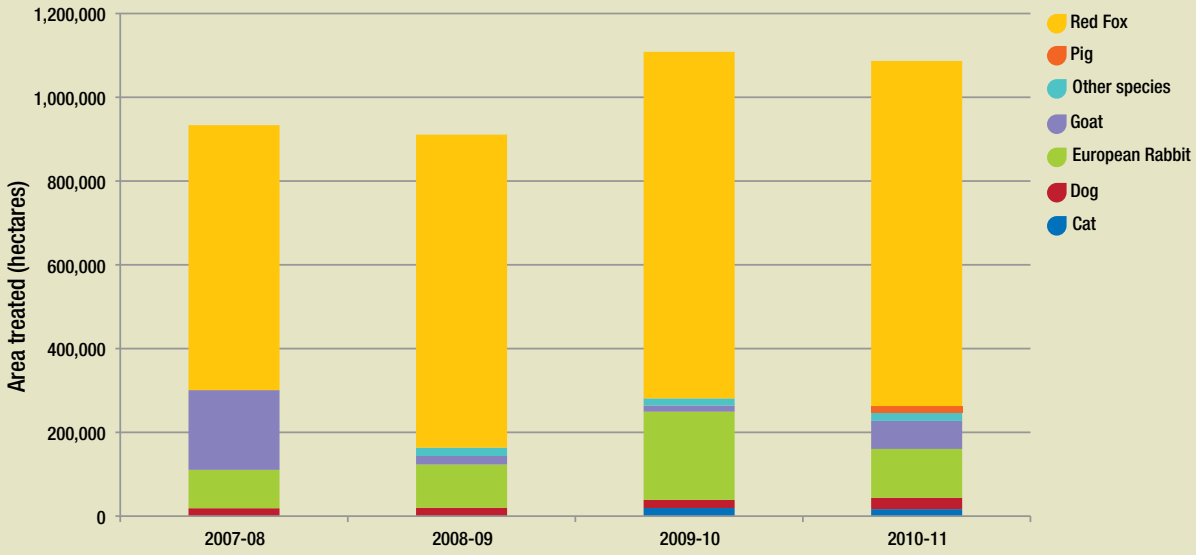


Figure A.2.20: Area treated for pest animal management in Victorian parks and reserves 2007–08 to 2010–11

Source: Parks Victoria.

Pest plants

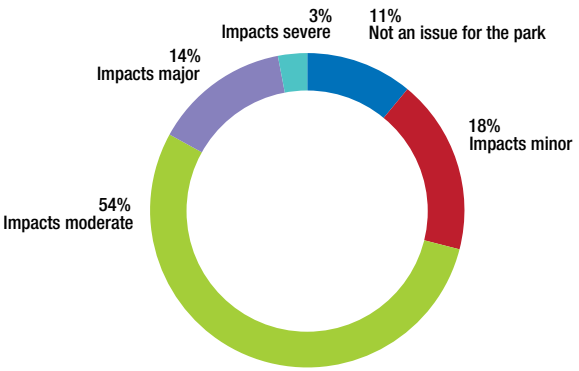
Pest plants are widespread in Victoria's parks and reserves. In 2010, 1,224 introduced plant species (both exotic species from overseas and Australian native species growing beyond their natural range) were known to occur within Victoria's parks. In over 40% of parks where adequate data was available, introduced species constituted up to 20% of the total flora.

Pest species vary in their distribution, extent and impact on natural values. Some weeds are found in a broad range of habitats across the state (e.g. Blackberry) while others are restricted to just one or two parks (e.g. Orange Hawkweed in the Alps). Weeds that have established in parks are often a result of previous land use, or adjacent land use (e.g. garden escapes).

In 2010, 311 parks were assessed for pest plants. Weeds were reported as an issue in 89% of the assessed parks constituting 91% of the assessed area (Figure A.2.21). Weeds were found to have major or severe impacts in 17% of the parks assessed, moderate impacts in 54%, and minor or insignificant impacts in 29% of assessed parks. Impacts of weeds were found to be increasing in 19% of assessed parks, and remaining stable or declining in 52%.

Figure A.2.21: Impacts of all weeds across 311 assessed parks, 2010

Source: Parks Victoria.



Pest animals

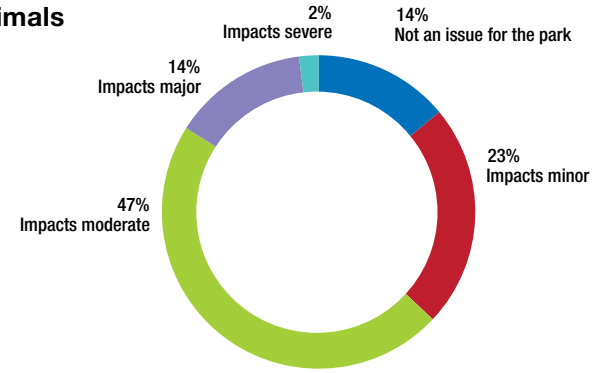
In 2010, pest animals were an issue in 84% of the 311 assessed parks, which represented 94% of the assessed area (Figure A.2.22). Some 54% of parks assessed had moderate impacts from pest animals, with 16% having major or severe impacts. Pest animal impacts were found to be increasing in 17% of assessed parks and remaining stable or declining in 35%.

The severity of impact from priority pest animals species varied with Red Fox, European Rabbit and cats reported as having the greatest impact. The introduced Sambar and Fallow deer, and European Wasp were reported as increasing in impact in around half of the parks where they were considered an issue.

An increased emphasis on landscape scale programs, such as the Southern and Glenelg Arks, Grampians Ark and Mallee Bounceback rabbit control programs, have resulted in a reduction in the level of threat by foxes and rabbits at priority parks.

Figure A.2.22: Impacts of all pest animals across 311 assessed parks, 2010

Source: Parks Victoria.



Indicator LB5: Impact of Fire on Victorian Ecosystems

This chapter examines the impact of fire on native vegetation and terrestrial biodiversity. Information on the occurrence, risks and impacts of fires in Victoria, including the Black Saturday fires in 2009, can be found in Foundation Paper One: *Climate Change Victoria: The Science, Our People, and Our State of Play*.[2]

Victoria has one of the most fire-prone environments in the world, owing to its particular combination of climate, vegetation and topography. Bushfire is a normal feature of our environment and plays a key role in many ecosystems. While it may produce a temporary loss of vegetation, fire is necessary for the regeneration and regrowth of many plant species.

While many plant species need fire to stimulate regeneration, the appropriate fire regime (intensity, frequency, season, extent and type of fire) varies between ecosystems. In general, grasslands and heathlands require more frequent burning than eucalypt forests to maintain diversity and community structure. Too little or too much fire can change the composition of vegetation communities and the ecosystems they support.

However, the ecologically appropriate natural fire regimes to which species have evolved in Victoria have changed, with fire increasing in some areas and decreasing in others. This is due to increased human sources of ignition, the suppression of natural fire to protect human life and assets, and planned burning practices for the management of fuel loads. In addition, the recent period of prolonged drought and higher temperatures has increased the frequency and severity of fires. Climate change is expected to further influence the occurrence of bushfires in Victoria.

Planned burning is used in the management of Victoria's 8.5 million hectares of mostly forested public land. It is mainly used to decrease the occurrence of large bushfires and potential impacts on life, property and the environment through the reduction of fuel loads. Planned burns are also applied for ecological purposes where ecosystems rely on fire for regeneration and the maintenance of vegetation composition and structure. The challenge for land managers is to balance the need for suppression and prevention of fires with the requirement of many ecosystems for ecologically appropriate burning.

The impacts of bushfires are not restricted to terrestrial ecosystems. Fires have important implications for river health, water quality and water yields because of changes in vegetation cover, soil structure and sedimentation (see Part A: 3 Inland Waters). Fire also impacts on air quality, significantly contributing to summer smog and particle pollution (see Part A: 1 Climate Change and Air Quality)

Area of native vegetation burnt in planned fires and bushfires

Planned fires

The Victorian Government has been progressively increasing the annual planned burning target. Prior to 2010–11, the annual target was 130,000 hectares, this increased to 200,000 hectares in 2010–11, 225,000 hectares in 2011–12 and 250,000 hectares in 2012–13. The increase in planned burning has been in response to recommendations from various inquiries into large bushfires since 2002, including the 2009 Victorian Bushfires Royal Commission, which recommended an annual planned burning target of 390,000 hectares (5% of public land).[22] This figure was suggested as sufficient to significantly reduce risk to life and property from major fires.

Regardless of annual burning targets, the actual area of planned burning achieved in any year is highly dependent on the occurrence of favourable weather conditions, both prior to and during planned burning activities. Consequently, it is often not possible to meet planned burning targets.

The increase in the annual planned burning target is the focus of much discussion, particularly around the impacts on native vegetation and ecosystems (see Part B: 1.4 Review of Impacts on Ecosystems due to Planned Burning).

Between 2001–02 and 2012–13, 1.7 million hectares of native vegetation was burnt by planned fires in Victoria (Figure A.2.23 and Figure A.2.24). The vast majority of planned burns were carried out for fire suppression purposes, with 85% of planned burns used for fuel reduction. The total area burnt represents over 20% of the total area of public land, and is equivalent to nearly half of the total area burnt by bushfires over the same period.

The annual area of planned burning for fuel reduction purposes has been increasing in Victoria, with annual burns of 120,000 hectares or higher since 2006–07. The largest area burnt was 201,000 hectares in 2012–13. The area of ecological burns has also increased significantly, with annual burns of between 22,000 hectares and 52,000 hectares between 2008–09 and 2012–13. Prior to 2008, the largest annual area of ecological burning was 14,000 hectares.

The increase in planned burning has been in response to recommendations from various inquiries into large bushfires since 2002.[22–24] These recommend that opportunities for planned burning should be maximised where possible to reduce fuel loads in Victorian forests. However, this only relates to fire suppression and does not take into account ecosystem health.

Despite the increase in planned burning activities, the annual area burnt remains well short of the Victorian Bushfires Royal Commission target of 390,000 hectares per year.[22]

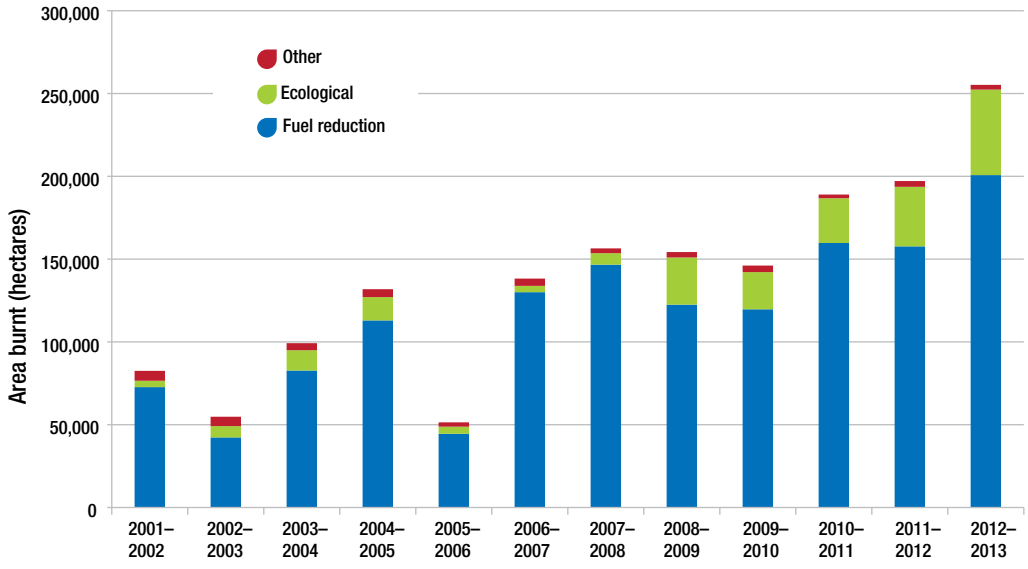


Figure A.2.23: Area of planned burning by type, 2001–02 to 2012–13

Source: DEPI.

Note: Other burns include those for forestry-related activities such as regeneration burns after harvesting.

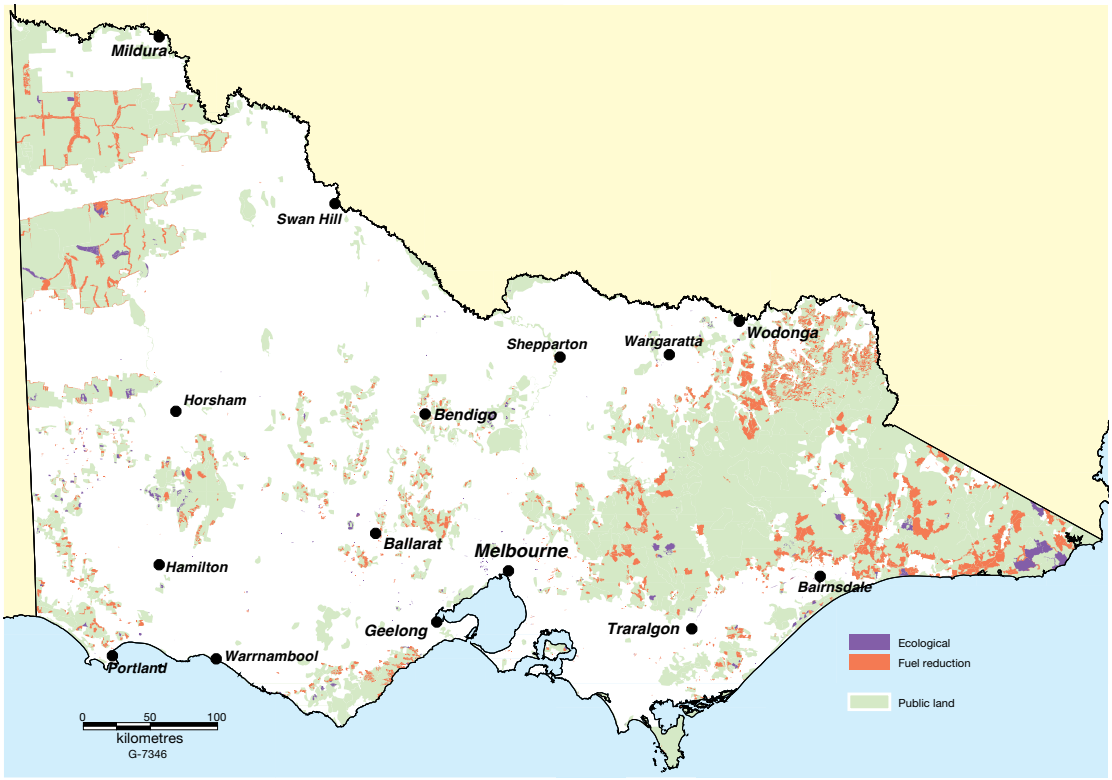


Figure A.2.24: Planned burns in Victoria, 2002 to 2012

Source: DEPI.

The Gippsland region accounted for the largest area of planned burns between 2001–02 and 2012–13, with 501,000 hectares or 37% of the total planned burn area (Figure A.2.24 and Figure A.2.25). The North East region was the next highest accounting for 379,000 or 28% of the total planned burn area. This reflects the highly forested nature of these regions. The Orbost and Mallee districts were subject to extensive burning over the period, accounting for 16% (221,000 hectares) and 15% (201,000 hectares) of the total area burnt over the period respectively (Figure A.2.24 and Figure A.2.26).

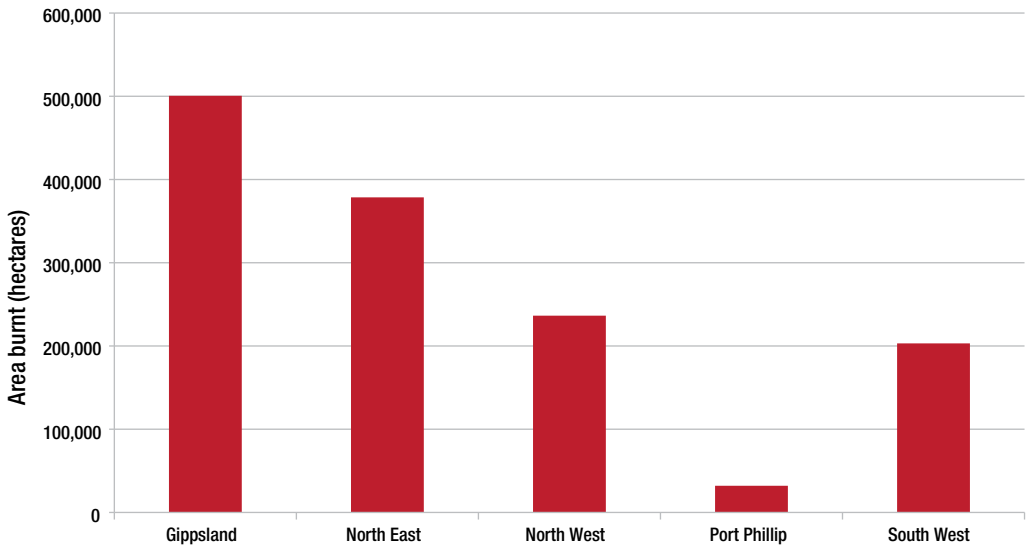


Figure A.2.25: Area of planned burning by region, 2001–02 to 2012–13

Source: DEPI.

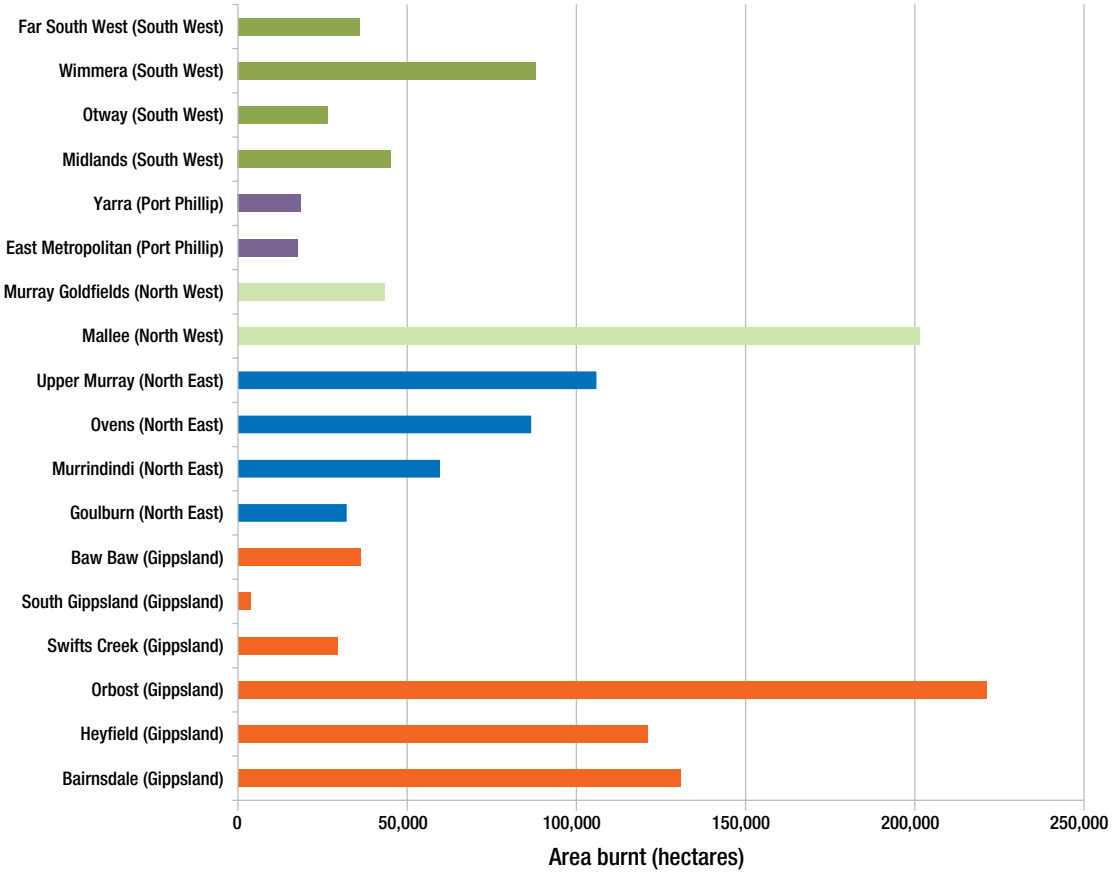


Figure A.2.26: Area of planned burning by fire district, 2001–02 to 2012–13
Source: DEPI.

Bushfires

Between 2001–02 and 2012–13, nearly 3.6 million hectares were burnt in bushfires, the vast majority of which was on public land (Figure A.2.27 and Figure A.2.28).

Some 85% of this area was burnt during three extensive bushfire seasons in less than a decade: 2002–03 (1.3 million hectares), 2006–07 (1.2 million hectares) and 2009 (430,000 hectares). This period saw prolonged drought and higher temperatures across Victoria, which increased the frequency and severity of large bushfires. The dry and hot conditions leading up to these fires are consistent with predictions that climate change will increase the occurrence and risk of bushfires in the future.

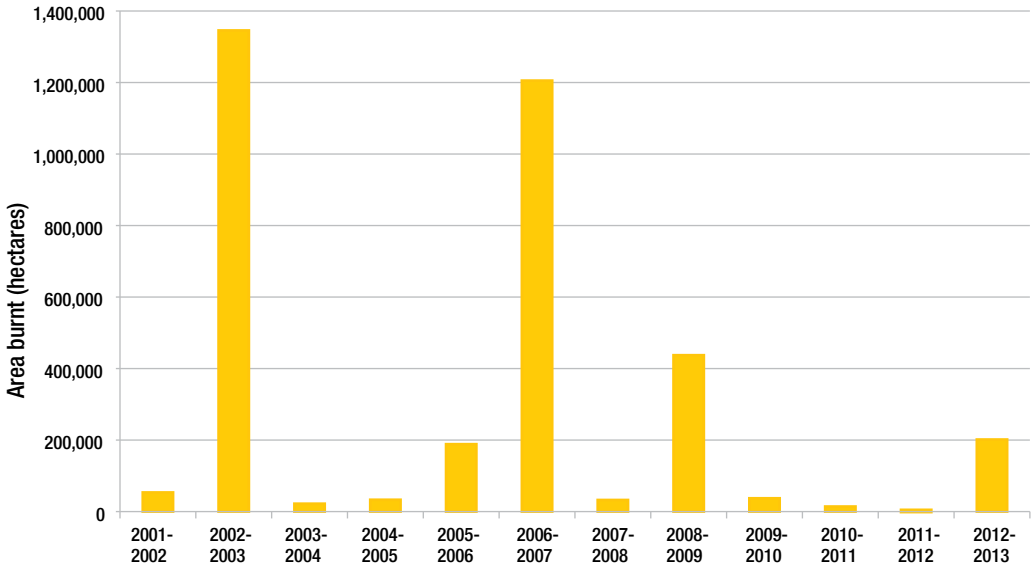


Figure A.2.27: Area burnt in Victorian bushfires, 2001–02 to 2012–13

Source: DEPI.

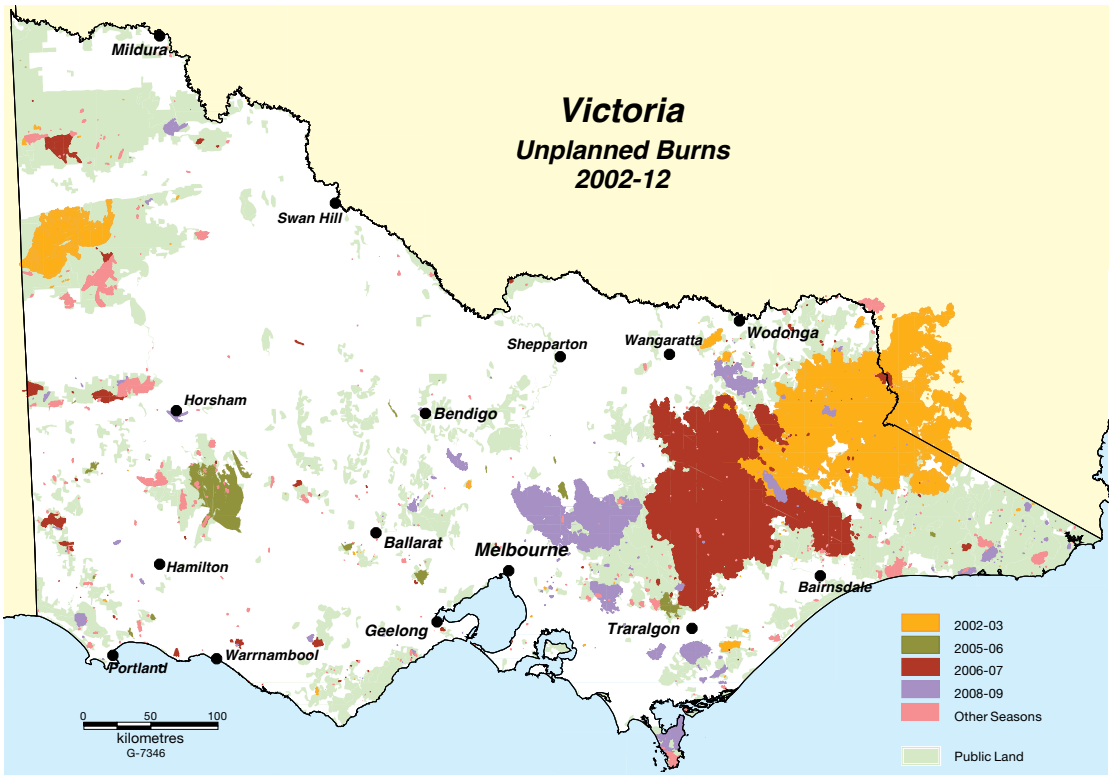


Figure A.2.28: Victorian bushfires, 2002 to 2012

Source: DEPI.

Victorian regions most impacted by bushfires were the North East and Gippsland, which accounted for nearly 80% of the area burnt between 2001–02 and 2012–13 (Figure A.2.28 and Figure A.2.29). This reflects the highly forested nature of these regions. Native vegetation in the Mallee area (North East) and the Grampians (South West) also experienced significant bushfires of over 200,000 hectares over the period. In addition, large areas of Wilsons Promontory were burnt. Over 165,000 hectares of vegetation was burnt more than once as a result of the large fires in 2002–03, 2006–07 and 2009. Changes to vegetation structure and a loss of biodiversity can occur in areas subject to frequent severe bushfires.

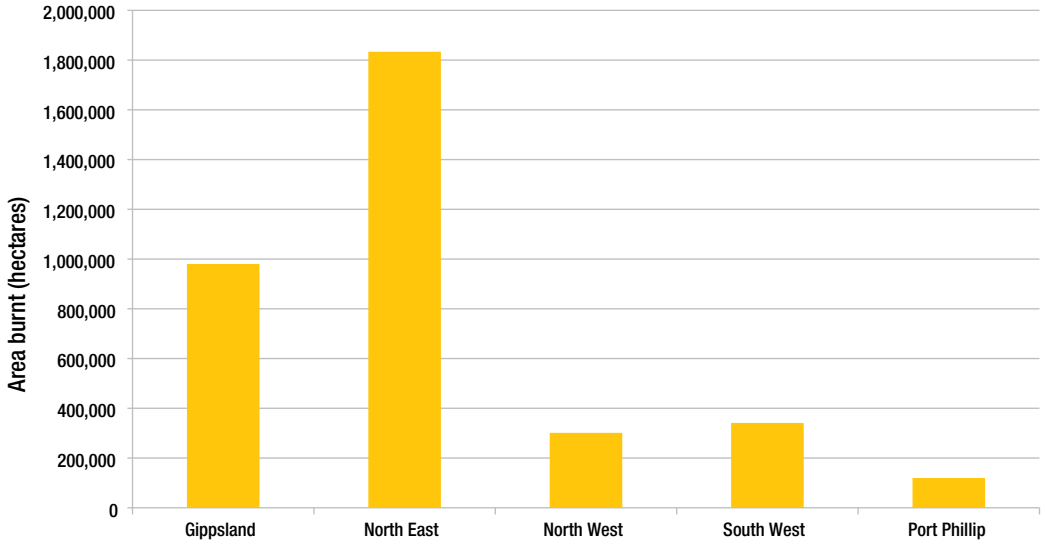


Figure A.2.29: Area burnt in Victorian bushfires by fire region, 2001–02 to 2012–13

Source: DEPI.

Actual fire regimes compared to optimal fire regimes

A fire regime is the frequency, intensity, season, extent and type of fire events in a given area. Inappropriate fire regimes threaten biodiversity by changing the structure of plant communities and is listed as a threatening process under the *Flora and Fauna Guarantee Act 1998*. The appropriate interval between fires for any given plant community is determined by the time taken by each species to reach maturity and set seed, and the time to extinction in the absence of fire. If fire is too frequent, species that are not able to reproduce may be lost from the community. If the interval between fires is too long, species that depend on fire for regeneration may die out.[25]

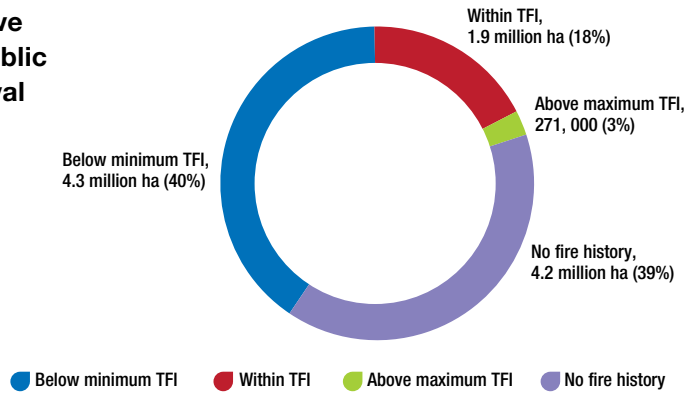
The Department of Environment and Primary Industries has characterised tolerable fire intervals (TFI) for each Ecological Vegetation Division (EVD) on Victoria's public land.[25] TFI reflects the history of bushfires and planned burning in Victoria over recent decades, including the extensive areas affected by bushfire over the past 10 years. In interpreting the results of the TFI analysis, it should be noted that Victoria applies a conservative approach by doubling the time to reproductive age of key fire response species. This provides a greater risk buffer and earlier detection of fundamental ecological change.

In 2012, 40% of native vegetation was found to be below minimum TFI (fire frequency too high to maintain vegetation in its current state) with 3% above the maximum TFI (fire frequency too low to maintain vegetation in its current state). Only 18% of native vegetation assessed was found to be within the required TFI to maintain vegetation communities.

A further 39% of native vegetation had no fire history and consequently TFI could not be calculated (Figure A.2.30). Because of the high percentage of native vegetation without fire history, it is difficult to ascertain the full extent of impacts from fire frequency changes. However, given the high area of vegetation outside of TFIs, it is likely that inappropriate fire regimes exist for the majority of Victoria's native vegetation.

Figure A.2.30: Area of native vegetation on Victoria's public land by tolerable fire interval status, as at 30 June 2012

Source: DEPI.



Note: Below minimum TFI refers to fire frequencies that are too high to enable plant maturation and seeding. Above maximum TFI refers to fire frequencies that are too low for regeneration. Within TFI refers to fire frequencies appropriate for maintaining vegetation communities. No fire history means no data is available for the occurrence of fire.

For the 32 EVDs assessed, only eight had 25% or more of their assessable area within the required TFI, none had over 50% of their area within the required TFI (Figure A.2.31). Fourteen EVDs had less than 10% of their assessable area within the required TFI. Hummock-grass Mallee and Tall Mixed Forest had the highest area within TFI with 43% and 36% respectively.

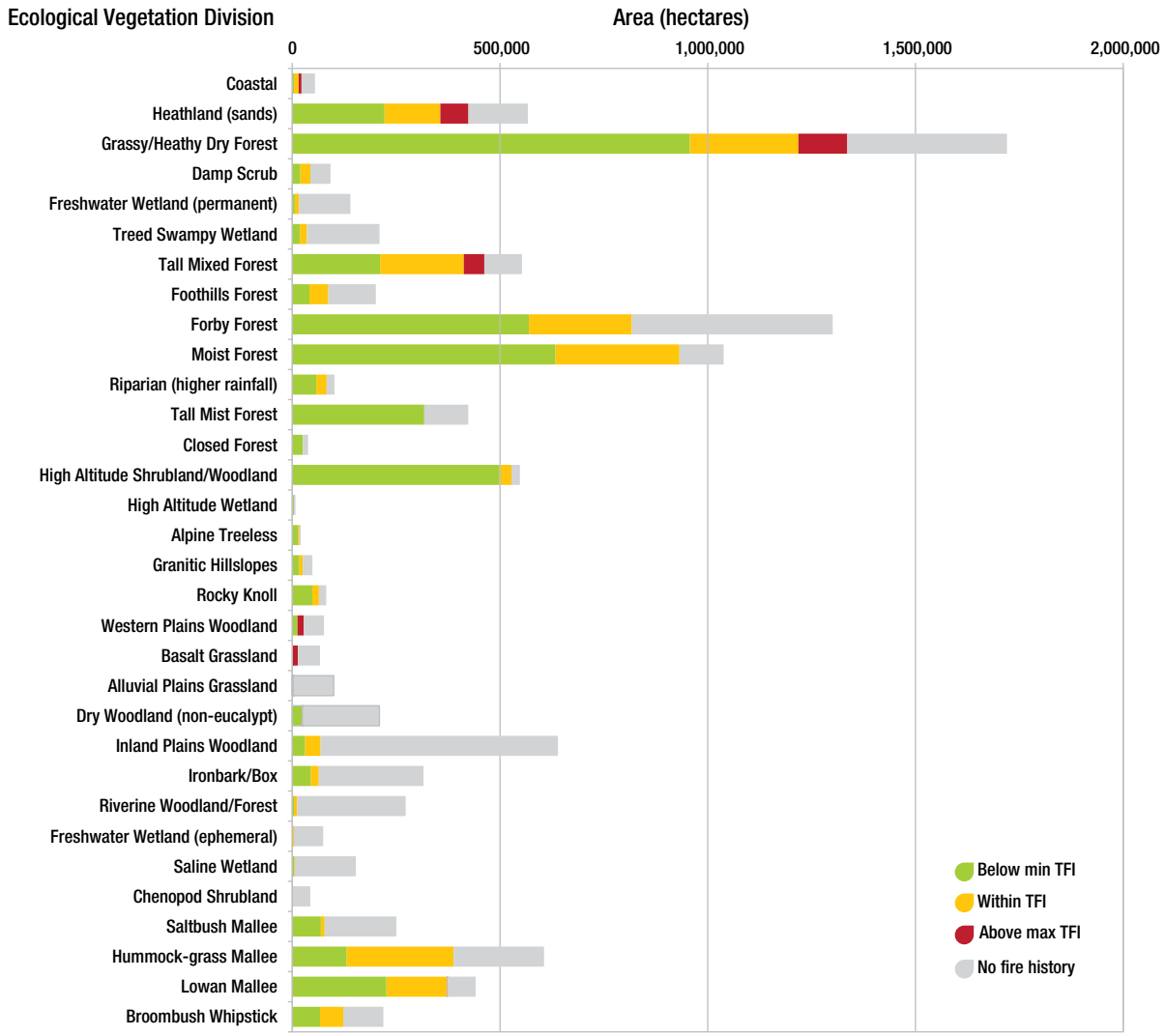


Figure A.2.31: Area of Ecological Vegetation Division on Victoria's public land by tolerable fire interval status, as at 30 June 2012

Source: DEPI.

Tolerable fire interval status has changed considerably since 2000 due to large fire events. The distribution of areas that are below, within and above TFI are shown for 2012 and 2000 (Figure A.2.32 and Figure A.2.33). These clearly show the increase in the area of native vegetation below the minimum TFI, and decrease of areas within TFI as a result of increased bushfires and planned burning.

Over the next decade, large areas of Victoria will remain below minimum TFI irrespective of the level of planned burning and future fire events. This potentially places species with life cycles dependent on long inter-fire intervals at increased risk, particularly in EVDs with little long unburnt vegetation.

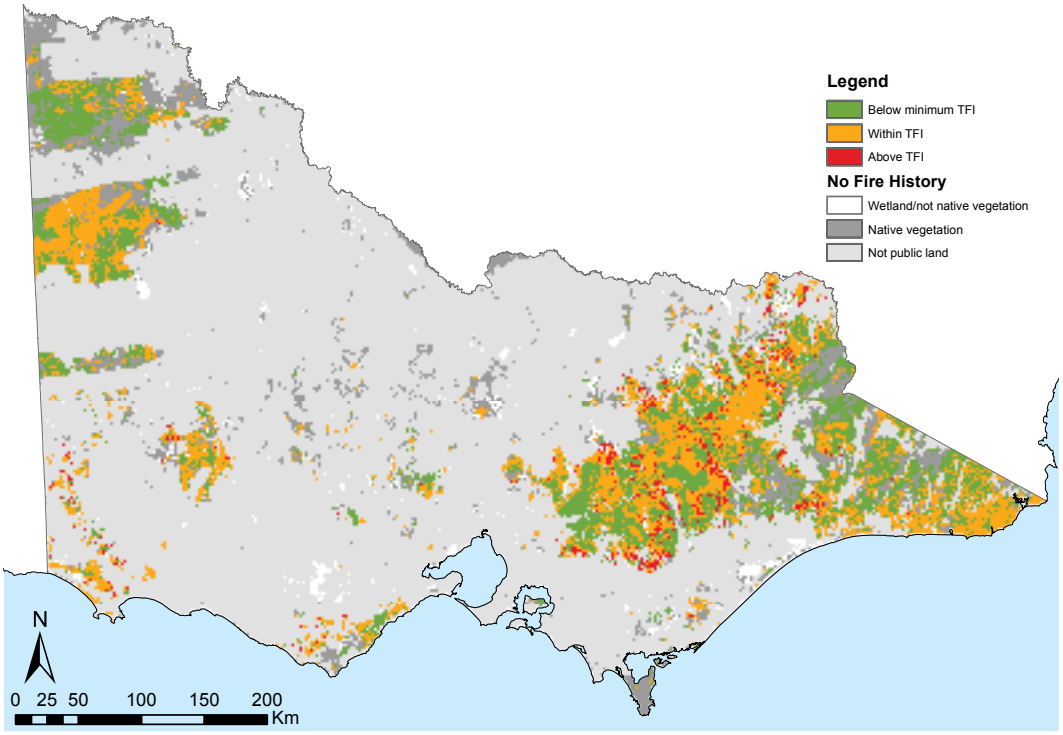


Figure A.2.32: Tolerable fire interval status of vegetation on public land in Victoria as at 2000

Source: DEPI.

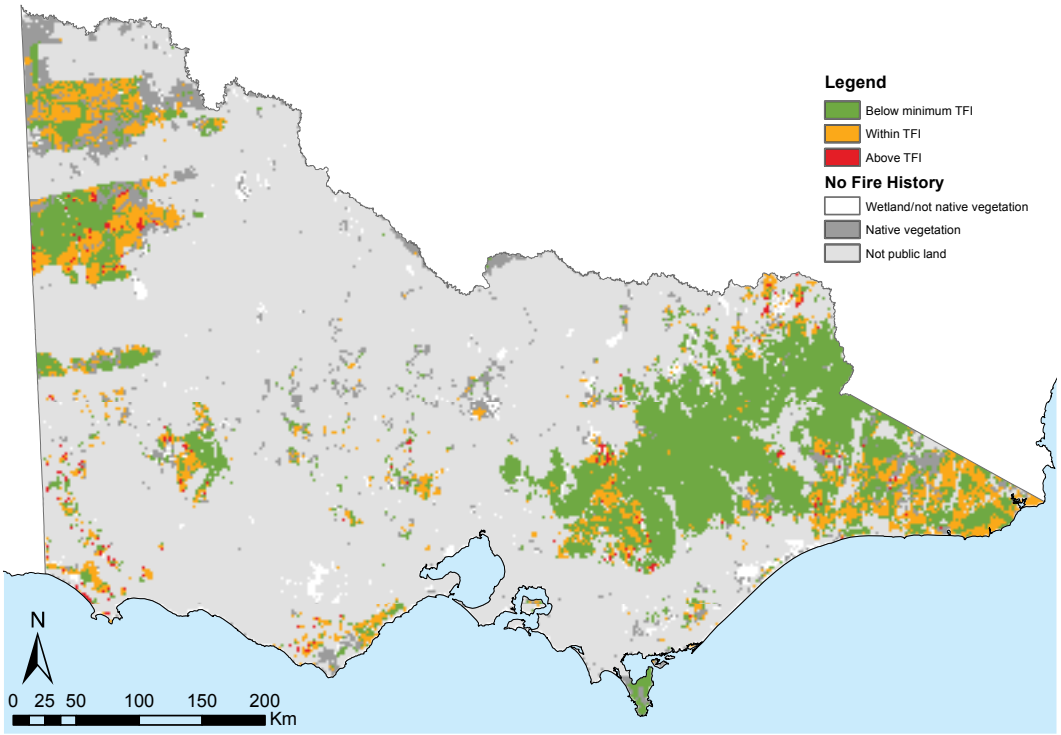


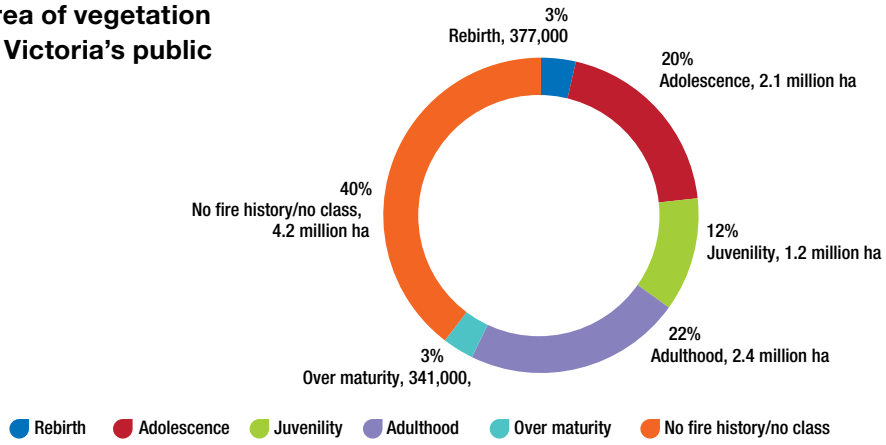
Figure A.2.33: Current tolerable fire interval status of vegetation on public land in Victoria as at June 2012

Source: DEPI.

In addition, recent large-scale bushfire events means that early growth stages are now over-represented in Victoria's vegetation types. Of the assessed native vegetation, 35% were found to be in early growth stages compared to only 25% in mature or over mature stages (Figure A.2.34). These changes have severe implications for biodiversity, especially fauna that require older growth stages.

Figure A.2.34: Area of vegetation growth stage on Victoria's public land, as at 2012

Source: DEPI.



Impacts of fires on biodiversity

The impact of the frequent and extensive bushfires of the last decade on individual species is likely to be varied and is the subject of ongoing research and monitoring. For many species, the impacts can only be assumed based on life history traits and even with initial monitoring it may be too early to determine these impacts. While fire favours some species by triggering seed germination or by opening up new habitat, for threatened or restricted-range species, fires are likely to have had a negative impact where inappropriate fire regimes exist. In addition, many forest species such as possums and owls nest in tree hollows, the availability of which are strongly influenced by fire and tree age.

Adding to fire impacts is the detrimental impacts of salvage logging.[19, 20] Large trees killed by fire events provide nesting sites for marsupials and birds, and decaying logs are habitats for a range of animals.

Consequently, the removal of dead trees by salvage logging can lead to ongoing impacts on biodiversity greater than the impact of the fire alone. Research has shown that salvage logging after the 1939 bushfires contributed to a shortage of cavity trees for more than 40 species of vertebrates. This will take more than 200 years to rectify.

The harvesting of unburnt forest is also an issue where significant fires have occurred because they provide an important refuge for fauna. Logging of these unburnt areas reduces the availability of habitat for those species displaced by fires. This is particularly an issue where areas designated for harvesting have been set prior to large fire events. Such areas can greatly increase in importance for the protection of biodiversity.

The 2002–03 and 2006–07 fires are discussed in the previous State of the Environment report.[4] Their impacts on Victoria's biodiversity, particularly alpine communities, are considered to be severe. Alpine and mountainous vegetation communities were particularly affected by these large bushfires with nearly 2.3 million hectares burnt, including over 145,000 hectares of vegetation burnt in both the 2002–03 and 2006–07 fires. The Mountain Ash (*Eucalyptus regnans*) and Alpine Ash (*Eucalyptus delegatensis*), which dominate Victoria's eastern forests, regenerate from seed following fire and need up to 20 years without fire to start producing seeds. The extent of these species is likely to be severely reduced in the areas that were burnt more than once. They may be replaced with species that resprout quickly from burnt trunks or from roots after fire, such as some *Acacia* species.[4]

The 2009 bushfires have been another significant event for Victoria's biodiversity. The once healthy population of the endangered Leadbeater's Possum on the Lake Mountain plateau was decimated by the fires, with only a few individual animals known to have survived the fire. The fires also threatened aquatic species due to the high risk of sedimentation following substantial rainfall on the exposed, post-fire soils. Populations of Barred Galaxias and Macquarie Perch were brought into captivity to ensure their survival. These fish have subsequently been returned to the wild and appear to be surviving.[12]

Biodiversity data gaps

Victoria generally has a lack of integrated and well-designed monitoring to answer key biodiversity and ecological and management questions. In addition, the accessibility of available data is severely reduced by the disparate nature of biodiversity datasets.

In the 2008 State of the Environment report, it was noted that despite an increase in the number of species listed as threatened and the increasing risks posed to them, monitoring effort for species distribution and abundance was declining. The ongoing lack of data on threatened (and non-threatened) species suggests that this trend has not changed. Victoria's conservation planning efforts and conservation needs are still hampered by the lack of monitoring, which limits the ability to track changes in species populations. Knowledge of the status of invertebrates, lichens and fungi also remains poor.

It is also difficult to determine biodiversity trends over time because of methodology changes. While this can mean improved data quality, it is often unclear whether biodiversity changes are due to actual changes or increased accuracy (e.g. vegetation extent and quality).

Important datasets, such as those on native vegetation, provide the foundation for many other natural resource values and processes. However, these basic datasets are not routinely updated and maintained.[12]

Other data gaps for biodiversity include a lack of knowledge of the distribution and abundance of pest plants and animals and their management, and the impacts of fire on biodiversity, especially individual species populations.

B LAND

MAIN FINDINGS

General

- Current understanding of land and soil health is hampered by the lack of data and long-term monitoring programs, with existing datasets often limited in extent or out of date. This makes it difficult to detect trends in land and soil health over time and remains a critical gap in our understanding of environmental condition.

Land use

- Victoria's public land is mainly divided between parks and reserves (18% of Victoria's total area) and State forests (14% of Victoria's total area), which account for 90% of Victoria's public land.
- Nearly two-thirds of Victoria is privately owned and is predominantly used for agricultural production. Agriculture accounts for 56% of Victoria's total area, making it the dominant land-use type in the state.
- Dryland cropping and grazing (rain-fed or unirrigated) accounts for the vast majority of Victoria's agricultural area, covering 90% of all agricultural land. Irrigated agriculture and horticulture accounts for over 8% of agricultural land.
- The area of parks and reserves has increased with a corresponding decrease in the area State forest due to the transfer of State forest into the reserve system.
- Irrigated agriculture has increased with a corresponding decrease in dryland agriculture. This is likely driven by water trading which is producing significant land-use change in irrigation areas.
- Urban areas have increased with population growth driving urban expansion in Melbourne and regional centres, as well as in coastal areas.

Salinity

- Knowledge of the extent and severity of salinity are poor in Victoria, with ad hoc and infrequent data collection and little information on irrigation salinity.
- It is estimated that around 247,000 hectares is affected by dryland salinity, 2% of the total area of dryland agriculture in the state. Regions most affected include Victoria's north (particularly the Mallee) and west, and near Sale in the state's east.
- Western Victoria is generally more severely affected by salinity than eastern Victoria, largely because it is flatter and poorly drained, and also because conversion of native vegetation to agriculture has been much more extensive in western Victoria.
- The spread of dryland salinity in Victoria slowed or receded in many areas during the recent dry period due to lower groundwater tables. However, the area impacted by salinity is likely to increase with the recent return to wetter conditions.
- There is no current data for irrigation salinity in Victoria.

Soil health

- No new data on soil structure decline and erosion has become available since that reported in the 2008 Victorian State of the Environment report.
- At least 60% of Victoria soils are prone to erosion and soil structure decline.
- Expert opinion indicates that the recent drought conditions experienced across much of Victoria reduced the threat of water erosion, primarily in cropping regions. However, the extended dry is likely to have increased wind erosion because of the decrease in vegetative cover.
- No new data on soil acidification has become available since that reported in the 2008 Victorian State of the Environment report. Expert opinion suggests that soil acidity has generally decreased since the 1990s due to the prolonged drier conditions.
- Data on soil carbon levels is poor in Victoria, particularly for private land.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
LB6 Land use	Due to differences in methodology, land-use changes since the previous State of the Environment report cannot be determined. However, the area of parks and reserves, irrigated agriculture and urban land are all known to have increased since 2007, with decreases in State forest and dryland agriculture.		
LB7 Area affected by salinity	Knowledge of salinity is limited in Victoria. It is believed that around 247,000 hectares are currently affected by dryland salinity. Regions most affected include Victoria's north and west, and near Sale in the state's east. The spread of dryland salinity slowed during the recent dry period but is likely to increase with a return to wetter conditions.		
LB8 Soil health	No new statewide data on soil structure decline, erosion or acidification is available. Expert opinion indicates that the recent drought conditions reduced the threat of water erosion and acidification but increased wind erosion. Knowledge of land and soil health remains poor in Victoria.		

Indicator Assessment Legend

Status

- Environmental condition is healthy across Victoria, **OR** comprehensive protection of natural ecosystems and biodiversity.
- Environmental condition is neither positive or negative and may be variable across Victoria, **OR** moderate protection of natural ecosystems and biodiversity.
- Environmental condition is under significant stress, **OR** inadequate protection of natural ecosystems and biodiversity.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

NA Assessments of status, trends and data quality are not appropriate for the indicator.

Indicator LB6: Land Use

Victoria's land is used for a variety of purposes, including urban areas for residential and business, agricultural lands for production of food and fibre, and conservation areas to protect biodiversity. Development for urban and agricultural uses has resulted in declines in the condition of land, water and biodiversity.

Many of the environmental challenges currently facing Victoria are the products of past decisions about land use and land management. Consequently, land use is a key driver of environmental change in Victoria.

Land-use change is driven by a range of social, economic and environmental pressures. For example, population growth is a key driver of urban land-use change (see Part A: 5 Human Settlements), leading to urban expansion in Melbourne's fringe areas and parts of regional Victoria. Urban land use is also strongly affected by social pressures through the property market, which drives land use towards the highest values (for example, housing in fringe areas). In addition, preference for living in coastal or rural areas close to Melbourne is resulting in the loss of natural ecosystems and agricultural land. Such losses threaten biodiversity and promote more intensive agriculture to compensate for reductions in the availability of productive land.

The main drivers of agricultural land-use change are climate (e.g. water availability), commodity prices, supporting infrastructure and land capability (soil type). These factors determine the type of farming that can be carried out as well as those types that will maximise returns.

Availability of water is particularly important for agricultural land-use change. The establishment of a water market in the Murray–Darling Basin has produced an escalation in the price of water and the trading of water away from irrigated pastures (predominantly for dairy production) towards high-value horticulture. Because water shares can now be traded independently of land, water is being permanently transferred between regions, resulting in substantial land-use change.

The environmental impacts of land-use change may be unpredictable and unintended. Areas where land use is not suited to land capability are at most risk from significant environmental impacts. Changes in the condition of land, water and biodiversity resources can be both outcomes and drivers of land use. Impacts of previous land use and management practices on land and water resources limit the capacity of these resources to support future activities and to provide some essential ecosystem services.

Climate change is likely to produce unprecedented changes in the distribution of agricultural enterprises across the State (see Foundation Paper One: *Climate Change Victoria: The Science, Our People, and Our State of Play*).[2]

Land use types in Victoria

Land use in Victoria is shown in Figure A.2.35 and Figure A.2.36. Public land is mainly divided between parks and reserves (18% of Victoria's total area), managed under the *National Parks Act 1975*, and State forests (14% of Victoria's total area) managed under the *Forests Act 1958*. State forests are managed for multiple purposes, including timber harvesting, conservation, recreation and water production. Parks and reserves and State forests account for approximately 90% of Victoria's public land. Other uses include conservation reserves not managed by Parks Victoria (e.g. roadside reserves), water catchments and a small area of plantation forest.

Nearly two-thirds of Victoria is privately owned. This land is predominantly used for agricultural production, which accounts for some 56% of Victoria's total area. Agriculture is Victoria's dominant land-use type, with dryland cropping and grazing (rain-fed or unirrigated) accounting for over 90% of agricultural land. Irrigated agriculture and horticulture accounts for over 8% of agricultural land. Victoria's main agricultural products are beef, dairy, wool, grain crops, and fruit and vegetable crops. Agricultural production occurs mainly in the flatter and more accessible areas in western and northern Victoria. Other private land uses include urban areas (5% of Victoria's area) and plantation forest (2% of Victoria's area). Melbourne occupies less than 1% of Victoria's land area but is home to 75% of Victoria's population.

The total area of land-use types is not necessarily a good indicator of the potential impacts on the environment. For example, urban and irrigated agriculture each account for only 5% of the total land area. However, their impacts on Victoria's environment are significant because of the degree of land change they require and the resources they consume. Consequently, these land uses have greater impacts on land and water health and biodiversity.

Figure A.2.35: Major land-use classes in Victoria, as at 2012
Source: DEPI.

Land use	Area (million hectares)	% of Victoria
Public land		
Parks and reserves	3.98	18
State forest	3.14	14
Other public [A]	1.10	5
Coastal parks and reserves	0.75	0.3
Marine parks and reserves	0.12	NA
Private land		
Dryland agriculture	11.50	51
Irrigated agriculture	1.07	5
Plantation forest	0.52	2.3
Urban/built environment [B]	1.13	5
Total area	**22.70**	

Notes:

[A] Conservation reserves, including roadsides.

[B] Includes residential, commercial, industrial and community services land uses.

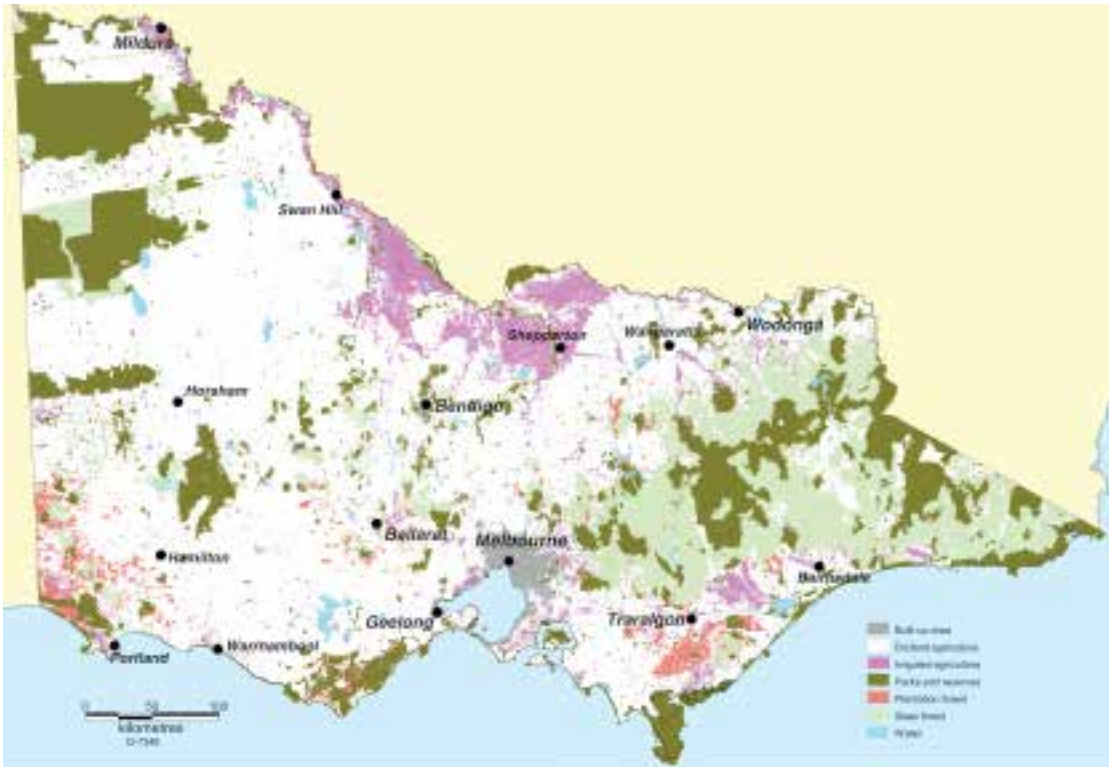


Figure A.2.36: Land use in Victoria, as at 2012

Source: DEPI.

Changes in major land uses in Victoria

Because of differences in methodologies, it is not possible to compare current land-use areas with that reported in the last State of the Environment report. However, the following changes are known to have occurred:

- The area of parks and reserves has increased, with a corresponding decrease in the area State forest. This is due to the transfer of State forest into the reserve system.
- Irrigated agriculture has increased, with a corresponding decrease in dryland agriculture. This is likely driven by water trading which is driving the distribution of irrigation water towards highest value uses and producing significant land-use change in irrigation areas. In addition, changes may be in response to market forces leading to changes in production types, or the migration of irrigation industries.
- Urban areas have increased, with population growth driving urban expansion in Melbourne and regional centres, as well as in coastal areas (see Part A: 5 Human Settlements).

Indicator LB7: Area Affected by Salinity

Salinity refers to the presence of salt in soils as a result of raised water tables. While Victoria has significant naturally occurring saline areas, most salinity has been caused by, or exacerbated by, the clearing of native vegetation (dryland salinity) and excess irrigation (irrigation salinity). These actions alter the hydrology of Victorian landscapes, increasing drainage to groundwater.

The area affected by salinity changes over time in response to water availability. Seasonal and long-term variation in rainfall leads to fluctuations in groundwater levels and salinity impacts. In addition, improved irrigation technology and water management also reduces the area impacted by salinity.

Salinity caused by human land-use practices is a significant issue for land management and biodiversity. Salinity produces extensive on and offsite effects, and often has long management time frames and lasting effects on soil and water resources. As most plants have evolved in the absence of salt, the majority of plant species (both native and introduced) are unable to grow in saline soils. This leads to a decline in the condition of native flora and the loss of agricultural productivity. Salinisation of surface water is also an important consequence of rising saline groundwater.

Salinity can severely degrade rivers and wetlands, and can prevent water from being used for agriculture and other purposes. Wetlands and surrounding native vegetation are particularly at risk because their low elevation coincides with groundwater discharge areas.

In addition to implications for natural and agricultural systems, salinisation of soil and water has implications for the built environment. Increased salt content of water can corrode pipes, pumps and taps, and increase costs for water treatment. At the same time, high saline water tables affect infrastructure such as roads, bridges, building foundations, footpaths and paving, fencing and railways.

Area of salt-affected land

Available data on the area of land affected by dryland salinity is shown in Figure: A.2.37. Estimates of the extent and severity of salinity are poor in Victoria, with ad hoc and infrequent data collection and little information on irrigation salinity. This has resulted in fragmented data that does not provide a complete picture of current soil salinity in Victoria.[26]

Best available information from the Department of Environment and Primary Industries estimates that around 247,000 hectares of soil in Victoria is affected by dryland salinity – 2% of the total area of dryland agriculture in the state.[27] Regions most affected include substantial areas of Victoria's north (particularly the Mallee) and west, and near Sale in the state's east.[12] Western Victoria is generally more severely affected by salinity than eastern Victoria, largely because it is flatter and poorly drained, and also because conversion of native vegetation to agriculture has been much more extensive in western Victoria.

The spread of dryland salinity in Victoria slowed or receded during the recent dry period due to lower groundwater tables, although many incidences of dryland salinity still occurred during the drought. The area impacted by salinity is likely to increase with the recent return to wetter conditions. Periods of higher rainfall will renew the threat that salinity poses to agricultural productivity and land and water.[28]

There is no current data for irrigation salinity in Victoria. However, in the previous State of the Environment report a substantial decline was found for the area affected by irrigation salinity. This was due to improvements in drainage and land management.

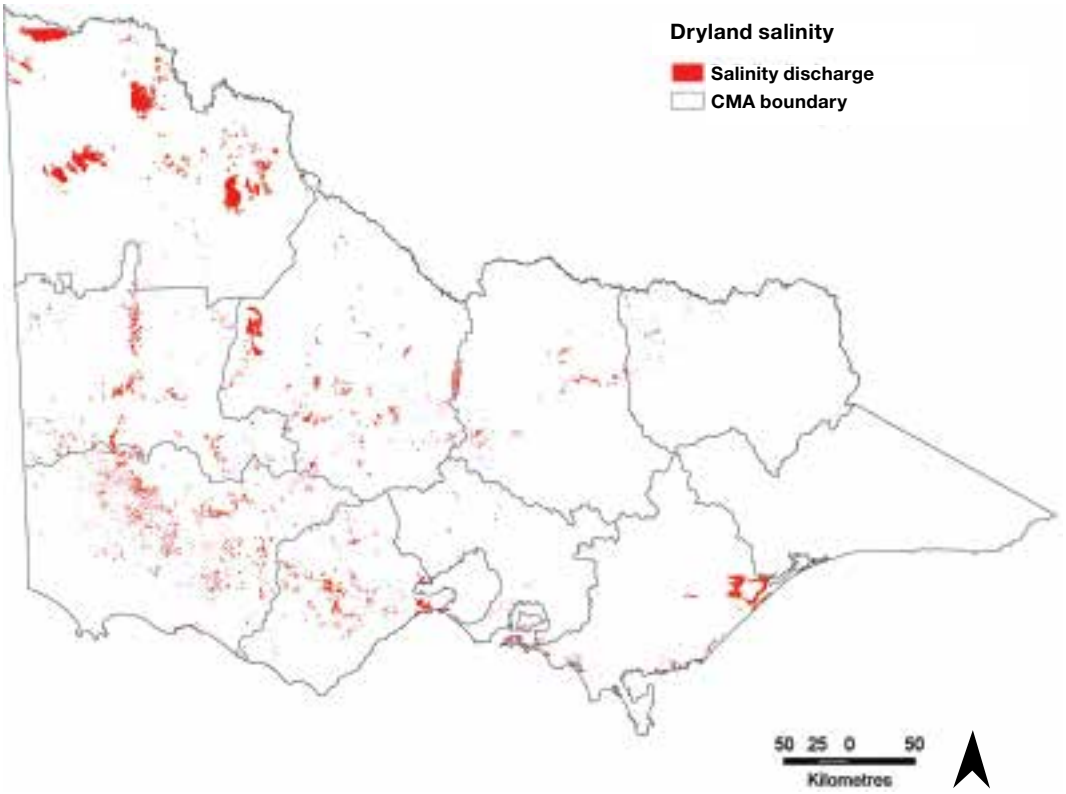


Figure A.2.37: Estimate of area affected by dryland salinity in Victoria (data from 1976–2011)

Source: DEPI.

Indicator LB8: Soil Health

Good soil health is vital for Victoria's agriculture, native ecosystems and ecosystem services. Healthy soils support essential ecosystem services such as the production of food, fibre, timber and clean water, as well as the decomposition and detoxification of wastes.

Victoria's soils are subject to a range of pressures, including clearing, cropping, grazing and fire. Activities that leave soils bare of vegetation promote erosion, while those that physically disrupt or compact soil threaten soil structure.

In particular, extensive erosion has been caused by historic broad-scale vegetation clearing, especially in higher rainfall, sloping regions of Victoria. Cropping activities such as cultivation and sowing physically disrupt soil structure, while the repeated passage of vehicles can cause soil compaction, as can overstocking.

Such impacts degrade soil structure and biological activity, and reduce the ability of soil to cycle and store nutrients and carbon, and to decompose and detoxify organic wastes. In addition, soil lost during erosion events is not readily replaced because soil-forming processes are extremely slow, occurring over tens of thousands of years.

Degraded soil has a range of social, economic and environmental impacts, including:

- Erosion of topsoil can result in the loss of seedbanks for native vegetation, limiting the capacity for regeneration and promoting the spread of weeds. Removal of topsoil also exposes subsoil layers, which may be hard or impermeable to water, limiting the establishment of seedlings.
- Eroded soil can be deposited into rivers and streams, increasing sediment, nutrient and other pollutant levels. These affect streamflow, riparian vegetation, aquatic biodiversity and water quality, and increase the risk of flooding (see Part A: 3 Inland Waters).
- Sediments transported to estuarine and enclosed marine environments can smother habitat and raise nutrient levels, impacting on ecosystem health (see Part A: 4 Marine and Coastal Environments).
- Wind erosion has implications for human health due to the impacts of dust storms (see Part A: 1 Climate Change and Air Quality).
- Erosion can also damage fencing, undermine roads and buildings and decrease the storage capacity of water reservoirs.
- Increased reliance of fertiliser to restore soil fertility to the levels needed to support agricultural production.
- Loss of land productivity through reduction in capacity to support crop and pasture growth. Also additional costs from increased fertiliser use.

Climate change is likely to further increase soil degradation (see Foundation Paper One: *Climate Change Victoria: The Science, Our People, and Our State of Play*). More frequent drought and fires will reduce vegetation cover, and more severe storms and rainfall are likely. These will create great potential for severe erosion and reductions in soil nutrients and carbon.

Soil structure decline and erosion

Soil structure decline and erosion are intimately linked. The disruption of soil structure increases the likelihood of erosion, which removes the top layer of soil. This layer is vital for soil health because it contains organic matter and nutrients, and provides habitat for biological populations (for example, microorganisms, fungi, earthworms) that bind and stabilise soil structure.

Soil erosion and structure decline is a natural process, determined by factors such as soil type and slope. However, it can be accelerated by human activities, including vegetation clearing, some cropping activities (e.g. cultivation, sowing, harvesting, burning of crop residues), soil compaction from farm traffic and livestock, forestry activities (heavy vehicle compaction), mining, and development of land for residential and other purposes. Impacts on soil can also occur as a result of bushfires which remove ground cover.

Since the 1980s, impacts from cropping activities have been alleviated to some extent by the adoption of minimum and zero-tillage farming systems, and the use of stubble retention instead of crop residue burning. However, conventional cultivation is still the dominant methodology across Victoria and burning is still widely practised.[4]

Extent of soil structure decline and erosion

No new data on soil structure decline and erosion has become available since that reported in the 2008 Victorian State of the Environment report. Main findings included:

- At least 60% of Victorian soils are prone to erosion and soil structure decline. Climate, land form and management practices also contribute to risks of erosion and soil structure decline.
- Erosion still ranks as a significant concern on agricultural land in Victoria, with 37% of farm businesses reporting erosion as a land management problem in 2006–07. It is also a challenge on public land, particularly in the context of fire, which greatly increases the likelihood of erosion.
- Victorian soils naturally vary in their susceptibility to water erosion, ranging from low in the relatively dry, flat areas of western Victoria to very high in the Central Highlands and East Gippsland. Over 55% of soil in Victoria's public land is highly susceptibility to water erosion due to the higher rainfall and steep slopes that dominate public land in central and eastern Victoria. Only 0.2 million hectares of Victoria's cropping land is highly susceptible to water erosion.
- The soils of greatest susceptibility to wind erosion occur mostly in the drier areas of north-western and western Victoria. Nearly 1.2 million hectares of soils in Victoria's cropping region are considered highly susceptible to wind erosion, with a further 1.7 million hectares classed as moderately susceptible. On public land, approximately 1.5 million hectares of soil area is considered highly susceptible to wind erosion, mainly in the Wimmera and Mallee regions. In contrast, 84% of forest on public land is of low susceptibility to wind erosion.
- The extent of gully erosion in Victoria was mapped in detail in the 1970s and early 1980s but has not been comprehensively mapped since 1982.
- The real significance of soil structure decline as an environmental issue in Victoria is unclear, as no statewide data have been collected since 1991. At that time approximately 30% of the state's agricultural land was considered to be severely degraded due to soil structure decline. Nearly half of Victorian farmers still consider soil compaction to be a significant issue. Soils in central and western Victoria are generally more susceptible to soil structure decline than those in eastern Victoria.
- Advances in farming systems and awareness of the issues have reduced erosion and may have reduced soil structure decline in some areas, but significant episodes still occur during severe weather events.

Expert opinion indicates that the recent drought conditions experienced across much of Victoria reduced the threat of water erosion, primarily in cropping regions. However, the extended dry is likely to have increased wind erosion because of the decrease in vegetative cover. In addition, any rainfall that fell during the drought conditions is likely to have caused erosion of bare soil. The return to wetter conditions has improved the amount of ground cover, reducing the threat of wind erosion.[12]

Rate of soil acidification

Soil acidification is a naturally occurring soil chemical process. This process occurs very gradually in undisturbed ecosystems but can be accelerated by agriculture (particularly the increased use of fertiliser soils which has increased threefold since the 1960s)[4] and vegetation clearing.

Soil acidification impacts include a reduction in plant growth and productivity, decreased availability of nutrients, reduction in soil biological activity, loss of vegetation, and increased risks of soil structure decline and erosion.

No new data on soil acidification have become available since that reported in the 2008 Victorian State of the Environment report. Main findings included:

- The cost of lost productivity due to soil acidification to Victoria is estimated at $470 million per year.
- Productivity declines due to soil acidification also reduce the amount of land that could be used for biodiversity conservation in agricultural landscapes.
- Soil acidification is accelerated by some land management practices and the area of acid soil is increasing. Almost half of Victorian farm businesses reported soil acidity as a land management issue in 2006–07. However, Victoria has large areas of naturally acidic soils that cannot be distinguished from soils acidified by agriculture;
- The use of acidifying fertiliser is increasing to support the increasing cropping intensity in Victorian agriculture.
- Only 5.5% of the area requiring treatment to restore critical pH levels is sufficiently treated with lime.
- The last statewide assessment of soil pH was made in 1994.
- Victorian regions most at risk of soil acidification are the North East, Goulburn Broken, Glenelg Hopkins, West Gippsland, southern parts of the North Central region and the southern Wimmera.

The most recent statewide assessment of soil acidity made in 1994 estimated that 23%, or 3 million hectares, of Victoria's agriculturally productive soil were affected by soil acidification.[29] Expert opinion suggests that soil acidity has generally decreased since the 1990s due to the prolonged drier conditions.[12]

Soil carbon content

Soil organic carbon is a measure of the organic content (e.g. plant roots, vegetation debris, soil organisms) held in the soil. Soil organic matter, most of which is organic carbon, is a vital component of soil health, with higher amounts generally indicating more healthy soils. It builds soil structure, prevents erosion, increases soil water-holding capacity and drainage, improves soil nutrition and maintains soil micro-organism diversity. Carbon content determines the productivity of soil for both agriculture and natural ecosystems. The stable fraction of soil organic matter (humus) also sequesters carbon in soil, potentially helping to mitigate climate change. Organic matter and carbon are lost when soils are cultivated, although this loss is decreased for minimum tillage practices, when soils are less disturbed.

Data on soil carbon levels is poor in Victoria, particularly for private land (for information on above-ground carbon stocks on public land see Part A: 1 Climate Change and Air Quality). Figure A.2.38 shows modelled total soil carbon on public land. Because the majority of public land is forested, soil carbon differences are mostly related to forest types and rainfall. High soil carbon is particularly evident in the dense, upland forests of eastern Victoria.

It is likely that soil carbon on private lands is lower than on public land and will vary with agricultural type and climate. Soil organic carbon levels are usually higher in high rainfall regions and under pasture compared to cropping.[30] In general terms, soil carbon levels in topsoils (up to 30 cm in depth) are thought to be relatively high in Victoria compared with some other parts of Australia, although they remain low by world standards.[12]

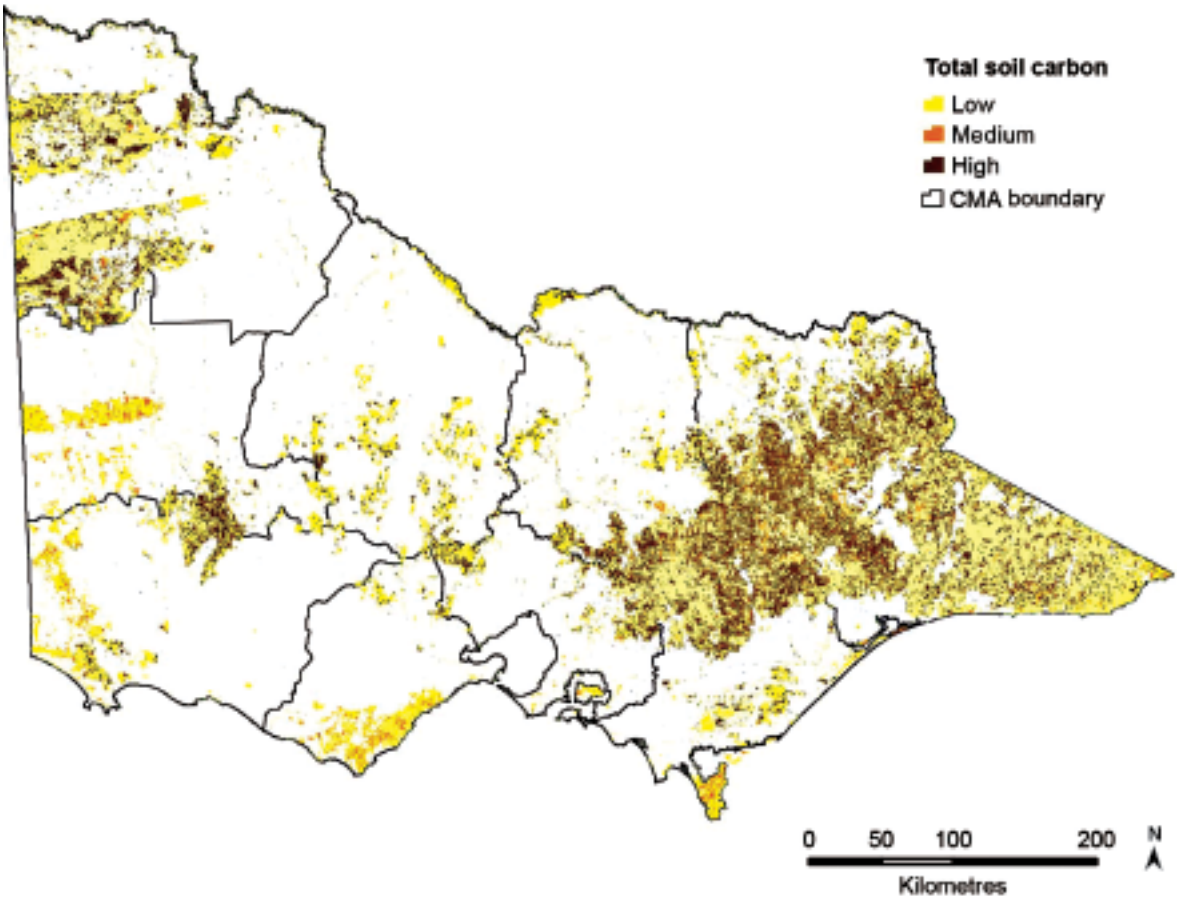


Figure A.2.38: Amount of total soil carbon in Victoria's public lands (modelled)

Source: Department of Sustainability and Environment LandCarbon Project 2011.

Land data gaps

Current understanding of land and soil health is hampered by the lack of data and long-term statewide monitoring programs, with existing datasets often limited in extent or out of date. Although local-scale data has been collected for specific land and industry management programs, there has been no statewide assessment of soil health in Victoria. The lack of strategic, long-term monitoring makes it difficult to detect trends in land and soil health over time and remains a critical gap in our understanding of environmental condition.

Soil health data gaps include:

- Neither soil structure decline nor erosion is routinely monitored in Victoria, so our understanding of the true extent of these problems is limited.
- Data on the spread of soil acidification is also very limited, particularly in areas containing irrigated agriculture. The last statewide assessment of soil acidity was made in 1994.
- Estimates of the extent and severity of salinity are poor in Victoria, with ad hoc and infrequent data collection and little information on irrigation salinity.
- Some information on soil carbon concentrations is becoming available, but much of this is modelled with no program of routine or systematic on-ground monitoring. This precludes the analysis of trends in soil carbon in response to changes in land management and climate change.

Agnes Falls, Foster
Courtesy of Dean Gorissen

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CHAPTER THREE INLAND WATERS

BACKGROUND

This chapter assesses the status of Victoria's inland waters. Estuarine and coastal waters are discussed in Part A: 4 Marine and Coastal Environments. The management of Victoria's land and biodiversity on private land is strongly related to the health of inland waters and is discussed in Foundation Paper Two: *Land and Biodiversity Victoria: The Science, Our Private Land Holders, Incentives and Connectivity*.[1]

Victoria's inland waters (rivers, streams, wetlands, lakes and groundwater) and their surrounding riparian and floodplain lands provide a range of environmental benefits and ecosystem services that support biodiversity, agriculture and industry, and rural and urban communities. They provide habitat for both aquatic and terrestrial species, supply water resources, cycle nutrients and purify water, and are sites of recreation and social interaction.

Pressures on Victorian inland water

Inland waters are intimately connected with the land because all land forms part of a catchment. Consequently, the degradation of land health has significant impacts on inland waters. Inland waters are also connected to estuaries and as such are a significant influence on the health of coastal waters.

Around half of Victoria's native vegetation has been cleared, including riparian vegetation, increasing runoff and erosion. This has resulted in a significant decline in water quality with increases in sedimentation, nutrient pollution, algal blooms, as well as toxicants from roads, agriculture and industry.

The clearing of vegetation, combined with irrigation practices, has also resulted in shallow watertables and increased groundwater recharge, leading to salinity problems in some inland waters. In addition, point-source pollution from domestic and industrial wastewaters impacts on water quality, although pollution from unregulated diffuse sources remains the major cause of poor water quality. Poor water quality not only affects aquatic biodiversity, but limits the use of water resources and increases treatment costs.

Almost all rivers and catchments in Victoria, and almost all larger streams, have been modified to some degree. A history of works designed to store, drain, control and change the direction and speed of water as it moves through the landscape has extensively degraded flow regimes and reduced the volume of water available to the environment. Changes to flow regimes place pressure on river, wetland and floodplain ecosystems and their biodiversity. Drought, combined with current levels of extraction compounds pressures on flow regimes, and has implications for all issues discussed in this chapter of the report.

Major storages (dams), weirs and levees are the most common cause of alteration to flow regimes. At least one major on-stream storage has been constructed in 19 of Victoria's 29 river basins, affecting most major rivers throughout Victoria. The level of water extraction is another significant impact on flow regimes, with large proportions of the total surface water in several of Victoria's river basins extracted for consumption, particularly in dry years. Other activities impacting on flows are channel modification (including that to decrease the duration and frequency of flooding, e.g. de-snagging, straightening, and the construction of artificial levees), and changes in land use.

Impacts on aquatic biodiversity

Alteration of habitat is a major pressure for aquatic fauna and a primary cause of decreasing native fish populations. Altered flow regimes and increased sedimentation changes the physical habitat in river systems by smothering pools and rocky substrate. Removal of snags and other woody structures reduces available habitat for fish and other aquatic and terrestrial organisms, increases erosion and decreases variation in channel shape. Loss of connectivity due to

structures such as dams, weirs and levees threatens aquatic fauna, as it excludes migratory fish such as Murray cod and golden perch from their spawning grounds and reduces the prospect of recolonisation when conditions improve after drought. The extensive modification and fragmentation of inland waters has also aided the spread of invasive species such as carp.

The loss and degradation of riparian zones and wetland vegetation impacts both aquatic and terrestrial biodiversity. Riparian and wetland vegetation supports aquatic ecosystems by providing woody habitat, shade, stable banks, filtering out sediments and processing nutrients (particularly nitrogen), and providing organic matter, a major source of food for aquatic plants and animals.

Riparian vegetation also buffers freshwater ecosystems from disturbances in the catchment and promotes recovery afterwards, helping to maintain biodiversity. Riparian zones provide habitat for terrestrial species and are areas of refuge during drought. In cleared catchments riparian vegetation is often the only native vegetation remaining making them vital wildlife corridors. Many riparian species, particularly those on floodplains such as River Red Gum forests, require regular flooding for regeneration. Changes to flow regimes have significantly reduced the flooding of such areas, leading to a decline in floodplain vegetation health.

Some of the other significant pressures on aquatic fauna are:

- Inputs of sediment, salt and nutrients, and a broad range of toxic substances such as pesticides.
- Water released from dams to supply irrigation and other industries does not mimic natural seasonal flows and can be much colder than receiving waters. This interferes with the lifecycles of aquatic species, including the breeding cycles of fish. Water temperature depression from dam releases is known to occur at up to 49 dams across Victoria.[2]
- Introduced species and translocated native species that place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification.
- Fishing can impact on species already affected by other pressures, particularly unregulated recreational fishing.
- Bushfires have important implications for river health and water quality because of their impacts on vegetation cover and soil structure. Fire can remove riparian vegetation, affecting the availability of food resources. Large sediment and ash slugs can be deposited in rivers when rain follows a bushfire, dramatically reducing water quality and smothering habitat. In addition, forest regrowth following bushfire increases the uptake of water and can have a significant impact on streamflow.

Climate change

Climate change will exacerbate the impacts of many pressures on aquatic fauna. Reduced rainfall and increased evapotranspiration are likely to increase the frequency and severity of drought, and permanently reduce the availability of water for freshwater systems.

Under climate change, streamflow is projected to decrease by up to 50% across much of Victoria by 2070.[3] Decreases in the frequency of flooding will have severe consequences for floodplain ecosystems and the projected reduction in snow cover (see Part A: 1 Climate Change and Air Quality) has significant consequences for alpine and downstream inland waters in Victoria.

A warmer climate will lead to higher water temperatures, affecting the distribution of many aquatic species. Increased temperatures also have water quality implications through reduced concentrations in dissolved oxygen and potential increase in algal blooms. Increased bushfires will also impact on water quality and riparian vegetation.

The impacts of climate change on inland waters is discussed in Foundation Paper One: *Climate Change Victoria: The Science, Our People, and Our State of Play*.[4]

MAIN FINDINGS

Condition of freshwater aquatic ecosystems

- Results from the Index of Stream Condition 2010 (ISC) show that 23% of major rivers and tributaries in Victoria were in good or excellent condition, 43% were in moderate condition and 32% were in poor to very poor condition.
- Almost half the basins in Victoria have less than 10% of major rivers and tributaries in good or excellent condition. These are mainly in the mid-west of Victoria and have been extensively cleared for agriculture. The basins in the east of the state had more river length in good or excellent condition compared with basins in the west.
- There was no substantial difference between the 2004 and 2010 ISC results. This was despite data for the ISC 2010 being collected during the Millennium Drought. This result shows that rivers in good or excellent condition are likely to be resilient to prolonged periods of drought.
- Results for riparian vegetation show that 21 of 29 river basins had less than 50% of their assessed river length with riparian vegetation in good condition. Basins in the east of the state were in generally in better condition than those in the west due to extensive clearing for agriculture.
- Since European settlement, 23% of natural wetlands have been lost, reducing Victoria's wetland area by an estimated 200,000 hectares, over a quarter of the pre-existing area. Expert opinion suggests that the extent of wetlands is declining further.
- Only 56% of Victoria's high-value wetlands were assessed as being in good or excellent condition and 14% were in poor or very poor condition. For non-high-value wetlands, 51% were assessed as being good or excellent condition and 26% in poor or very poor condition.
- The condition of wetlands was poorer on private land. This is because threat sources were up to 10 times more prevalent at wetlands on private land.

Freshwater biodiversity

- As at 2013, three species of fish were regionally extinct. A further 20 aquatic fauna species were critically endangered, 17 endangered, 26 vulnerable, and seven near threatened.
- Fish and amphibian species make up the majority of critically endangered and endangered aquatic species. 43% of amphibians and 55% of freshwater fish are threatened in Victoria.
- Between 2007 and 2013, nine inland aquatic vertebrate species declined in status and four species were added to the Advisory List because of decreasing populations. Only five species improved their threatened status.
- Native fish communities are being affected by a range of pressures. For the majority of river basins, consistently lower numbers of native species were found compared to those predicted to be present.
- Alien fish species are common in many Victorian streams. Alien fish were found in all but one river basin (Millicent Coast) and accounted for 10% or higher of the total fish abundance in all but four river basins, and over 50% in the Campaspe, Maribrynong and Kiewa river basins.
- In 20 of Victoria's river basins, alien fish accounted for 60% of the total fish biomass, and for over 90% of the total biomass in seven river basins. This has significant implications for native fish communities, particularly with regard to competition for food and habitat resources.

- The significant presence of non-native fish species in Victorian rivers indicates that modified landscapes and river systems have created favourable conditions for alien species to thrive.
- To increase the population of native fish, stocking has more than doubled since 2008, with over 2 million fingerlings released annually from 2011. The vast majority of stocked fish were Murray cod and golden perch.
- Assessments of macroinvertebrate community health from spring 2009 to autumn 2012 show that western catchments, including Hopkins, Wimmera, Avoca and Loddon, are generally in poor health. Eastern catchments show improved health, with the exception of the Broken and Kiewa catchments. The Werribee and Maribyrnong catchments have continued to see a decline in the health of macroinvertebrate communities. This is likely to be because of increases in urban development.
- Statewide information on the number and distribution of introduced aquatic species remains poor and has not been updated since the 2008 Victorian State of the Environment report.

Condition of flow regimes

- The drought conditions between 1996 and 2010 severely reduced Victoria's river flows across many catchments, particularly in central and western Victoria. Many catchments experienced some of the lowest streamflows on record, with 2006–07 and 2008–09 volumes only 27% and 32% of the long-term average respectively.
- Results from ISC 2010 show that only eight of the 29 river basins had flow regimes in good condition for more than 50% of the length assessed. The basins in the east of the state generally had more river length in good or excellent condition for flow regimes compared with basins in the west. Results also showed that virtually all reaches were adversely affected by the Millennium Drought and that the south-west of Victoria was the most severely affected.
- Increases in rainfall since 2010, including the severe flooding over the 2010–11 summer, are likely to have improved flow regimes in many areas of Victoria.
- Between 2005–06 and 2009–10 (during the drought period), over 25% of Victoria's river basins had more than three-quarters of their annual streamflow harvested for consumption, and over 40% had more than half their streamflow harvested. The most impacted river basins were the Avoca, Werribee, Loddon, Moorabool, Campaspe, Wimmera and Goulburn.
- After significant increases in rainfall and widespread flooding in 2010–11, less than half of the annual streamflow was harvested for all river basins.
- In many rivers and aquifers the current Environmental Water Reserve (EWR) is inadequate and vulnerable, placing environmental values at risk.
- The EWR available between 2006–07 and 2009–10 was affected by drought conditions. However, less than 50% of available water was used over this period, with only 22% used in 2006–07. During times of low river flow, the water allocation system reduces environmental flows more than it reduces water for consumptive uses. This has severe consequences for aquatic systems which receive lower amounts of water during times of increased need.
- With greater river flows in 2010–11, the EWR available increased five-fold, and almost 70% of the available water was used for environmental purposes.

Surface water quality

- The Commissioner for Environmental Sustainability was unable to obtain a comprehensive statewide assessment of water quality for Victoria. Consequently, it is not possible to report on water quality trends since the previous State of the Environment report, including whether water quality objectives are being met.

Groundwater

- There remain critical gaps in our understanding of the condition of Victoria's groundwater resources. An investigation by the Victorian Auditor-General's Office was unable to determine if groundwater use in Victoria is sustainable.
- There is no statewide information on long-term changes in groundwater salinity or the statewide occurrence of groundwater contamination.
- For shallow aquifers, groundwater levels declined from the late 1990s to 2010 due to a combination of increased groundwater use and reduced recharge both from surface water irrigation and rainfall. Since 2011, groundwater levels across Victoria have generally risen or remained stable in response to increased rainfall.
- For deep aquifers, long-term declines have continued in Gippsland associated with the Latrobe Valley coal mines and offshore oil and gas extraction. In other areas, restrictions on use and a return to wetter conditions have led to stable or rising groundwater levels.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
IW1 Condition of freshwater aquatic ecosystems	Assessments of river health carried out for the Index of Stream Condition 2010 shows that only 23% of major rivers and tributaries in Victoria were in good or excellent condition, 43% were in moderate condition and 32% were in poor to very poor condition. Almost half the basins in Victoria have less than 10% of major rivers and tributaries in good or excellent condition. The basins in the east of the State had more river length in good or excellent condition compared with basins in the west. Just over half of Victoria's wetlands are in good condition, the extent of wetlands is also declining.		
IW2 Freshwater biodiversity	Continued decline in freshwater biodiversity with many species listed as threatened. Between 2007 and 2013, nine inland aquatic vertebrate species declined in status and four species were added to the Advisory List because of decreasing populations. Only five species improved their threatened status. Native fish populations are under pressure, with alien species common in many rivers. Waterbirds are showing a long-term decline across eastern Australia. Macroinvertebrate community health remains poor in western catchments.		
IW3 Condition of flow regimes of major rivers and tributaries	Drought conditions between 1996 and 2010 severely reduced Victoria's river flows across many catchments. Results from ISC 2010 show that only 8 of the 29 river basins had flow regimes in good condition for more than 50% of the length assessed. The basins in the east of the State generally had more river length in good or excellent condition for flow regimes compared with basins in the west. Results also showed that virtually all reaches were adversely affected by the Millennium drought and that the south-west of Victoria was the most severely affected. Many river basins continue to have large volumes extracted for consumption, particularly during drought periods. The current Environmental Water Reserve is inadequate to maintain the ecosystem health of many inland waters and is further reduced during drought periods.		
IW4 Water quality	The Commissioner for Environmental Sustainability was unable to obtain a comprehensive statewide assessment of water quality for Victoria. Consequently, it is not possible to report on water quality trends, including whether water quality objectives are being met. Previous statewide assessments have shown that water quality is generally poor in much of Victoria, particularly in Victoria's lowlands and in the west of the state.		
IW5 Groundwater levels and quality	There remain critical gaps in our understanding of the condition of Victoria's groundwater resources, including its sustainable use. Groundwater levels declined in many areas during the drought but some have recovered with increased rainfall from 2010. However, long-term declines have continued in Gippsland associated with the Latrobe Valley coal mines and offshore oil and gas extraction.		

Note:

** Although water quality monitoring is considered to be good across Victoria, the lack of statewide assessment means that trends cannot be determined. Consequently, data confidence is rated as poor for water quality.*

Indicator Assessment Legend

Status

- Environmental condition is healthy across Victoria, **OR** pressure likely to have negligible impact on environmental condition and/or human health.
- Environmental condition is neither positive or negative and may be variable across Victoria, **OR** pressure likely to have limited impact on environmental condition and/or human health.
- Environmental condition is under significant stress, **OR** pressure likely to have significant impact on environmental condition and/or human health.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

NA Assessments of status, trends and data quality are not appropriate for the indicator.

Indicator IW1: Condition of Freshwater Aquatic Ecosystems

The condition of freshwater aquatic ecosystems is dependent on a range of factors, including surrounding land-use types and their impacts, the level of native vegetation clearing (particularly riparian), physical modification of river and wetland systems, and the availability of water (influenced by rainfall and the presence of dams and other structures).

Victoria's highly modified landscapes and aquatic habitats, combined with high levels of water regulation and extraction, have put enormous pressure on aquatic ecosystems.

River health

The most comprehensive condition assessments for freshwater aquatic ecosystems are available for major rivers and streams, which are assessed using the Index of Stream Condition (ISC).[5] The ISC assesses five key aspects of river health: hydrology (amount, timing and duration of flow), water quality, streamside zone (riparian vegetation), physical form (bank condition and in-stream habitat) and aquatic life.

Three ISC assessments (1999, 2004 and 2010) have been conducted to date. The results from the ISC 2010 for overall condition and riparian vegetation are discussed below. For the condition of flow regimes see Indicator IW3: Condition of Flow Regimes of Major Rivers and Tributaries. Direct comparisons between the 2004 and 2010 results are not possible due to changes in methodology. For example, the ISC 2010 has incorporated remote sensing technologies to provide a more accurate and extensive assessment of the condition of riparian vegetation, river banks and in-stream habitat. However, general comparisons of overall river health can be made.

The 2010 ISC assessed approximately 29,000 kilometres of Victoria's rivers and streams. Results show that 23% of major rivers and tributaries in Victoria were in good or excellent condition, 43% were in moderate condition and 32% were in poor to very poor condition (Figure A.3.1).

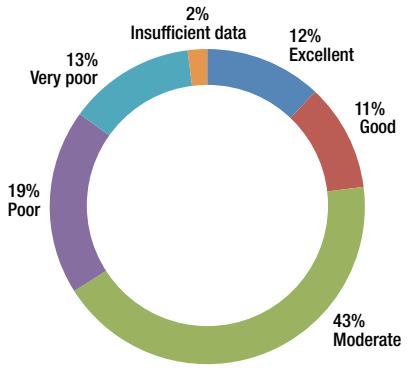
The results from the 2010 are very similar to those in 2004. For rivers and streams that were in good or excellent condition, there was no substantial difference between the 2004 and 2010 results, despite the fact that data for the ISC 2010 was collected over six years that coincided with the severe Millennium Drought (1997–2009). It is likely that rivers and streams that are in good or excellent condition are fairly resilient and able to withstand prolonged periods of drought. However, results also showed it is likely that the impacts of bushfires are continuing to influence river condition. Large fires such as the 2003 Great Divide fire, 2006 Grampians fire, 2007 Victorian Alps fire and the 2009 Black Saturday fires can impact on river health by removing vegetation and degrading water quality.

Management activities such as fencing, revegetation, weed control and the release of environmental flows have played an important role in maintaining and improving river condition.

These activities are likely to have improved river resilience during the long drought period, and will further improve resilience in the future. Many of the changes, as a result of these management activities, are not yet obvious in the ISC results. The improvements due to management works and increased environmental flows will take a number of years to detect and be reflected ISC results.

Figure A.3.1: Overall condition of river reaches (percentage of river reach length assessed), 2010 Index of Stream Condition

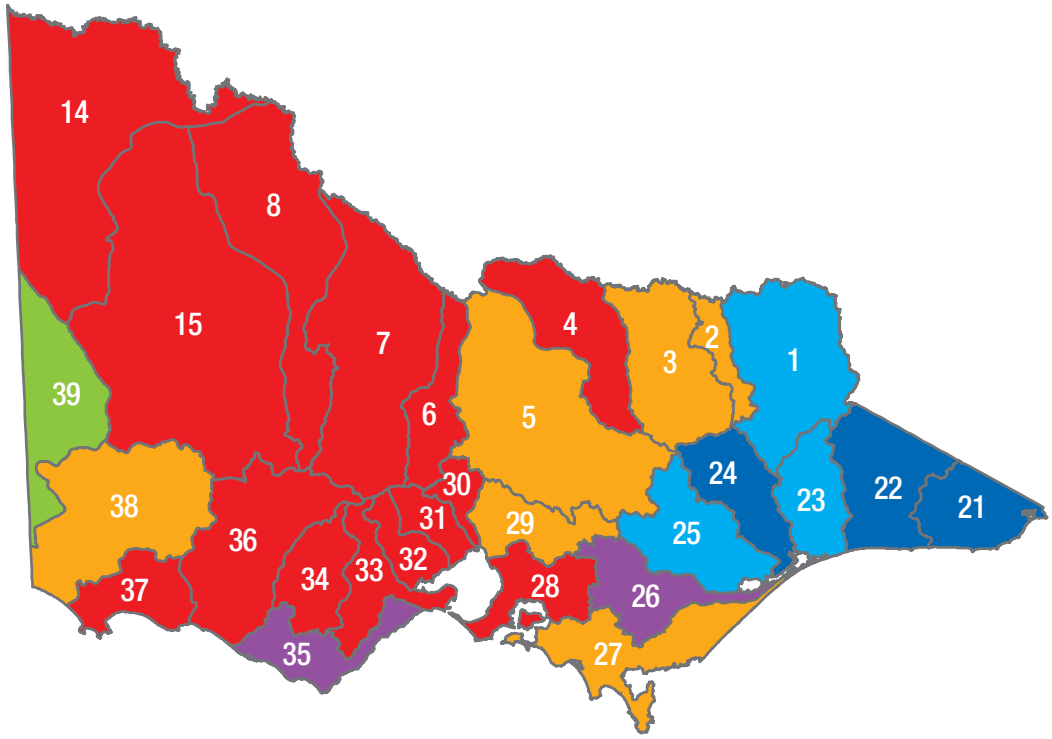
Source: DEPI.



The basins in the east of the state had more river length in good or excellent condition compared with basins in the west (Figure A.3.2 and Figure A.3.3). Three basins had at least 70% of their river length in good or excellent condition and include the East Gippsland, Snowy and Mitchell basins. These basins are largely inside National Parks. Another three basins (Tambo, Thomson and the Upper Murray) had at least 50% of their river length in good or excellent condition. Another two basins (Latrobe and Otway) have one-third of their river length in good or excellent condition.

Fourteen basins, almost half the basins in Victoria, have less than 10% of major rivers and tributaries in good or excellent condition. These represent a broad band of basins in the mid-west of Victoria. Typically these basins have been extensively cleared for agriculture.

It should be noted that stream condition within river basins can be variable. For example, the upper reaches or the Thomson are in good condition, whereas the lower reaches have been highly modified and are in poorer condition.



ENVIRONMENTAL CONDITION

- < 10%
- 11 - 30%
- 31 - 50%
- 51 - 70%
- >100%
- Insufficient Data

1. Upper Murray
2. Kiewa
3. Ovens
4. Broken
5. Goulburn
6. Campaspe
7. Loddon
8. Avoca
14. Mallee
15. Wimmera
21. East Gippsland
22. Snowy
23. Tambo
24. Mitchell
25. Thomson
26. LaTrobe
27. South Gippsland
28. Bunyip
29. Yarra
30. Maribyrnong
31. Werribee
32. Moorabool
33. Barwon
34. Corangamite
35. Otway
36. Hopkins
37. Portland
38. Glenelg
39. Millicent Coast

Figure A.3.2: Percentage river length in good or excellent condition, 2010 Index of stream condition

Source: DEPI.

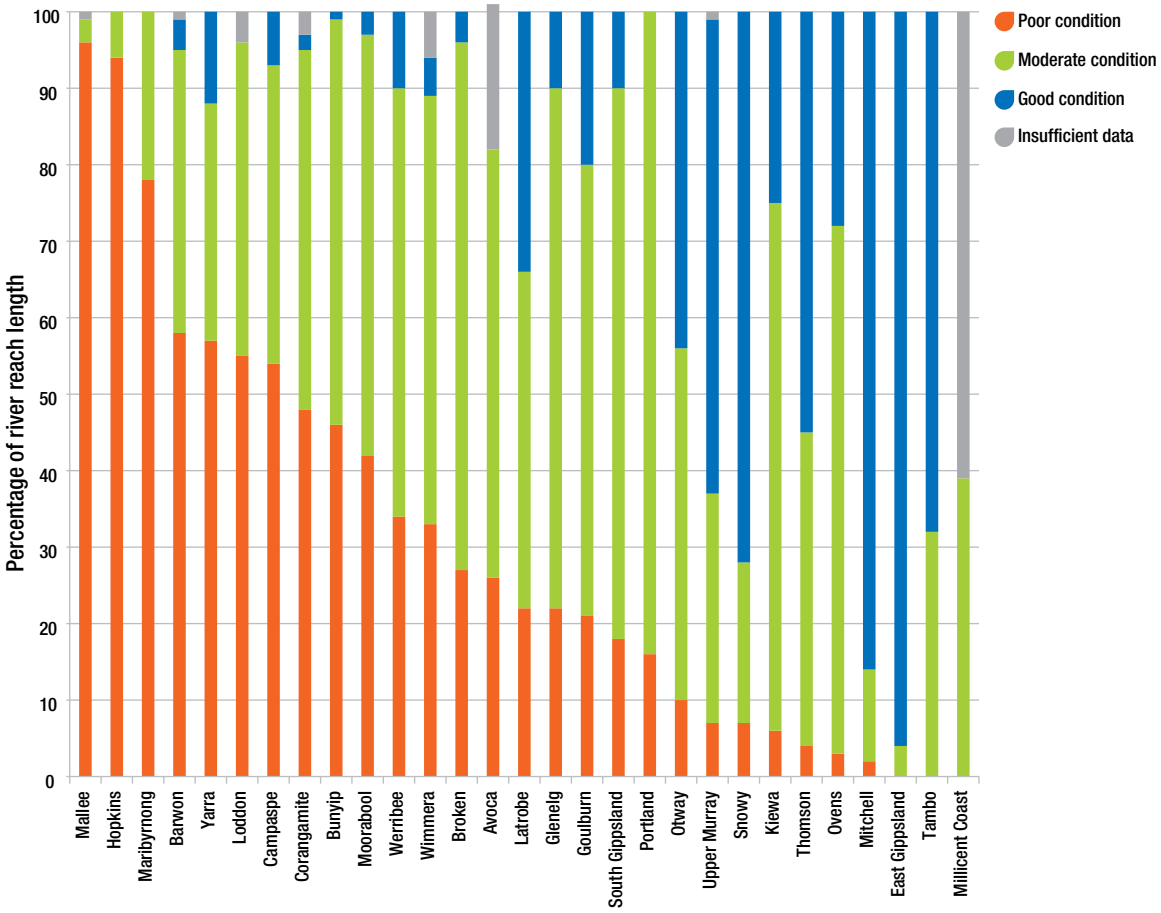


Figure A.3.3: Condition of river reaches in Victorian basins, 2010 Index of Stream Condition

Source: DEPI.

Riparian vegetation

The condition of riparian vegetation was assessed for the 2010 ISC.[5] Results showed that 21 of 29 river basins had less than 50% of their assessed river length, with riparian vegetation in good condition (Figure A.3.4). River basins with riparian vegetation in the poorest condition were the Hopkins, Corangamite and Portland basins. The basins in the east of the state had more river length, with riparian vegetation in good or excellent condition, compared with basins in the west. Again this is mainly because of extensive clearing for agriculture in the west of the state.

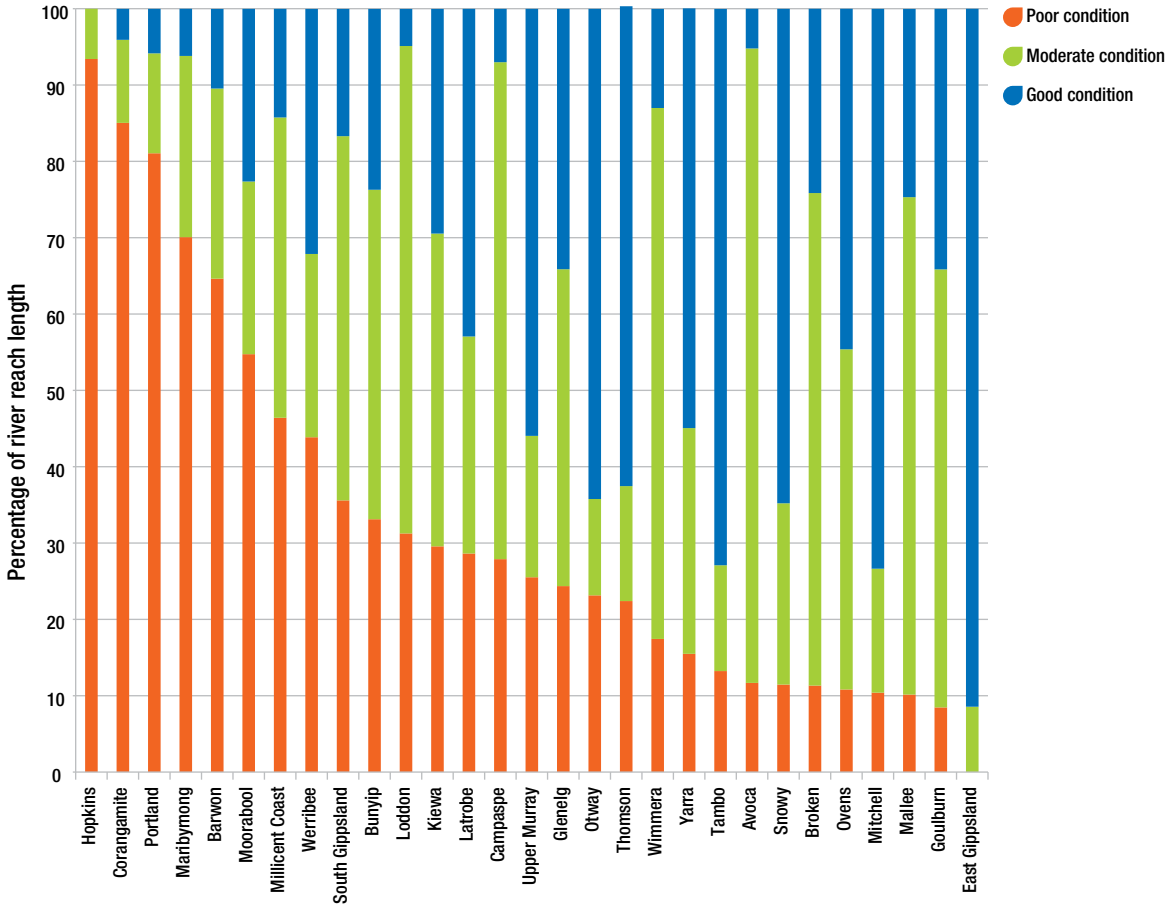


Figure A.3.4: Condition of streamside zone (riparian vegetation) in Victorian basins, 2010 Index of Stream Condition

Source: DEPI.

Wetland health

Healthy wetlands provide many benefits, including the mitigation of floods, water storage and groundwater recharge and discharge, improved water quality, and the retention of nutrients and sediments. They are also important areas for terrestrial and aquatic biodiversity.

Victoria's wetlands can be broadly classed as shallow and temporary or deep and more permanent, and as freshwater or saline. Wetland types include permanent lakes, seasonal lakes, floodplain wetlands, alpine bogs, mangroves, mudflats and seagrass areas.

Extent

There are more than 12,800 natural wetlands in Victoria, with a total area of more than 530,000 ha (Figure A.3.5 and Figure A.3.6). The majority of these (72%) are on private land, including 81% of shallow freshwater wetlands. There also at least 3,000 artificial wetlands, including farm dams, reservoirs, sewage treatment ponds and saltworks.[6]

Since European settlement, almost 4,000, or 23%, of natural wetlands have been lost, reducing Victoria's wetland area by an estimated 200,000 ha – over a quarter of the pre-existing area.[6] Some 90% of wetlands lost were on private land.

This assessment of change in wetland extent is mainly based on 1994 data. Wetland extent has not been assessed on a statewide basis since. However, expert opinion suggests that the extent of wetlands is declining.[7]

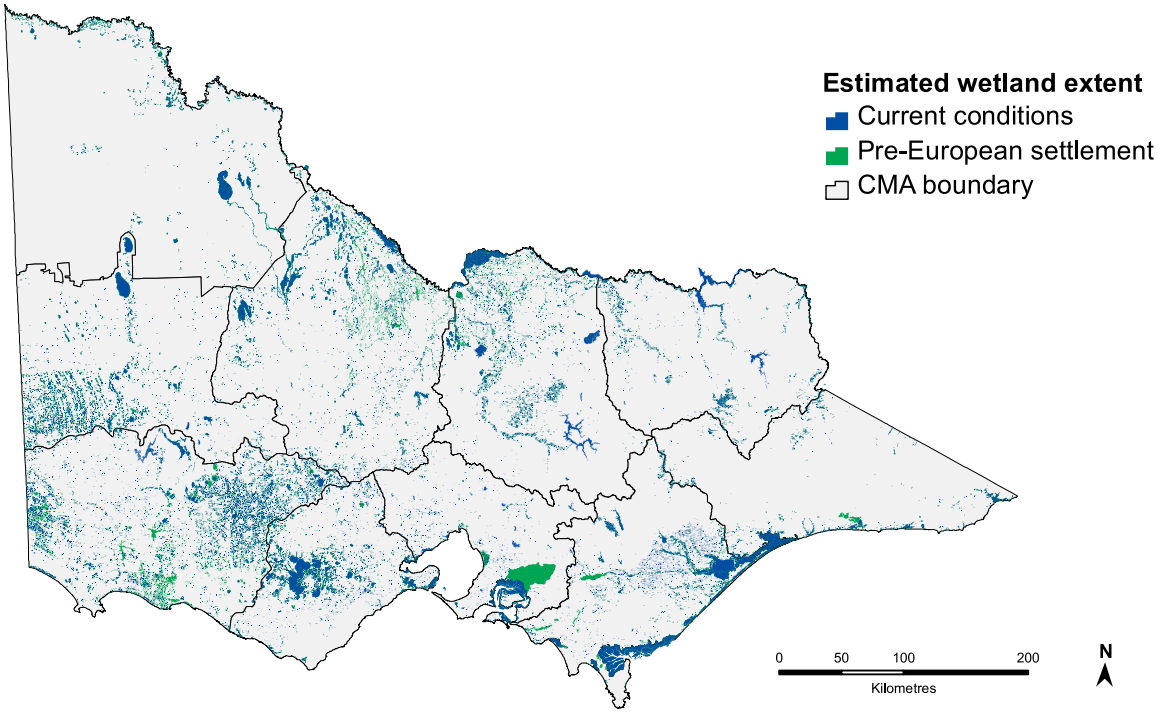


Figure A.3.5: Wetland Inventory Update Project, 2012

Source: DEPI.

Wetland type	Current number and area of wetlands (% of total)		% of current wetland numbers by tenure		Wetland loss since European settlement (% lost)	
	Number	Area (ha)	Public land	Private land	Number	Area (ha)
Shallow freshwater wetlands	9,140 (71%)	168,077 (32%)	19%	81%	3,532 (28%)	95,443 (31%)
Deep freshwater wetlands	2,303 (18%)	141,126 (26%)	55%	45%	349 (12%)	91,055 (37%)
Saline wetlands	1,373 (11%)	221,210 (42%)	44%	56%	44 (3%)	14,676 (7%)
Total	12,816	530,413	28%	72%	3,925 (23%)	201,175 (26%)

Figure A.3.6: Broad wetland types in Victoria, with their land tenure and loss since European settlement[6]

Condition

Wetland health is determined using the Index of Wetland Condition (IWC), the first statewide assessment of wetland condition in Victoria.[6] The IWC uses the following six sub-indices that affect the health of wetlands:

- wetland catchment (land-use intensity and buffer characteristics e.g. native vegetation)
- physical form (reduction in wetland area and changes in depth profile)
- hydrology (wetland water regime)
- water properties (nutrient enrichment activities and change in salinity)
- soils (amount and severity of wetland soil disturbance)
- biota (vegetation diversity, structure and health, weed presence)

Results are based on two survey periods. The first between spring 2009 and autumn 2010 following a period of extended drought. This assessment focused on 587 high-value wetlands, including 39% of those listed under the Ramsar Convention, Directory of Important Wetlands in Australia and high-value wetlands in the Wimmera region. The second assessment was made between spring 2010 and autumn 2011 after a period of widespread and severe flooding. This assessment focused on 240 representative wetlands selected to represent the range of Victorian wetland types.

Because this is the first assessment undertaken for the IWC, it is not possible to provide trends in wetland condition over time. However, this assessment will provide a baseline for future surveys with the next condition assessment planned for 2017–18.

Overall wetland condition

For high-value wetlands, 56% were assessed as being in good or excellent condition, 30% in moderate condition and 14% in poor or very poor condition (Figure A.3.7). The high percentage of wetlands in excellent or good condition despite the long period of drought may reflect the resilience of these wetlands, the effectiveness of management interventions, or both.

For representative wetlands, 51% were assessed as being good or excellent condition, 24% in moderate condition, and 26% in poor or very poor condition. The higher number of wetlands in poor and very poor condition is most likely because threats are less prevalent or more effectively managed at the high-value wetlands.

The condition of both high-value and representative wetlands was better on public land (Figure A.3.8). This is again likely to be the result of less prevalent threats on public land.

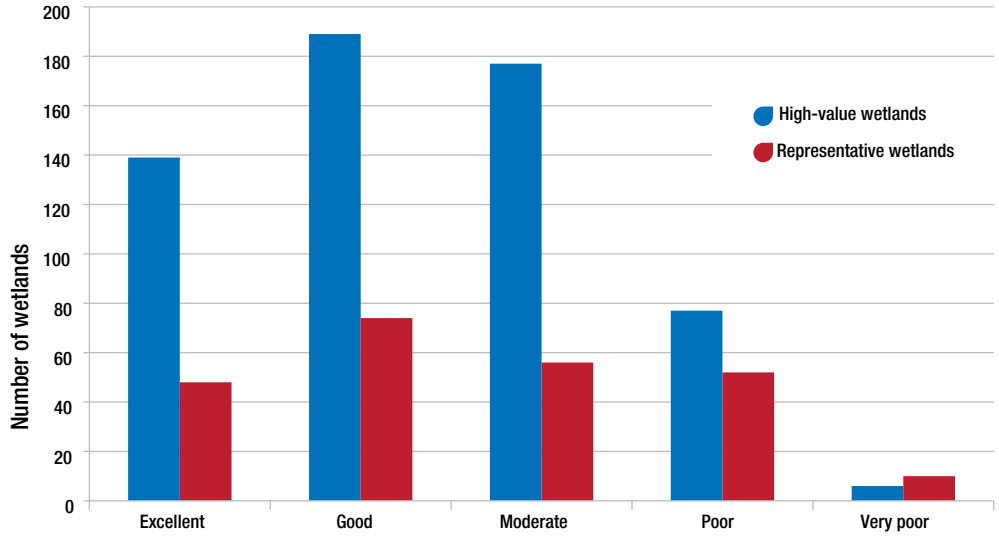


Figure A.3.7: Condition of wetlands in Victoria as assessed by the Index of Wetland Condition

Source: DEPI.

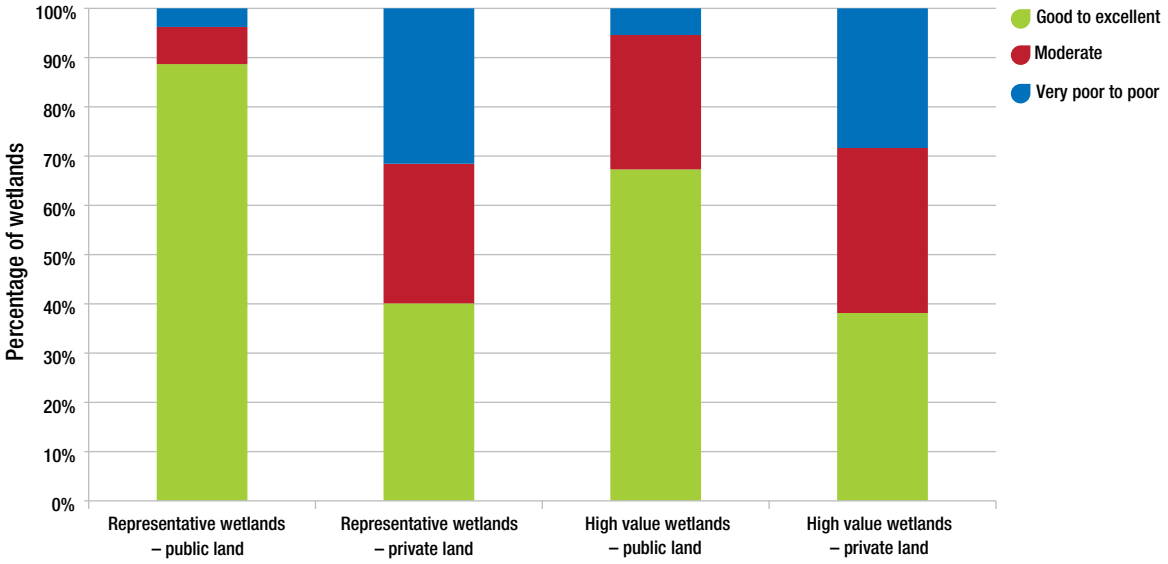


Figure A.3.8: Condition of wetlands in Victoria as assessed by the Index of Wetland Condition, by land tenure

Source: DEPI.

Threats to wetland condition

Over half the wetlands assessed were subjected to at least one threat. With the exception of altered hydrology, threats were more prevalent at representative wetlands than at high-value wetlands (Figure A.3.9). The most prevalent threat sources at high-value wetlands were livestock grazing, driving of vehicles on the wetland, and excavation of the wetland bed. For the representative wetlands the most prevalent were water pollution, livestock grazing, pugging by livestock and feral animals, excavation of the wetland bed, alteration of the flow regime of the water source, and alteration of the topography (e.g. levelling). Threat sources were up to 10 times more prevalent at wetlands on private land than for wetlands on public land.

Other findings include:

- Many of Victoria's high-value wetlands retain their original area and form, their soils are relatively unmodified and there is no change to salinity levels.
- Nearly half of high-value wetlands have altered water regimes, with a third substantially modified. This is largely due to the number of river-fed high-value wetlands affected by river regulation. Fewer representative wetlands had very poor hydrology compared to high-value wetlands.
- Wetlands fed by groundwater and local runoff were more likely to be in better condition than those fed by rivers.
- The condition of wetlands with no water present was significantly poorer than those that contained some water with the condition of wetland vegetation affected by the dry conditions.
- Over two-thirds of wetlands contain vegetation in 'moderate' to 'very poor' condition. This is likely due to changes in water regimes, grazing by livestock, cropping and weed invasion, exacerbated by long-term drought.
- At the representative wetlands, a larger proportion of seasonal wetlands were in poor condition, compared to permanent wetlands. Seasonal wetlands are more likely to be exposed to threats because they are more accessible and subject to activities such as grazing and cultivation.

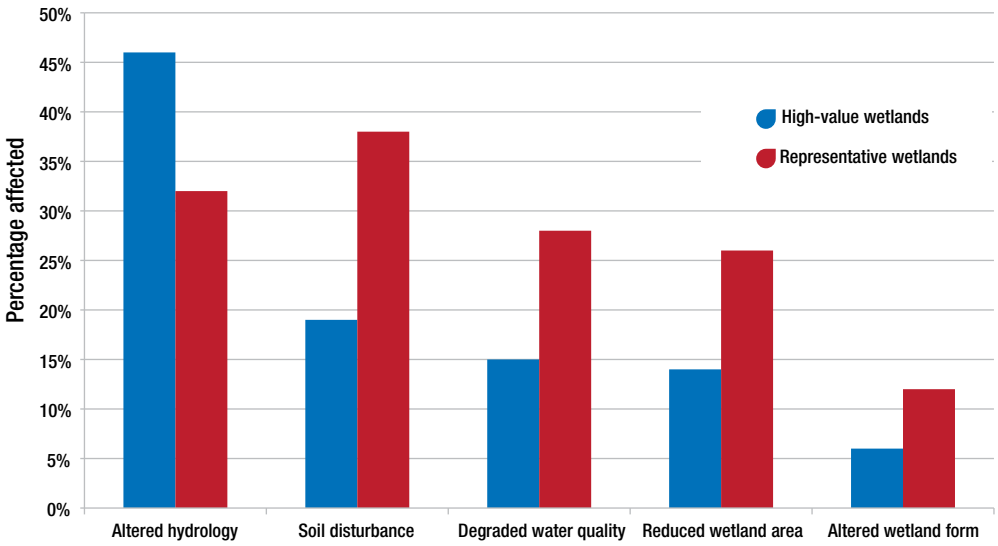


Figure A.3.9: Percentage of wetlands affected by threat category, as assessed by the Index of Wetland Condition

Source: DEPI.

Indicator IW2: Freshwater biodiversity

This indicator reports the status of aquatic fauna reliant on inland waters. It should be noted that many species of fish and waterbirds depend on a range of freshwater, estuarine and marine habitats. The status of such species can be affected by impacts on any of these habitats. Estuarine, coastal and marine fauna are reported in Part A: 4 Marine and Coastal Environments. The overall status of biodiversity, including threatened species, is reported in Part A: 2 Biodiversity and Land.

Freshwater fauna contribute significantly to Victoria's biodiversity, and are integral components of freshwater ecosystems.

Victoria's freshwater systems support two species of freshwater mammals (the platypus (*Ornithorhynchus anatinus*) and water rat (*Hydromys chrysogaster*), over 100 species of waterbirds, 33 species of amphibians, 46 species of freshwater fish, and several reptiles. There are also an undetermined number of invertebrate species, including insects such as dragonflies and stoneflies, crustaceans such as crayfish and shrimp, molluscs such as snails, and worms.

The other issues covered in this chapter of the report – condition of aquatic ecosystems, introduced species, flow regimes, water quality, and groundwater – can all impact on aquatic fauna. For example, declining water quality is listed as a threatening process for 35 native species (see Part A: 2 Biodiversity and Land). Declines in native aquatic fauna can result in the reduced survival and diversity of species, and degraded ecosystem function and ecosystem services.

Conservation status of inland aquatic species

The Department of Environment and Primary Industries (DEPI) maintains threatened species Advisory Lists, which document the threat status for various species.[8] Information about the Advisory Lists are provided in Part A: 2 Biodiversity and Land.

As at 2013, three species of inland aquatic vertebrate fauna were regionally extinct, 20 species were critically endangered, 17 endangered, 26 vulnerable, and seven near threatened. Data was found to be deficient for four species (Figure A.3.10). All of the regionally extinct species are native fish – Agassiz's chanda perch (*Ambassis agassizii*), freshwater herring (*Potamalosa richmondia*) and southern purple spotted gudgeon (*Mogurnda adspersa*).

Fish were the most listed of the inland aquatic fauna groups, with 33 species currently threatened. In addition, 25 species of birds and 18 amphibian species were also listed as threatened. Fish and amphibian species make up the majority of critically endangered and endangered species. These groups have a considerable proportion of their extant species threatened in Victoria (includes regionally extinct, critically endangered, endangered and vulnerable categories), with 43% of amphibians and 55% of freshwater fish listed.[7]

Between 2007 and 2013, nine inland aquatic vertebrate species declined in status and four species were added to the Advisory List because of decreasing populations. Only five species improved their threatened status.

The Advisory List for threatened invertebrate fauna contains many freshwater species, including critically endangered crustaceans, molluscs and insects.[9] The number of invertebrate species in Victorian freshwater systems is unknown, but it is estimated to greatly exceed the diversity of vertebrate fauna. Consequently, the knowledge of conservation status also remains poor, and the current number of threatened species is likely to be vastly under-reported.

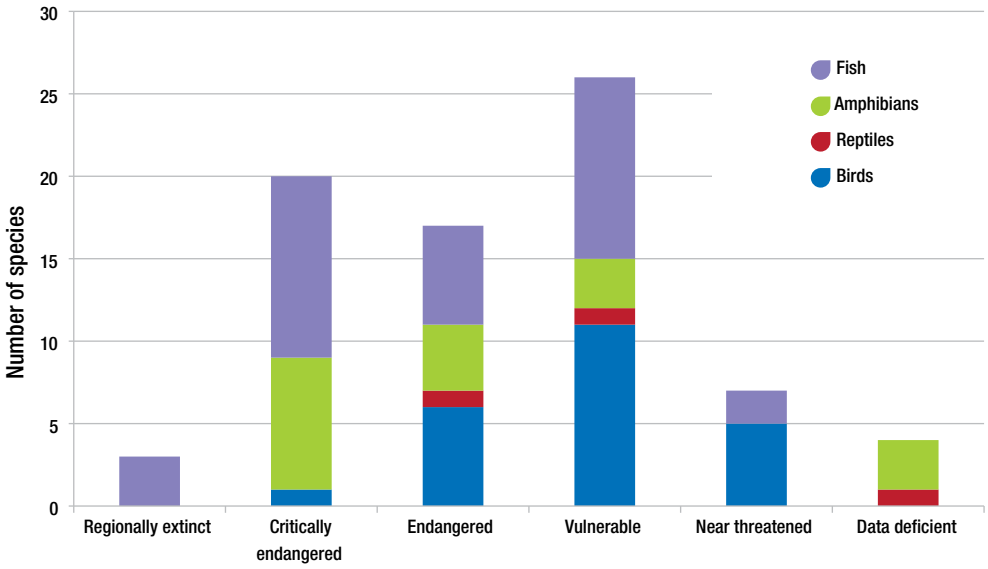


Figure A.3.10: Number of Victorian inland aquatic vertebrate species listed on the Advisory List of Threatened Vertebrate Fauna in Victoria, 2013

Source: DEPI.

Distribution and abundance of native fish

There is general consensus that many native freshwater fish have a reduced distribution and abundance, compared to before European settlement. In the Murray–Darling Basin, it is estimated that only 10% of fish communities remain, and these are in danger of further decline.[10]

Extraction of water, regulation of flow regimes, poor water quality, and alteration of habitat are primary causes of decreasing native fish populations. Structures such as dams, weirs and levees exclude migratory fish such as Murray cod and golden perch from their spawning grounds and prevent recolonisation when conditions improve after drought. Other pressures on native fish include introduced species and recreational fishing, particularly unregulated (unlicensed) fishing. Commercial fishing for native fish species, including Murray cod, golden perch and silver perch, is now banned in Victoria's inland waters except for some estuaries.

Since European settlement, several exotic species of fish have adversely affected native fish populations. Humans have played a major role in the dispersal of exotic freshwater species in Victoria for recreational fishing, ornamental purposes and biological control, while translocation of native species has been used for aquaculture and to enhance recreational fishing.

Introduced species and translocated native species place pressure on native aquatic fauna through predation, competition, aggressive behaviour, disease and habitat modification. In addition, cleared land, poor water quality and modified hydrology associated with major water storages are known to favour some alien species. Introduced fish include rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), which favour cool upland streams and lakes, and were stocked for recreational purposes. Most trout are now only stocked in 'closed systems' for recreational fishing. Carp, oriental weatherloach (*Misgurnus anguillicaudatus*), gambusia, goldfish (*Carassius auratus*) and redfin perch (*Perca fluviatilus*) are other significant exotic species that prefer slow-flowing or still water.

The impact of introduced species can be significant. For example, the aggressive gambusia has been implicated in the decline of at least nine species of fish and the decline of more than 10 frog species in Australia; carp may alter zooplankton levels, increase turbidity and bank instability, and even increase the risk of algal blooms; and the distribution and abundance of native galaxiid species in south-eastern Australia, has been seriously reduced wherever brown trout and rainbow trout have been introduced.[11]

Native fish in Victorian inland waters

Between 2004–05 and 2010–11, native fish surveys were undertaken in 29 Victorian river basins as part of the Sustainable Rivers Audit and Southern Basins Project.[12] A total of 73,164 fish were collected, 51,462 (70%) of which were native representing 39 species. Ten species of alien fish were recorded.

In nine of the river basins, only half or less of the number of predicted native species were found (Figure A.3.11). Only seven river basins had two-thirds or more of predicted native species. For the majority of river basins, consistently lower numbers of native species were found compared to those predicted to be present under reference conditions (unmodified rivers of high quality). This indicates that native fish communities are being affected by a range of pressures in these areas.

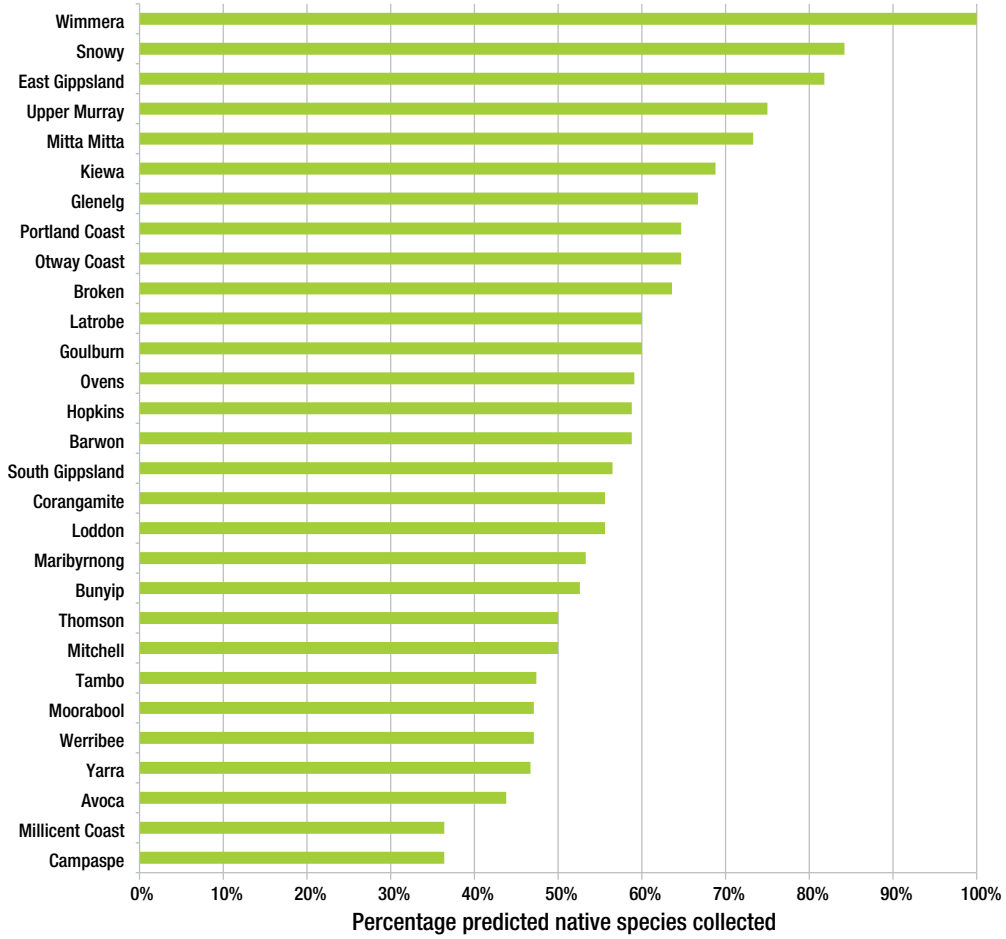


Figure A.3.11: Percentage of predicted native fish species found in Victorian river basins between 2004–05 and 2010–11

Source: DEPI.

Note: Predicted species are those expected to be captured under reference condition in each river basin. Urbanised sections of the Yarra and Maribyrnong basins were not assessed, which potentially lowered the number of species captured in these catchments.

Although the surveys found that native fish accounted for the majority of the species present in rivers, and were more abundant, it is clear that alien and introduced native species are common in many Victorian streams (Figure A.3.12 and Figure A.3.13). Alien fish were found in all but one river basin (Millicent Coast) and accounted for 10% or higher of the total fish abundance in all but four river basins, 25% or higher in 13 river basins, and over 50% in the Campaspe, Maribrynong and Kiewa river basins.

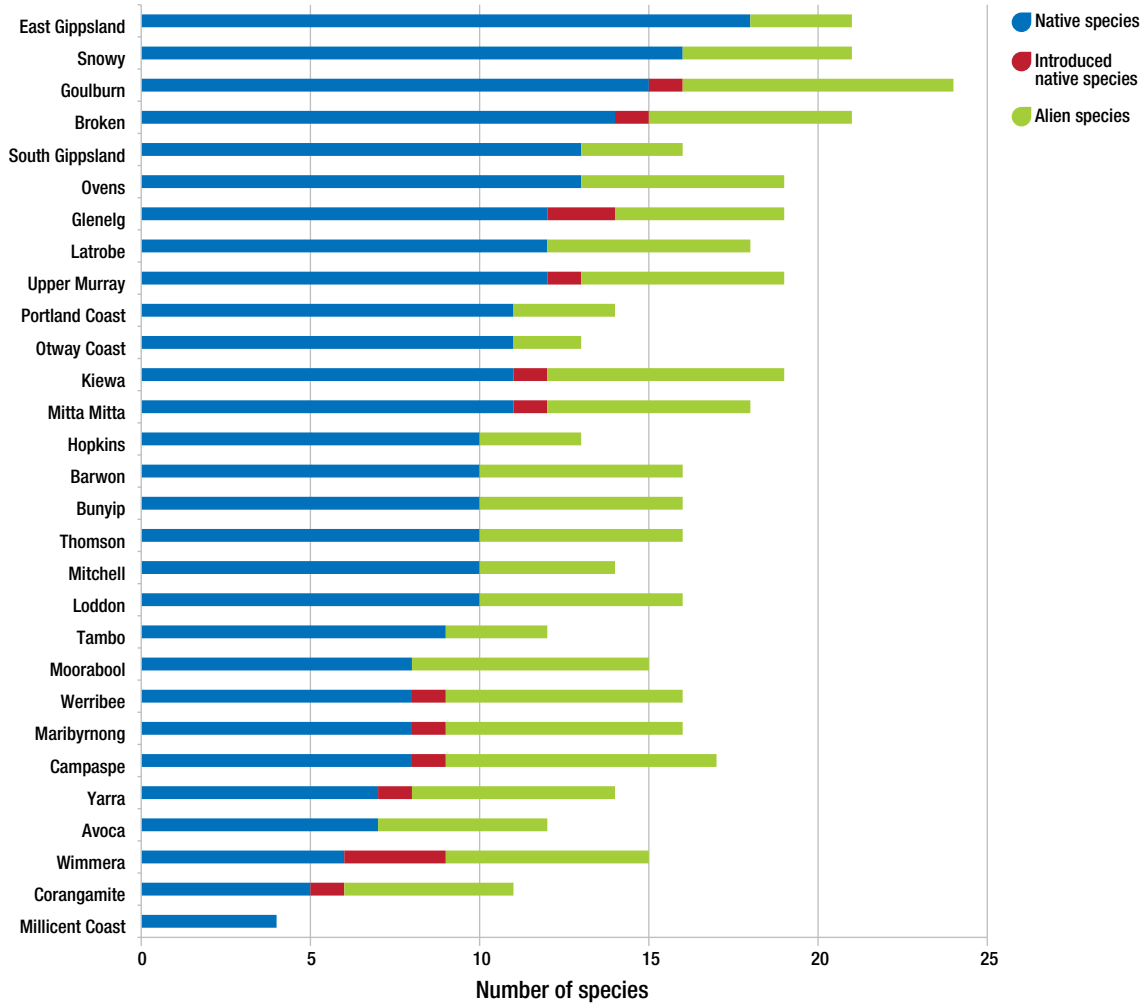


Figure A.3.12: Number of native, introduced native and alien fish species found in Victorian river basins between 2004–05 and 2010–11

Source: DEPI.

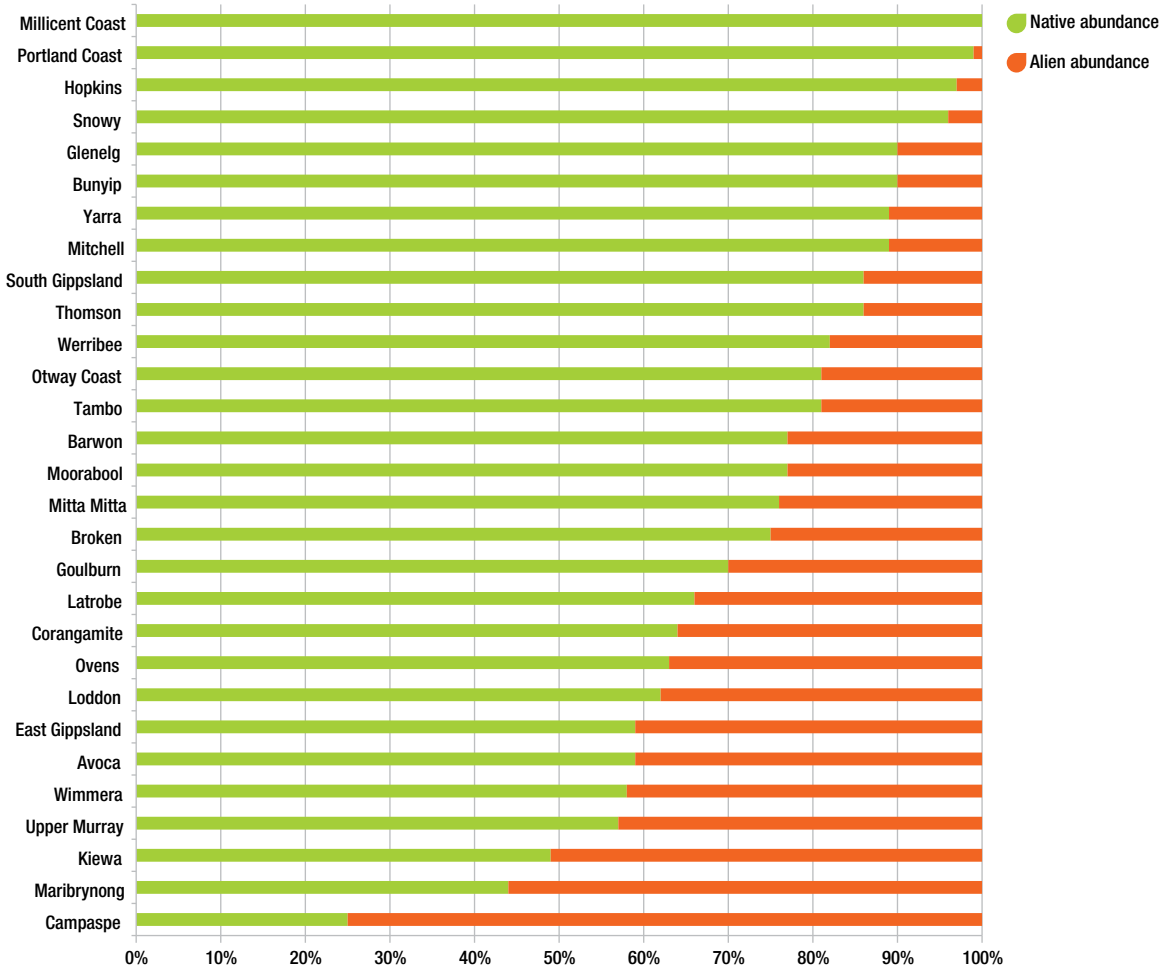


Figure A.3.13: Abundance of native and alien fish species found in Victorian river basins between 2004–05 and 2010–11, percentage of total numbers collected

Source: DEPI.

Despite the higher abundances of native fish species, the biomass (a measurement of the relative size of species) of alien species is far greater (Figure A.3.14). Alien fish accounted for 60% of the total fish biomass in 20 of Victoria's river basins, and over 90% of the total biomass in seven river basins. Only nine of the 29 river basins had a native fish biomass greater than alien species. This is mainly due to the size of introduced fish such as carp, rainbow trout and brown trout, which are often much larger than native species. The greater biomass of alien species has significant implications for native fish communities, particularly with regard to competition for food and habitat resources.

The significant presence of non-native fish species in Victorian rivers indicates that modified landscapes and river systems have created favourable conditions for alien species to thrive.

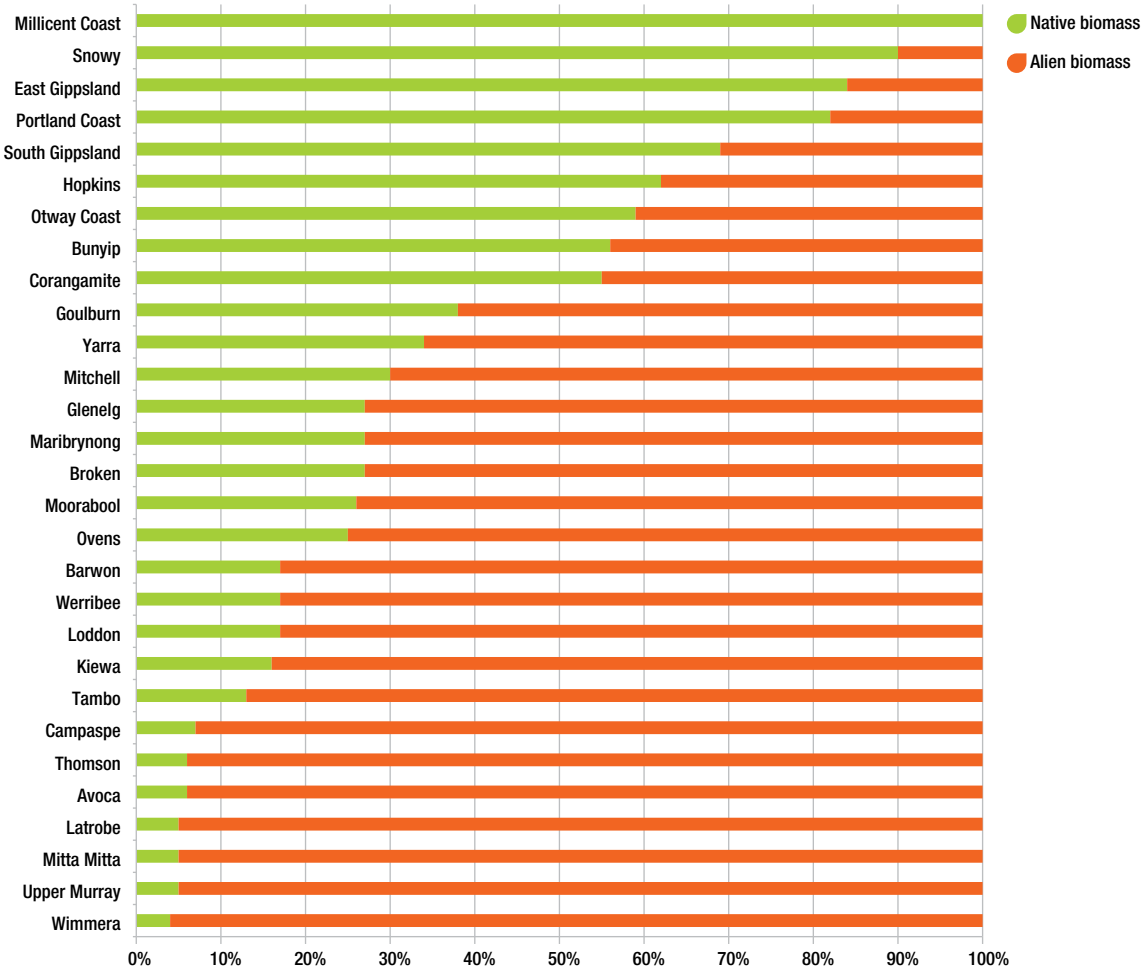


Figure A.3.14: Biomass of native and alien fish species found in Victorian river basins between 2004–05 and 2010–11, percentage of total biomass collected

Source: DEPI.

Fish stocking

Since 1988, the Victorian Government has augmented the populations of some native fish species through the stocking of fingerlings. The purpose of stocking is to support recreational fishing and maintain native fish populations. However, stocking is also important for conservation purposes with trout cod (critically endangered), Macquarie perch (endangered), Murray cod and silver perch (vulnerable), and golden perch (near threatened) all listed as threatened species in Victoria.[8]

Murray cod, golden perch, silver perch and trout cod are native to the Murray–Darling Basin and stocked into inland waters north of the Divide. Selected lakes south of the Divide are stocked with Australian bass, Macquarie perch, trout cod and estuary perch. Introduced salmonids such as brown trout, rainbow trout and salmon are also stocked to inland waters for recreational fishing, but most are released into lakes and impoundments.

The stocking of native fish has more than doubled since 2008, with over 2 million fingerlings released annually from 2011 (Figure A.3.15). The vast majority of stocked fish were Murray cod and golden perch, which accounted for over 90% of the total released.

While restocking programs contribute significant numbers of juvenile fish, the proportion of overall fish populations resulting from restocking has not been ascertained in Victoria. In addition, the loss of large, mature fish due from recreational fishing, degraded aquatic ecosystems, and significant pollution or drought events are not easily replaced by restocking programs, despite the large numbers of fingerlings released.

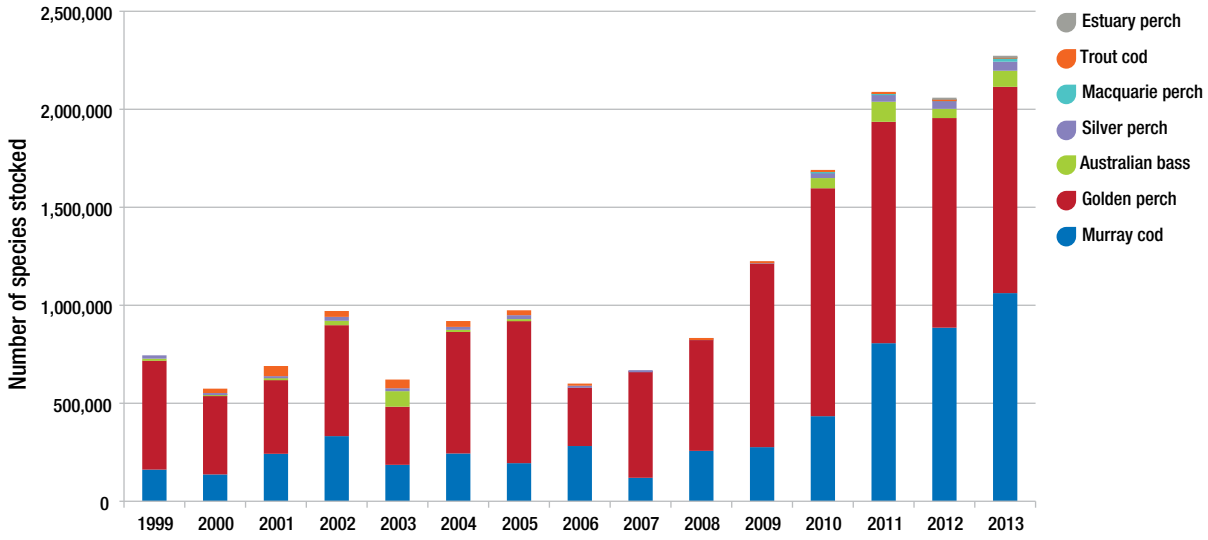


Figure A.3.15: Number of native fish species stocked to inland waters

Source: DEPI.

Distribution and abundance of waterbirds

Victorian inland waters provide critical habitat for indigenous and migratory waterbirds. Waterbird communities depend on a range of aquatic organisms for food and can provide an indication of changes to inland water biodiversity, as well as ecosystem health. The abundance and distribution of species can be indicative of the condition of individual species as well as waterbird species collectively. However, the high mobility of waterbirds makes population estimates difficult. Periods of lower rainfall can concentrate waterbirds in remaining wetlands and drought refuges, whereas increased rainfall can result in widely dispersed populations taking advantage of newly available habitat.

Populations of waterbirds are thought to be declining in parts of Australia. Surveys for eastern Australia over a 27-year period from 1983 to 2009 found that, while numbers are variable, generally corresponding to periods of flooding and drying, long-term declines in both the number of waterbirds breeding and the number of breeding species was evident.[13] Declines are in part due to river regulation reducing the extent of wetlands across eastern Australia.

Condition of macroinvertebrate communities of major rivers and tributaries

Freshwater macroinvertebrates are a diverse group of insects, crustaceans and molluscs, including snails, yabbies, water boatmen, dragonflies, stoneflies and worms. They are relatively sedentary, spend at least part of their life in aquatic ecosystems, and are critical to aquatic ecosystem health. Because of their sensitivity to a range of pressures, macroinvertebrates are routinely used as indicators of the condition of freshwater systems and their surrounding catchments. Land-use change, aquatic and riparian habitat modification, water pollution, and river regulation all impact on macroinvertebrate community health.

The Victorian EPA undertakes macroinvertebrate surveys, results of which are used in the Index of Stream Condition (see Indicator IW1: Condition of Freshwater Aquatic Ecosystems). Figure A.3.16 shows results from combined season sampling from spring 2009 to autumn 2012 for each Victorian catchment. Only catchments that contained four or more combined season samples in the period are shown. Macroinvertebrate community health is shown using Aquatic Life Scores (ALS); the higher the score, the healthier the community (scores are based on the presence of macroinvertebrate families and their sensitivity to pollutants).

The sampling period encompasses the final year a significant drought period in Victoria, and two above-average rainfall years (see Part A: 1 Climate Change and Air Quality). Results highlight an east-to-west gradient for macroinvertebrate health. Western Victoria is typically arid with lower streamflows, and has higher levels of native vegetation clearing and agriculture compared to catchments on the eastern side of the state. The western Hopkins, Wimmera, Avoca, and Loddon catchments are generally in poor health. Eastern catchments show improved health, with the exception of the Broken and Kiewa catchments. This may be related to increases in rainfall and streamflows.

The increase in rainfall since 2010 appears to have been disproportionately beneficial to the eastern catchments. This can be attributed to the better macroinvertebrate community health during the long drought period. In contrast, the health of macroinvertebrate communities was much poorer in the west and will take longer to respond to rainfall increases.

The slightly poorer health of the Broken catchment is not only because of drought impacts, but also because of significant flooding in 2010 and 2011 which impacted on water quality and in-stream habitat. The Werribee and Maribyrnong catchments have continued to see a decline in the health of macroinvertebrate communities, this is likely to be because of increases in urban development.

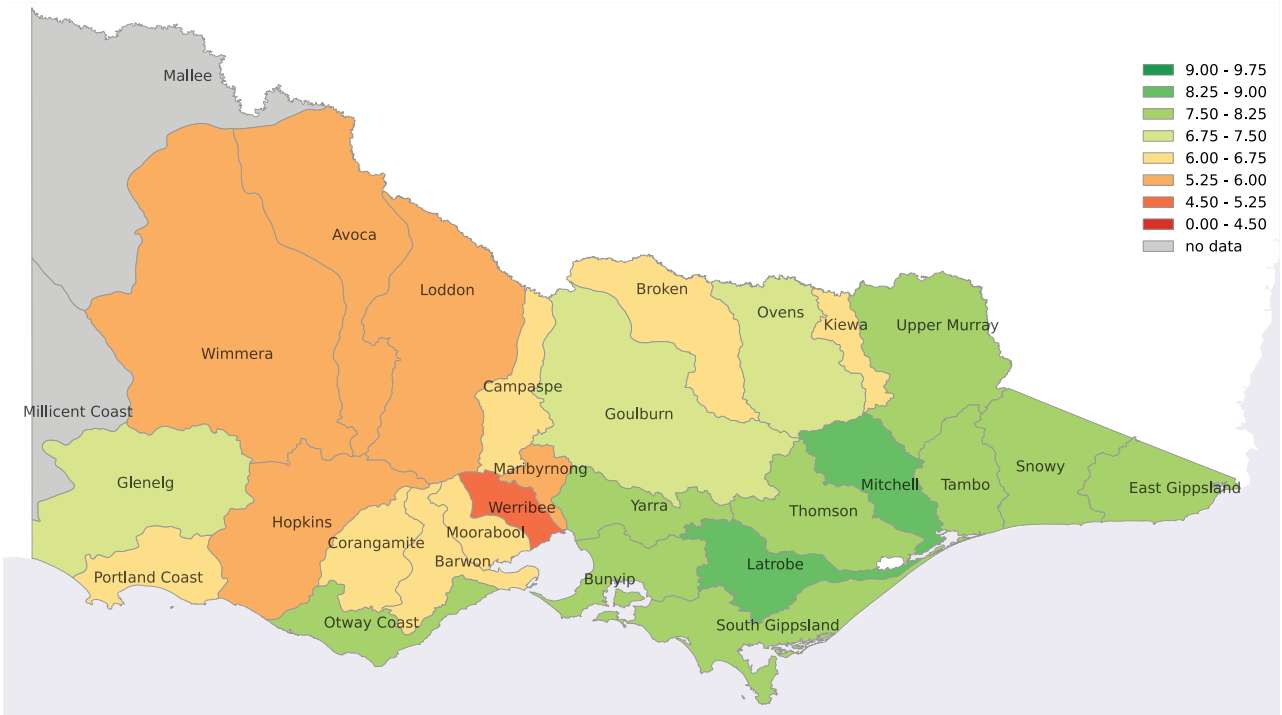


Figure A.3.16: Combined season (spring and autumn) macroinvertebrate Aquatic Life Score for Victorian catchments, spring 2009 to autumn 2012

Source: EPA.

Note: Data is for combined season sampling from spring 2009 to autumn 2012. Only catchments that contained four or more combined season samples in the period are shown. Macroinvertebrate community health is shown using Aquatic Life Scores (ALS); the higher the score, the healthier the community.

Introduced aquatic plants and animals

Background information on introduced plants and animals is provided in Part A: 2 Biodiversity and Land.

Aquatic ecosystem health is impacted by a range of introduced species, including fish and aquatic weeds. Aquatic weeds can dominate inland waters, degrading ecosystem health and threatening native species, and impacting on irrigation suitability and recreational values. Aquatic weeds can cover a water body in a short period of time, restricting the flow of water and substantially altering the flow regime of rivers. Weeds can also threaten biodiversity by out-competing native species, altering habitat and reducing sunlight penetration. Large amounts of aquatic weeds can also reduce the dissolved oxygen concentration of water through the bacterial breakdown of decaying plant matter.

Aquatic weeds are a serious problem for water authorities and irrigators when channels and drains become infested. For example, the spread of the aquatic weed Arrowhead cost Goulburn–Murray Water alone in excess of $1 million per year in control and eradication activities.[2] The extremely high costs associated with weed and pest control also compromise the delivery of other resource management activities by competing for available funding.

Terrestrial weeds that inhabit riparian zones and floodplains also impact on aquatic ecosystems. Weeds also degrade the quality of riparian vegetation by strangling native plants, out-competing native species and altering ground conditions, preventing the regeneration of native species and reducing biodiversity.

Statewide information on the number and distribution of introduced aquatic species remains poor and has not been updated since the 2008 Victorian State of the Environment report. Main findings included:

- Arrowhead (*Sagittaria graminea*) is a serious problem in the waterways of Northern Victoria.
- Presence of weeds is also an important indicator of the health of riparian vegetation. Common riparian weeds include willow (*Salix* spp.), blackberry (*Rubus fruticosis* aggregate), phalaris (*Phalaris aquatica)*, rye grass (*Lolium* spp.) and thistles. Both willow and blackberry are now recognised as weeds of national significance.
- Tree and shrub weeds such as willow and blackberry have a more detrimental impact than groundcover weeds.
- Watercourses dominated by willows exhibit reductions in numbers and diversity of invertebrates, fish and native plants.
- While extensive areas of willow in the upper catchment of the Snowy River have recently been removed, the extent and distribution of willow in Victoria has not been fully mapped.

Indicator IW3: Condition of Flow Regimes of Major Rivers and Tributaries

This indicator assesses the condition of flow regimes with regard to environmental health. Information on the use of water resources is discussed in Part A: 5 Human Settlements.

A flow regime is a specific combination of the timing, size and duration of river flow events. It is a key driver of river and floodplain wetland ecosystems. Each river has its own flow regime, which influences river morphology, biodiversity, and the processes that sustain aquatic ecosystems. Aquatic plant and animal species have evolved life histories directly in response to the natural flow regimes.

Streamflow in Victoria is highly variable, with most basins receiving only a fraction of their average flow in most years. The generally dry conditions are punctuated by wet years with flows well in excess of the average, which replenish storages and river systems.

Modification of natural flow regimes may affect biodiversity, alter riverine habitat, and facilitate the invasion of exotic species. Flow variability and volume underpin many ecosystem processes in inland waters, regulating the transport of nutrients, sediment and salt within inland waters and onto associated floodplains. Changes to flow variability and volume, combined with altered land-use practices, have resulted in many inland waters with modified loads and concentrations of natural contaminants such as nutrients.

The presence of dams and other barriers, regulation of flow, extraction of water for consumption, channel modification, and changes in land use all impact on flow regimes. These pressures affect groundwater and wetlands, as well as rivers. Indirect pressures such as the clearing of vegetation, agriculture, groundwater extraction, farm dams, plantation forestry and regrowth following bushfires have also altered catchment hydrology. The main pressures on flow regimes include:

- Regulation of flow by major storages, weirs and levees. At least one major on-stream storage occurs in 65% of Victoria's river basins (19 out of 29). Storages often result in large decreases in flow immediately downstream. For example, there is a 95% reduction in flow immediately downstream of the Upper Yarra Dam.[14] River regulation can significantly reduce the volume of high flows below natural levels, and can also increase the duration of low flows, with significant impacts on biodiversity and ecological processes.
- In irrigation areas, flow regimes are dictated by the needs of consumers rather than environmental requirements, as rivers are used to convey water released from storages. Consequently, river regulation reverses the seasonality of natural flows, with large volumes of water released for irrigation during the dry season. This is thought to have caused significant changes in some Victorian ecological communities, e.g. by diminishing the reproductive success of many aquatic species. Water is also released from storages for hydro-electricity generation.
- Extraction of water for consumption reduces the volume of water available for the environment. As competition for water resources has increased, the cumulative impacts of water harvesting have become more acute. These pressures have been compounded in the past decade by drought conditions that have resulted in streamflows well below the long-term average (see Part A: 1 Climate Change and Air Quality). During times of low streamflow, the water allocation system reduces environmental flows more than it reduces water for consumptive uses.

- Altered catchment hydrology has resulted in changes to runoff and groundwater recharge rates. Approximately half of Victoria's native vegetation has been cleared increasing surface water runoff and recharge to groundwater. This has placed pressure on terrestrial systems as well as inland waters (see Indicator IW4: Water Quality, Indicator IW5: Groundwater Levels and Quality, and Part A: 2 Biodiversity and Land).
- The proliferation of farm dams, which number over 350,000 in Victoria, reduces streamflow by intercepting runoff.[15]
- Widespread reforestation, through plantation forestry or smaller-scale agroforestry activities, can change the hydrology of catchments by intercepting groundwater recharge. Young, rapidly growing trees use much more water than mature forest. Fire may also affect water availability through its effects on vegetation.
- Urbanisation affects streamflow by making it much more variable, reducing low flow rates and, after heavy rain, increasing peak flow rates and shortening their duration.
- The construction of levee banks to prevent the flooding of land and property can isolate the river from the floodplain.

Impact of drought on river flows in Victoria

The drought conditions between 1996 and 2010 (see Part A: 1 Climate Change and Air Quality) severely reduced Victoria's river flows across many catchments, particularly in central and western Victoria (Figure A.3.17 and Figure A.3.18). Many catchments experienced some of the lowest streamflows on record, with 2006–07 and 2008–09 volumes only 27% and 32% of the long-term average respectively. Many environmental water rights across Victoria were used during the drought to augment consumptive supply.[7] This further reduced the volume of water available for aquatic ecosystems.

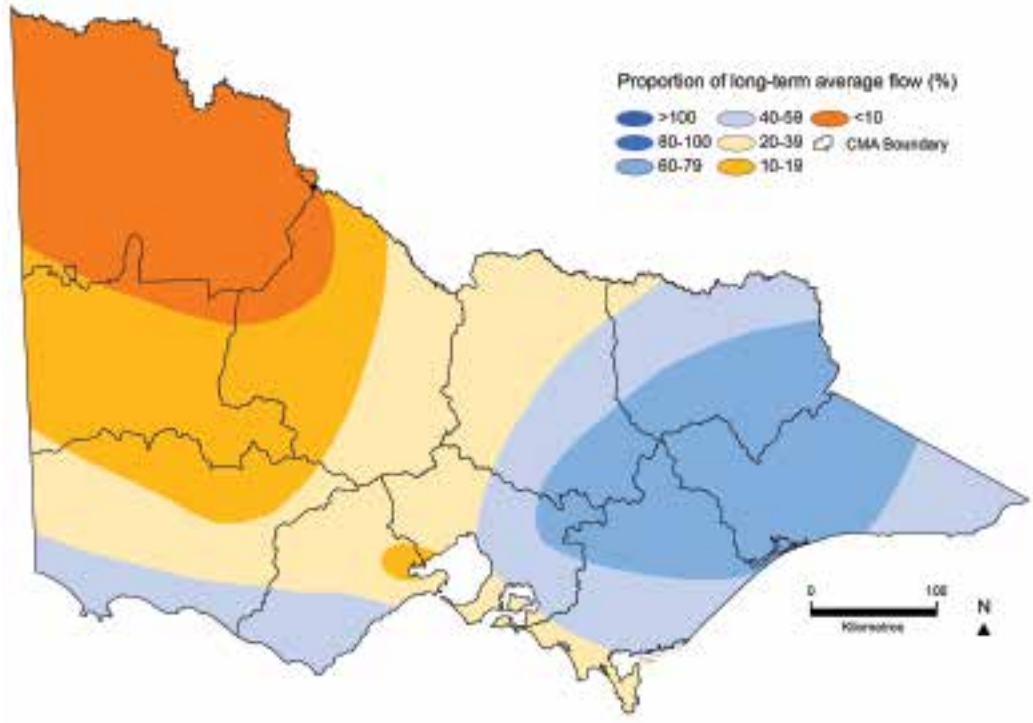


Figure A.3.17: Streamflow expressed as a percentage of long-term average flow, 1997–2010

Source: DEPI.

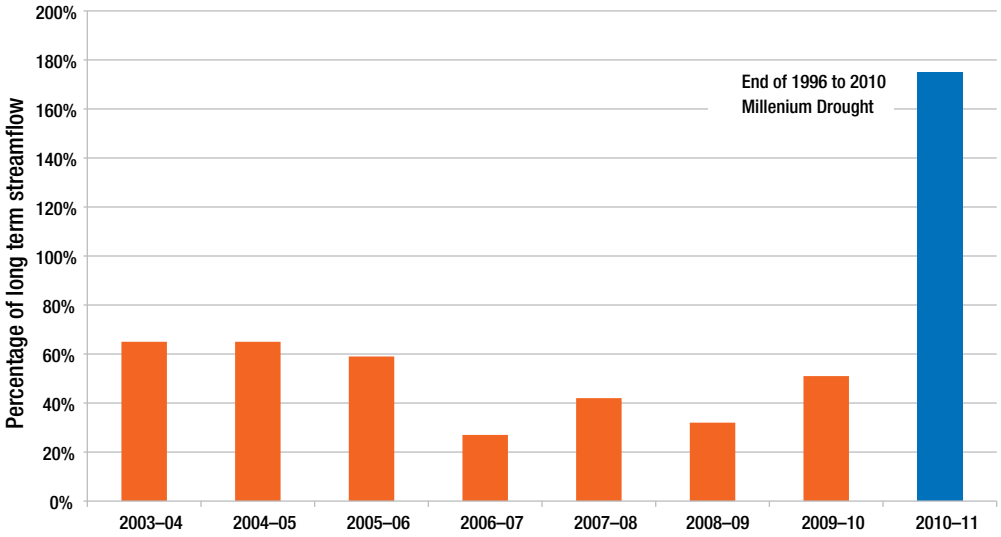


Figure A.3.18: Victorian streamflow compared to long-term average

Source: DEPI.

Condition of flow regimes

The condition of flow regimes is reported through the Index of Stream Condition (ISC – see Indicator IW1: Condition of Freshwater Aquatic Ecosystems).[5] Results from ISC 2010 show that only eight of the 29 river basins had flow regimes in good condition for more than 50% of the length assessed (Figure A.3.19). The East Gippsland, Mitchell, and Upper Murray basins had flow regimes in best the condition. Eleven basins had flow regimes in poor condition for 50% or more of their length assessed. The Hopkins, Mallee and Maribyrnong basins had flow regimes in the worst condition (highly modified flaws). The basins in the east of the state generally had more river length in good or excellent condition for flow regimes compared with basins in the west.

Results also showed that virtually all reaches were adversely affected by the Millennium Drought, and that the south-west of Victoria was the most severely affected. Drought had a major impact on flow regimes across the entire state, with rivers in the Wimmera, Portland and Glenelg basins being the most drought affected in Victoria.

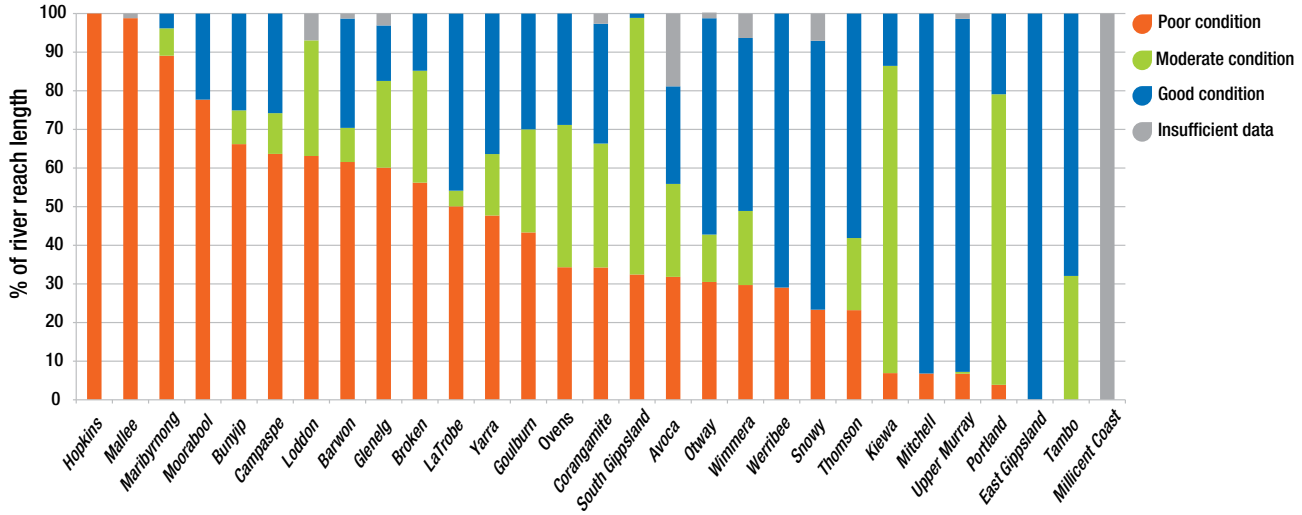


Figure A.3.19: Condition of hydrology (flow regime) in Victorian basins, 2010 Index of Stream Condition

Source: DEPI.

Surface water harvested for consumptive use

The percentage of total streamflow leaving a river basin (i.e. that remaining after water extraction) is an indicator of the pressure that consumption exerts in each basin. Water consumption reduces the water available to support aquatic ecosystems and increases the impact of dry conditions on biodiversity.

Between 2005–06 and 2009–10 (during the drought period), over 25% of Victoria's river basins had more than three-quarters of their annual streamflow harvested for consumption, and over 40% had more than half their streamflow harvested (Figure A.3.20). In 2006–07 and 2008–09, over 50% of river basins had more than half their steamflow harvested. The basins experiencing the greatest reduction in streamflow over this time also recorded the highest percentage of water harvested. The most impacted were the Avoca, Werribee, Loddon, Moorabool, Campaspe, Wimmera and Goulburn river basins. After significant increases in rainfall and widespread flooding in 2010–11, less than half of the annual streamflow was harvested for all river basins.

These results show the increased pressure placed on aquatic ecosystems during times of low flow when water resources become more scarce. In some river basins, the absence of rainfall means that large percentages of available water are extracted to supply domestic, industrial and agricultural needs. It is clear that too much water is now being taken out of many of Victoria's rivers, wetlands and aquifers.

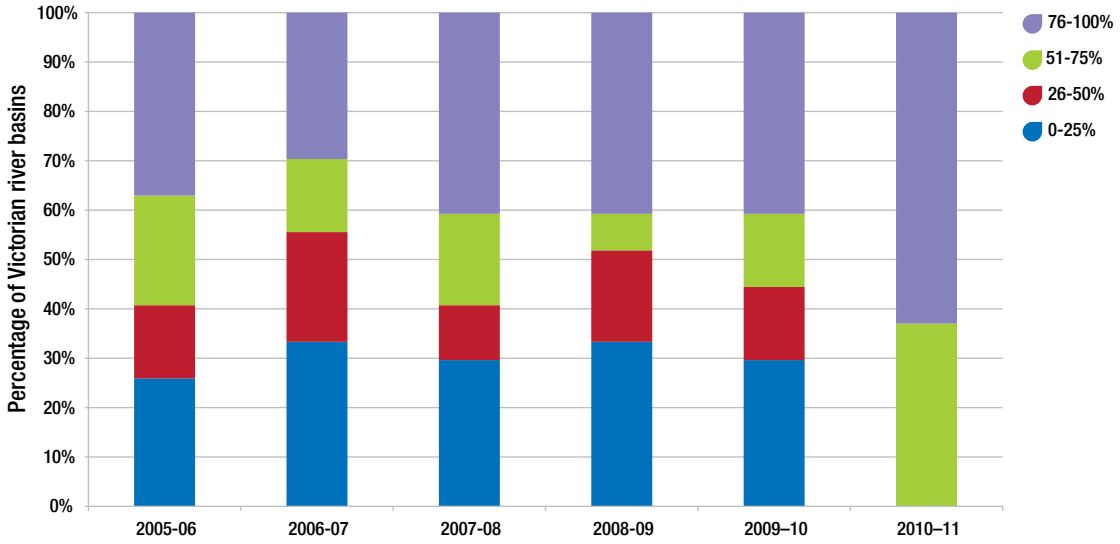


Figure A.3.20: Proportion of streamflows leaving Victorian river basins, 2005–06 to 2010–11

Source: DEPI Water Accounts.

Environmental flows – delivering the Environmental Water Reserve

Environmental flows are vital in regulated river systems, where water storages and extraction alter natural variations in streamflow, including the reduction in the size and frequency of flood events. Environmental flows help to maintain aquatic ecosystem health by improving the quality and connectivity of in-stream habitat, flooding wetlands and floodplain and riparian vegetation, improving water quality and providing conditions required for aquatic fauna life histories (e.g. fish breeding).

The availability of the Victorian Environmental Water Reserve (EWR) and its usage is shown in Figure A.3.21. The EWR available between 2006–07 and 2009–10 was affected by drought conditions, which saw severely decreased river flows across much of Victoria. However, less than 50% of available water was used over this period, with only 22% used in 2006–07. With greater river flows in 2010–11, the EWR available increased five-fold, and almost 70% of the available water was used for environmental purposes.

During times of low river flow, the water allocation system reduces environmental flows more than it reduces water for consumptive uses.[2] This has severe consequences for aquatic systems, which receive lower amounts of water during times of increased need. In many rivers and aquifers the current EWR is inadequate and vulnerable, placing environmental values at risk.

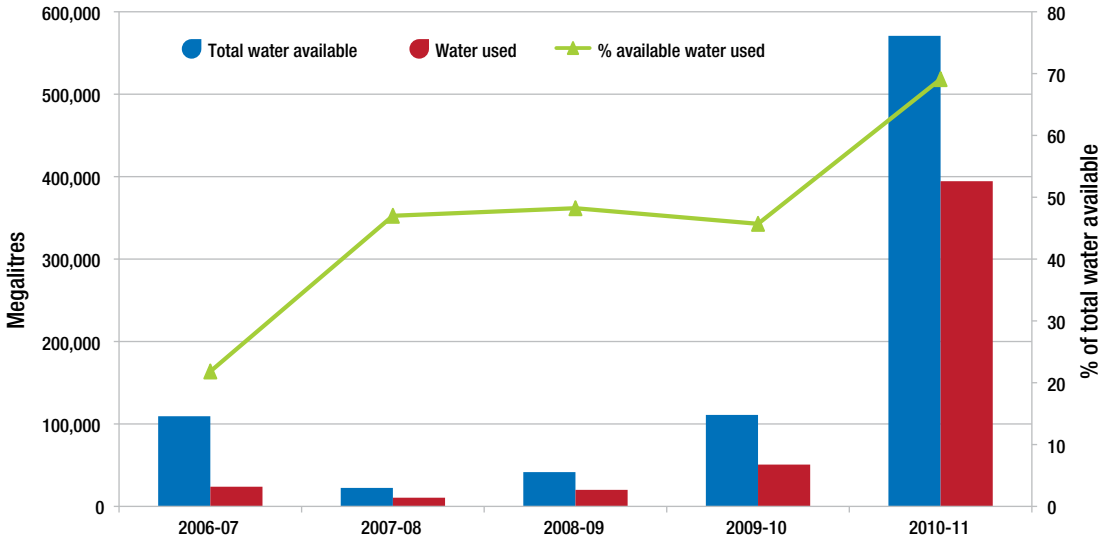


Figure A.3.21: Environmental Water Reserve availability and usage, 2006–07 to 2010–11

Source: DEPI Water Accounts.

Indicator IW4: Water quality

Water quality is fundamental to the ecosystem services that inland waters provide, such as drinking water, cycling of nutrients, maintenance of biodiversity, and recreational and cultural opportunities. Poor water quality has serious implications for the ecological health of inland waters, biodiversity, and human and livestock health.

Inland waters have long been used as drains for the catchment, degrading the ecosystem services provided by high-quality water. As water quality degrades, inland waters can fundamentally change, increasing the cost of water treatment, marginalising agricultural activity and reducing the viability of other economic and recreational activities that support community wellbeing.

Impacts on water quality

Sources of water quality pollutants can be broadly classified as point (directly from industry and treatment plants) or diffuse (runoff from catchments). With significant improvements in the regulation of point-source pollution, diffuse sources are now the major cause of water pollution. For example, urban stormwater is the most significant source of pollution to Melbourne's rivers, creeks and wetlands.

Water quality is influenced by a range of environmental factors, including land use, flow regimes, riparian vegetation and in-stream habitat. Land clearing for agriculture and urbanisation has led to major catchment-wide changes, including increased erosion and salinity and the increased runoff of a range of pollutants. Agricultural use of chemicals and fertilisers has increased concentrations of nitrogen and phosphorus in waterways, as well as concentrations of herbicides and pesticides. In-stream pressures on water quality include stock access to streams, sedimentation, river regulation and extraction of water, and the impact of invasive species such as carp and willow.

Water pollutants

The main water quality issues for Victoria are salinity, turbidity, nitrogen and phosphorus. At a statewide and national level, these variables are considered to be the most significant river contaminants. However, there are numerous other variables that contribute to water quality, such as pH, pesticides, heavy metals and temperature, which may have particular local or regional significance. Water quality is also affected by interactions between these components. For example, salinity and temperature both affect the saturation concentration of dissolved oxygen.

Salinity

Water salinity is a serious issue for many lowland inland waters throughout Victoria. While Victoria has some naturally occurring saline areas, most salinity has been caused by the clearing of native vegetation or by excess irrigation (for information on salinity see Part A: 2 Biodiversity and Land). The occurrence of land salinity slowed during the recent dry period due to lower groundwater tables.[16] However, drought conditions can cause water salinity problems when high evaporation rates concentrate the salt already in surface waters.

Salinisation presents a direct threat to aquatic ecosystems, particularly groundwater-dependent wetlands. While some aquatic species tolerate a range of salt concentrations, changes in salinity can kill a wide range of plants and animals. Human settlements are also affected by salinity because it accelerates corrosion and can damage infrastructure, such as roads and bridges. It also affects soil, plant and livestock health, and can therefore reduce agricultural productivity.

Turbidity and sedimentation

Many inland waters in Victoria are naturally turbid due to high concentrations of suspended sediment. Sediment transport is a natural and important function of inland waters, but excessive quantities of sediment are an ecological threat. Erosion is the main cause of turbidity and sediment problems in Victorian inland waters.

Turbidity reduces light and consequently the ability of aquatic plants to photosynthesise and makes it more difficult for animals to live within the waterway, particularly those that are visual predators. At very high levels, suspended sediment can clog and damage fish gills and the filter-feeding apparatus of animals such as mussels.

Sediment contaminated with heavy metals, nutrients and toxic organic compounds may cause a loss of biodiversity through the direct impact of toxicants or indirectly through cyanobacterial blooms.

Large-scale sediment deposition can bury entire reaches, replace diverse river habitats with uniform sand beds, and create shallow flow areas that are subject to greater temperature extremes and the risk of invasion by aquatic weeds.

Nutrients

Although nitrogen and phosphorus are essential plant nutrients, elevated concentrations can cause excessive plant growth (eutrophication), including toxic algal blooms. Nutrient enrichment affects aquatic communities by changing community composition and dissolved oxygen levels. The major cause of increased nutrient levels is runoff from urban and agricultural catchments, particularly in areas with high fertiliser usage. Point sources of pollution, such as discharges from agriculture, industry and wastewater treatment plants, have also elevated concentrations of phosphorus and nitrogen.

Research undertaken nationally in 2001 showed that phosphorus concentrations in inland waters were three times higher than pre-European estimates, while nitrogen concentrations were estimated to be at least double.[17]

Impact of bushfires on water quality

Rainfall and runoff after bushfires can result in intense short-term increases in turbidity, sediment and nutrients, and decreases in dissolved oxygen in streams and rivers. These issues may then lead to longer-term problems in receiving waters, including impacts on biodiversity such as the loss of fish and macroinvertebrate communities. Fire suppressant chemicals that enter waterways can also cause fish kills and affect nutrient concentrations. Severe fires can result in the loss of riparian vegetation and the shading it provides. This can affect the survival of fauna species through increased water temperatures, reduced dissolved oxygen levels, and the loss of food resources. In addition, nutrient and sediment loads received by storages and estuaries may be significantly higher than normal following bushfires, contributing to long-term water quality problems and increased treatment costs. This has significant implications for water supply to towns depending on river water.

Water quality in Victoria

In 2012–13, water quality monitoring was conducted at some 451 Regional Water Monitoring Partnership sites across Victoria. A range of water quality parameters were either continuously monitored or sampled at regular intervals at these sites. In addition, Melbourne Water collected water quality data from a large number of sites within the greater metropolitan region.

At the time of writing this report, DEPI was unable to provide a statewide assessment of water quality in Victoria. Consequently it is not possible to update information presented in the previous State of the Environment report, nor to determine whether water quality objectives are being met. Main findings from the previous report included:

- Land clearing for agriculture and urbanisation, and contemporary land-use change has led to major catchment-wide changes, including erosion and salinity, which have significantly affected water quality in inland waters.
- Water quality is generally poorer in Victoria's lowlands.
- In 2005, water quality objectives for salinity were met at 68% of sites across Victoria, but objectives for total nitrogen, total phosphorus, and turbidity were met at less than half of the sites monitored.
- Concentrations of total nitrogen and total phosphorus posed a risk to ecosystem health at about 80% of lowland sites in 2005.
- Increasing trends in total nitrogen were detected at over half the sites across Victoria.
- River regulation, along with increased nutrient inputs and low streamflow, are now recognised as a major cause of cyanobacterial blooms in rivers.
- Degradation of important receiving waters such as Port Phillip Bay, Western Port and the Gippsland Lakes is occurring because of poor inland water quality.

Algal blooms

Cyanobacteria (blue–green algae) are naturally present in Victoria's inland waters. Under certain conditions their populations can increase causing a potentially toxic bloom. Low flows caused by river regulation have been identified as a primary cause of cyanobacterial blooms, with the availability of nutrients affecting the size of the bloom.

Some species of cyanobacteria can produce toxins that are dangerous to animals and humans if they are consumed or possibly even touched. This makes waterways unsuitable for agricultural and recreational activities and can result in substantial financial costs for agriculture and recreational and tourism operations. Large blooms in reservoirs can cause major difficulties for drinking water supply, as they block filters and produce tastes and odours that are difficult to treat.

Between 2008–09 and 2010–11, there were 90 cyanobacterial blooms in Victorian inland waters. Because of the high variability in algal bloom number and extent, it is not possible to determine any trends, particularly as blooms are heavily influenced by climate and flow conditions. However, the reported number of cyanobacterial blooms has increased dramatically since 1990, although this has been largely due to improved scrutiny of water bodies.[2]

Indicator IW5: Groundwater Levels and Quality

This indicator assesses the condition of groundwater resources with regard to environmental health. Information on the use of groundwater resources is discussed in Part A: 5 Human Settlements.

Groundwater is underground water, stored in gaps or pore spaces between rocks, sand and gravel. Due to the different depths of aquifers, and varying speed with which the water moves through the ground, some groundwater may not have any interaction with surface waters for thousands of years (e.g. in the Mallee), whereas other groundwater is functionally part of river and wetland ecosystems. Groundwater is often connected to rivers and wetlands, and most rivers derive base flow from groundwater most of the time. This connectivity means that groundwater is important for maintaining the health of rivers, floodplain wetlands and other groundwater-dependent ecosystems.

Impacts on groundwater quality, such as increases in salinity or contamination by pollutants, have serious implications for the ecological health of inland waters and both aquatic and terrestrial biodiversity.

Changes to groundwater levels through climate variability and extraction also impacts on the ecological health of inland waters by reducing river flows and wetland inundation (see Indicator IW3: Condition of Flow Regimes of Major Rivers and Tributaries; and Indicator IW4: Water Quality).

Groundwater is an important resource for agriculture, industry and domestic use. Although useable groundwater resources are small compared to surfaces waters (approximately 10% surface water resources), it is widely used in more than 80 cities and towns in Victoria. Poor groundwater quality limits groundwater use by domestic, agricultural, commercial and industrial users and the productivity of lands reliant on borewater irrigation. It can also have severe implications for human and livestock health.

Groundwater quality

Groundwater salinity is a commonly used measure of groundwater quality although statewide data are patchy in spatial and temporal coverage. Groundwater contaminants such as nitrates, phosphates and toxicants also affect groundwater quality. Victoria has relatively little contaminated groundwater, with groundwater contamination only occurring in isolated instances primarily associated with man-made sources such as manufacturing sites, chemical and petrol storage, and munitions storage.

The salinity of groundwater in Victoria is shown in Figure A.3.22. The most saline groundwater occurs in the state's north-west.[7] Groundwater in this part of the state has typically been in the aquifer for an extended period, providing more opportunity for salts to become concentrated, and less surface water is available for groundwater recharge in this semi-arid area, meaning that salts remain concentrated. In addition, the high level of native vegetation clearing in the state's west has led to shallower water tables, increasing the concentration of salts through evapotranspiration (see Part A: 2 Biodiversity and Land).

The Great Dividing Range of central and eastern Victoria has fresher groundwater. Rainfall is generally higher in these areas, and groundwater flow is often within rock cracks. This leads to the water generally being in the aquifer for shorter periods of time, particularly near the surface, resulting in less opportunity for concentration of salts through evapotranspiration and dissolution of rock material.

There is no statewide information on long-term changes in groundwater salinity, since data are not collated or analysed to demonstrate trends at this level. Similarly, while data on groundwater contamination are collected regularly (generally as part of environmental audits associated with manufacturing, chemical storage, petroleum product storage and other industrial processes), these data are not collated and cannot be easily reported at the statewide level. Consequently, groundwater contamination cannot be reported here.

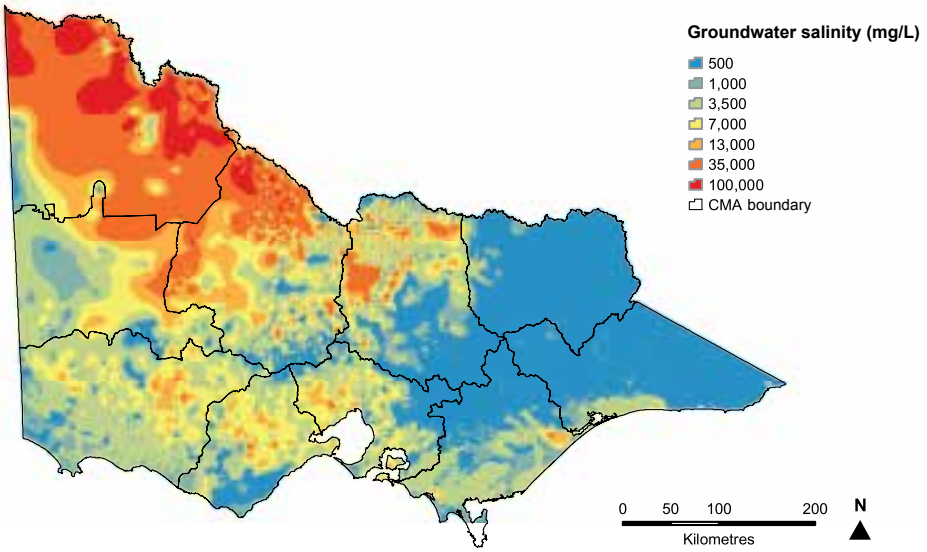


Figure A.3.22: Groundwater salinity in Victoria

Source: DEPI.

Groundwater levels

Trends in groundwater levels reflect differences between what flows into (recharge) and what flows out of (discharge) an aquifer. Groundwater levels, coupled with knowledge of the aquifer, climate, and groundwater extraction can be used as an indicator of the sustainable use of groundwater resources.

As with river flows, groundwater levels are greatly affected by climate trends. The drought conditions between 1996 and 2010 severely reduced groundwater recharge. Subsequent high rainfall during the summer in 2010–11 reversed this trend, particularly in the north of the state (see Part A: 1 Climate Change and Air Quality). In addition, the use of groundwater resources is increased in times of drought when the availability of surface water is greatly reduced, further impacting on groundwater levels. For example, groundwater extracted after the summer 2010–11 rainfall was much lower than during the drought period: about 30% of the long-term average north of the Divide and about 50% south of the Divide.

There remain critical gaps in our understanding of the condition of Victoria's groundwater resources. The legacy of historic groundwater extraction on river flow is an emerging issue. The time lag between the commencement of groundwater extraction and its full impacts being observed in rivers may be decades.[2] An investigation by the Victorian Auditor-General's Office was unable to determine if groundwater use in Victoria is sustainable.[18] Australia still has no agreed method for assessing the sustainable yield of groundwater.

Figure A.3.23 and Figure A.3.24 show groundwater levels in shallow and deep aquifers in Water Supply Protection Areas (WSPAs) and Groundwater Management Areas (GMAs). Deep aquifers are confined aquifers, or aquifers where the water table is generally deeper than 40 metres. Groundwater level trends in shallow aquifers are more likely to reflect changes in recharge, from either rainfall or irrigation, whereas deeper aquifer trends may show a greater influence from pumping. Deeper aquifers are less likely to contribute water to groundwater-dependent ecosystems.

Shallow aquifers

Groundwater levels in the Riverine Plains (Goulburn, Campaspe and Loddon Valleys) declined from the late 1990s to 2010 due to a combination of increased groundwater use and reduced recharge both from surface water irrigation and rainfall.[7] Groundwater declines were also observed in the Upper Loddon GMA, Upper Ovens, Deutgam WSPA, Nepean GMA and Glenelg GMA (Figure A.3.23). However, since 2011 groundwater levels across Victoria have risen in response to rainfall, flooding and irrigation. Elsewhere, groundwater level trends are generally stable.

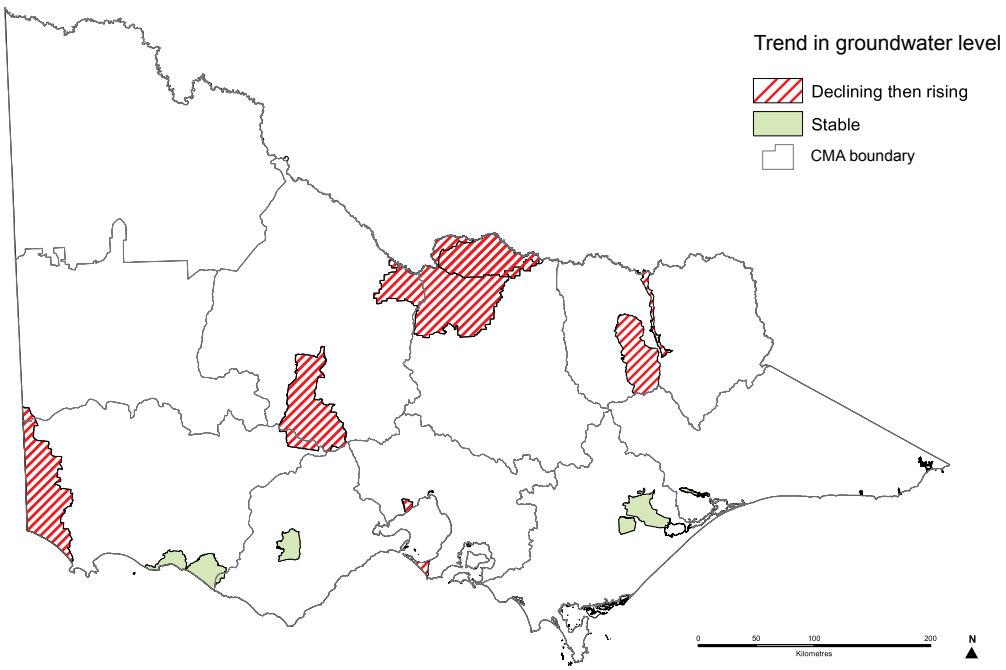


Figure A.3.23: Groundwater level trends in shallow aquifers, 2007–2012

Source: DEPI.

Deep aquifers

Since 2007, long-term declines in deep aquifer levels have continued in Gippsland (Figure A.3.24).[7] This trend is associated with the Latrobe Valley coal mines (dewatering) and offshore oil and gas extraction (Bass Strait). In other areas of the state, restrictions to groundwater use and a return to wetter conditions in 2011, have contributed to the recovery of groundwater levels in deep aquifers with groundwater levels either stable or rising.

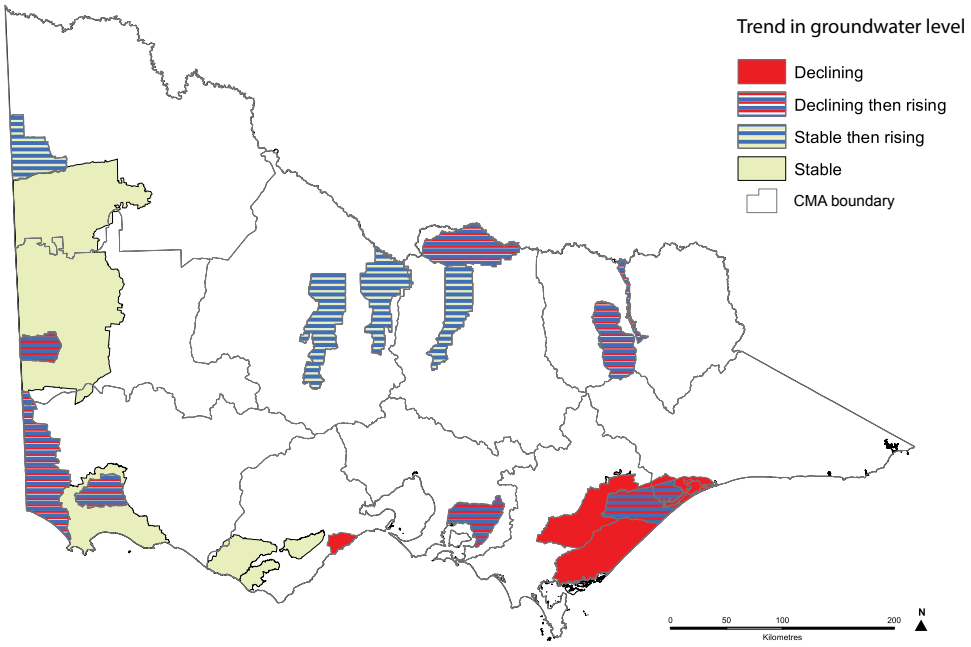


Figure A.3.24: Groundwater level trends in deep aquifers, 2007–2012

Source: DEPI.

Data gaps

Data remains poor for the following:

- Regular statewide assessment of water quality in Victoria, particularly against water quality objectives.
- Long-term changes in groundwater condition, including contamination. This is because data are not collated or analysed to demonstrate trends at the statewide level.
- Very limited data on water quality for wetlands.
- Little information exists on the condition of small streams, anabranch networks and floodplain connections, which comprise 93% of the total stream length in Victoria.
- Improved information is required on freshwater biodiversity, particularly waterbirds, with most survey effort in Victoria devoted to duck species for recreational hunting management.
- Knowledge of aquatic invertebrates remains poor for aquatic ecosystems. Very limited data exists on wetland macroinvertebrate communities.
- Improved information is required on aquatic pests. Although data on alien fish is available, statewide data on pest plants and animals remains poor.

Venus Bay

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CHAPTER **FOUR** MARINE AND COASTAL ENVIRONMENTS

BACKGROUND

Victoria's marine and coastal environment is one of the most diverse in the world.* The southern coast of Australia is one of the most significant south-facing sections of coast in the Southern Hemisphere. Victorian waters lie at the meeting point of the Southern and Pacific Oceans, creating a unique environment that supports over 12,000 species of plants and animals, with 80 per cent occurring nowhere else on earth.[1] Habitats include reefs, kelp forests, deep sponge gardens, sandy plains, seagrass meadows and open water. The Victorian coast contains approximately 120 bays, inlets and estuaries, ranging in area from 1 km^2 to 2,000 km^2.

The marine and coastal environment provides many social and economic benefits for Victorians, including recreation and tourism, commercial fisheries, oil and gas extraction, and through ports and trade activity. The coastal zone is also home to a significant and growing proportion of the Victorian population (see Part A: 5 Human Settlements) and attracts more visitors than any other area of the state, with approximately nine out of 10 Victorians visiting the coast every year.[2]

The coastal environment is the interface between catchments, rivers and the sea. Consequently, the health of coasts and estuaries is strongly influenced by the condition and management of Victoria's land and inland waters.

'Many of the headline findings in the the UN's latest climate report relate to ocean impacts from increased levels of carbon dioxide.'

IPSO Scientific Director and Professor of Conservation Biology at the Department of Zoology, University of Oxford Alex Rogers said:

'The IPCC's findings reflect exactly what we are seeing in the ocean: massive changes in the distribution of marine organisms and marine ecosystems globally. The IPCC's focus on the ocean is long over due and begins to reveal the extraordinary extent to which this critical Earth System is being impacted by climate change. There is no good news and no reason for optimism as our ocean continues to take the brunt of carbon absorption.'

Professor Rogers added,

'The combination of acidification, warming and deoxygenation that we are seeing - the so-called 'deadly trio' is unprecedented in the carbon record. It poses a serious threat not just to the ocean but to the Earth system services it supports and there can be no stronger imperative for action by governments and others to reduce greenhouse gas emissions to the lowest possible levels in the shortest amount of time.

The ocean experts at IPSO stressed that the IPCC report made clear there is not enough data to fully understand the heating effects of climate change in the oceans, and urged much more research is urgently needed to understand what is occurring.'**

* For this report, the marine and coastal environment is classed as the near-shore environment, the seabed and marine waters out to the state limit of 5.5 km. It includes the foreshore and coastal hinterland. Coastal catchments are those that drain directly to the ocean.

** International Program on the State of the Ocean and IUCN, 2013, The State of the Ocean 2013: Perils, Prognoses and proposals - link to the report through www.stateoftheocean.org/pdfs/IPSO-Summary-Oct13-FINAL.pdf <http://www.stateoftheocean.org/pdfs/IPSO-Summary-Oct13-FINAL.pdf

Pressures on Victorian marine and coastal environments

Marine and coastal environments are impacted by a range of pressures, including coastal development, inputs from catchments, invasive species, fishing and maritime activities. These pressures can interact to cause significant impacts on biodiversity and ecosystem health. The main impacts on marine and coastal environments include:

- **Development of coastal areas** – Although 96% of the Victorian coast is on public land and mostly protected in parks and reserves, much of it has been impacted by development for industry, tourism and urbanisation. These development pressures are predicted to increase in the future.

  Extensive coastal modification has resulted in the significant disturbance or loss of coastal ecosystems and biodiversity, including coastal vegetation. Most of Victoria's estuaries, particularly those around the more populated coastal centres, have been degraded and modified to the extent that only a few, in the far east of the state, remain in near-pristine condition.

  The conversion of coastal land to intensive uses also places pressure on coastal water quality.

- **Water quality** – Marine and coastal water quality is impacted by the inflow of pollutants from catchments, particularly during storm events. Pollutants include toxins, pathogens and excess nutrients from agriculture, industry and urban runoff.

  Other impacts on water quality include point-source discharges from municipal sewage treatment plants and industrial facilities, and pollution incidents such as spills from shipping. Reduced water quality not only affects marine and coastal ecosystems but also human use of the marine environment. For example, toxicity, turbidity and the presence of harmful bacteria can prevent recreational and commercial activities – including the harvesting and consumption of marine species.

- **Reduced freshwater flows** – The alteration of natural river flows due to water regulation (See Part A: 3 Inland Waters) can affect marine and coastal biodiversity, particularly estuarine species that need both fresh and salt water habitats for their lifecycle. Reduced freshwater flows to the sea can increase the salinity of bays and estuaries, reduce nutrient and other inputs, and also result in the closure of estuary mouths. These can severely affect ecosystem health and biodiversity.

- **Invasive species** – Introduced species threaten marine and coastal ecosystems by altering the structure and dynamics of ecological communities. In extreme cases, introduced species can displace native species and dramatically modify habitats. Such changes can also threaten Victoria's fisheries by severely reducing the populations of commercial species.

- **Fishing** – Commercial and recreational fishing can place pressure on the populations of marine species (both target and non-target species), particularly where large numbers of fish, crustaceans and molluscs are taken. Although regulated fishing (commercial and recreational) is subject to quotas to ensure the sustainability of fisheries, it can alter the community dynamics and trophic (food chain) relationships of marine and coastal ecosystems, and increase the impacts of other disturbances. Unregulated commercial and recreational fishing has the potential to significantly impact on species populations and ecosystem health.

- **Maritime activities** – Commercial shipping, recreational boating and port activity, increase the risk of pollution and invasion by marine pests. The use of large ships increases the demand for dredging, which can affect marine water quality and ecosystem health.

- **Litter** – The presence of litter and other waste is an ongoing problem in marine environments. Sources of litter are varied and include terrestrial (e.g. food containers, plastic bags, etc.) and maritime sources such as discarded fishing gear (e.g. nets and lines). Fish, seabirds and marine mammals can ingest or become tangled in litter, often resulting in death. Marine debris from fishing and other sources is listed as threatening process under the *Flora and Fauna Guarantee Act 1998*.
- **Recreation activities** – People visit marine environments for a range of reasons, including fishing, boating, swimming, snorkelling, diving and sightseeing. These activities can cause environmental damage such as disturbance to seagrass habitats from boat anchors, excessive or illegal harvesting of intertidal species, and trampling of plants and habitat. The extent of damage caused by many of these activities is largely unknown but could be substantial, particularly in small areas receiving large numbers of visitors.
- **Mineral exploration and extraction** – Oil and gas are currently being extracted off Victoria's coast and the exploration for new reserves is continuing. Activities associated with extraction and exploration of minerals in marine environments can disturb marine habitats and organisms. Oil and gas platforms and drilling operations directly disturb sea floor habitats in areas immediately adjacent to drilling operations. The use of seismic equipment for mineral exploration may interfere with cetaceans. Exploration and extraction of mineral resources in marine environments also increases the risk of spills of drilling fluids and hydrocarbons.

Climate change

Victorian marine waters have been identified as being extremely vulnerable to climate change. Changes to marine systems will not only affect biodiversity and ecosystem health, but also Victoria's fishing industries and coastal infrastructure.

Southern Australia has experienced some of the fastest increases in ocean temperatures globally. Influenced by the strengthening of the East Australian Current, sea surface temperatures have risen 2°C off Australia's south-east coast since 1925 with an ocean warming rate approximately four times the global average (see Part A: 1 Climate Change and Air Quality).[3, 4, 5]

Warmer sea temperatures are likely to have severe consequences for marine ecosystems, including changes to the distribution and breeding patterns of some species. Those species unable to adapt will need to migrate to more suitable habitats. However, Victoria's south-facing coastline presents a physical barrier to migration for many species. Rising sea temperatures also alter ocean currents, raise sea levels, and increase the occurrence of storms.

Other predicted climate change impacts include:

- Increasing oceanic acidification will impact on marine biodiversity, particularly crustaceans and molluscs, and the industries and communities that depend upon them. Acidification is not reversible in human time scales.
- Reductions in river flows (see Part A: 1 Climate Change and Air Quality) and terrestrial runoff will impact inshore ecosystems such as estuaries by increasing salinity, decreasing nutrients and other inputs, and altering estuary openings. This will have consequences for species that rely on inshore habitats for breeding, migrations, spawning habitats, and nursery areas.
- Climate change will compound existing pressures on Victoria's marine and coastal ecosystems.
- Coastal environments will be subject to increased storm surges in the short term and permanent sea-level rise in the longer term, these will have a significant impact on coastal form and coastal vegetation. The increased flooding and inundation of coastal settlements will also damage housing and infrastructure, and put lives at risk.

The impacts of climate change on the marine and coastal environment is discussed in Foundation Paper One, *Climate Change Victoria: The Science, Our People, and Our State of Play*.[6]

MAIN FINDINGS

Marine and coastal health

- Data on the condition of marine and coastal ecosystems is not gathered in a comprehensive manner, making assessment of the condition of coastal and marine systems difficult. A lack of knowledge and understanding of marine systems is a major hindrance to our ability to protect marine biodiversity and to report on its current condition.
- Monitoring by Parks Victoria and scientifically rigorous community monitoring undertaken for the Sea Search and the Reef Life Survey programs, has shown some positive changes in marine and coastal communities as a result of the establishment of marine parks and sanctuaries. However, changes in ecological community structure have also been observed such as a decrease in the key habitat-forming seaweed in Port Phillip Heads Marine National Park, increased presence of pests like the Long-spined Sea Urchin (*Centrostephanus rodgersii*), decline of the Southern Rock Lobster population, and a decline in Broad-leaf Seagrass (*Posidonia australis*). These changes show that marine parks and sanctuaries are subject to a range of pressures and natural variation.
- There remains little data available on the ecological condition of estuaries, although it is evident that most of Victoria's estuaries have been degraded.
- Victoria's bays and inlets are under substantial environmental pressure and so are vulnerable to environmental changes.
- The long-term impacts of the Channel Deepening Project are thought to be minimal. However, ongoing monitoring is required to determine this. Over the dredging period, the effects of climatic influences such as rainfall and temperature variations had much larger and more widespread effects on many environmental indicators than the dredging itself.

Conservation of marine and coastal areas

- Victoria has 13 marine national parks and 11 smaller marine sanctuaries covering some 123,000 hectares. These protected areas cover only 5.3% of Victoria's marine and coastal waters, compared to the protection of 18% of Victoria's land in parks and reserves. The area protected in marine parks has remained unchanged since 2002.
- There are some 75,000 hectares of coastal parks and reserves in Victoria. Coastal areas remain under threat from development, especially urbanisation.

Marine biodiversity

- Six species of marine and coastal vertebrate fauna were listed as critically endangered on the *Advisory List of Threatened Vertebrate Fauna in Victoria, 2013*. A further nine were endangered, 19 vulnerable and 13 near-threatened, and data was found to be deficient for four species. Three-quarters of the total species listed were birds.
- Between 2007 and 2013, six marine and coastal bird species declined in status and two bird species were added to the Advisory List because of decreasing populations. Only one species improved their threatened status over the period.
- Two of Victoria's marine communities, the Port Phillip Bay Entrance Deep Canyon Marine Community and the San Remo Marine Community, are listed as threatened under the *Flora and Fauna Guarantee Act 1988*.
- Assessment of threatened communities and species in marine environments is poor compared to terrestrial environments, particularly for marine flora, invertebrates and fish.
- Knowledge of the conservation status of marine and coastal invertebrates remains poor and the current number of threatened species is likely to be vastly under-reported.
- Marine and coastal ecosystems are under increased threat from invasive species. Some of Victoria's bays and inlets have been heavily invaded by introduced species. Port Phillip Bay is considered to be one of the most invaded marine ecosystems in the Southern Hemisphere. Monitoring of invasive species remains poor and is limited to Victoria's commercial ports and harbours.
- All major Victorian fisheries are considered to be either close to full exploitation or are already fully exploited, particularly those of economic importance, such as the Southern Rock Lobster. Victoria's annual commercial fishing effort has decreased significantly since the 1980s to ensure fisheries resources are harvested sustainably.

Marine and coastal water quality

- Monitoring by EPA Victoria indicates that Victoria generally has good marine and coastal water quality.
- Estuarine and bay systems such as Port Phillip Bay, Western Port and the Gippsland Lakes are subject to reduced water quality. Poor water quality usually occurs after episodic storm events when high pollutant levels are discharged from rivers and drains. Water quality is also reduced during periods when reduced mixing and flushing of water occurs.
- During the Millennium Drought (1996–2010), salinity concentrations in Port Phillip Bay exceeded neighbouring ocean levels in Bass Strait. The high rainfall in 2010–11 returned salinity levels to that recorded during the 1990s.
- A severe storm on 25 December 2011 resulted in a large volume of stormwater entering Port Phillip Bay. The resulting water-quality impacts led to algal blooms, fish deaths and elevated bacteria levels.
- Water quality in the Gippsland Lakes is generally good during dry periods but is often degraded after heavy rainfall leading to algal blooms. Poor water quality clearly reflects the negative influence of catchment inflows on the Gippsland Lakes.
- Between 2007–08 and 2011–12, recreational water quality of Port Phillip Bay was generally good during fine weather, but the number of swim advisories increase after rainfall, particularly at beaches in close proximity to rivers, creeks and stormwater drains that flush out into the bay.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
MC1 Marine and coastal health	Data on the condition of marine and coastal ecosystems is not gathered in a comprehensive manner, making assessment of the condition of coastal and marine systems difficult.		
MC2 Conservation of marine and coastal areas	Victoria's 13 marine national parks and 11 marine sanctuaries protect only 5.3% of Victoria's marine and coastal waters. The area protected in marine parks has remained unchanged since 2002. Coastal land remains threatened by development, especially urbanisation.		
MC3 Marine and coastal biodiversity	Assessment of threatened communities and species in marine environments is poor compared to terrestrial environments. According to the *Advisory List of Threatened Vertebrate Fauna in Victoria* (2013), six species of marine and coastal fauna are critically endangered, nine endangered, 19 vulnerable, 13 near-threatened, and data was deficient for four species. Between 2007 and 2013, six marine and coastal bird species declined in status and two bird species were added to the Advisory List because of decreasing populations. Only one species improved its threatened status over the period. Marine and coastal ecosystems are under increased threat from invasive species.		
MC4 Marine and coastal water quality	Estuarine and bay systems such as Port Phillip Bay, Western Port and the Gippsland Lakes are subject to reduced water quality. Poor water quality usually occurs after episodic storm events when high pollutant levels are discharged from rivers and drains. This has resulted in algal blooms, high turbidity, fish kills and elevated bacteria levels. During the 1996–2009 drought, salinity concentrations in Port Phillip Bay exceeded neighbouring ocean levels in Bass Strait. Water quality is generally good in open waters.		

Indicator Assessment Legend

Status

- Environmental condition is healthy across Victoria, **OR** pressure likely to have negligible impact on environmental condition/human health, **OR** comprehensive protection of natural ecosystems and biodiversity.
- Environmental condition is neither positive or negative and may be variable across Victoria, **OR** pressure likely to have limited impact on environmental condition/human health, **OR** moderate protection of natural ecosystems and biodiversity.
- Environmental condition is under significant stress, **OR** pressure likely to have significant impact on environmental condition/ human health, **OR** inadequate protection of natural ecosystems and biodiversity.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

NA Assessments of status, trends and data quality are not appropriate for the indicator.

INDICATOR ASSESSMENT

Indicator MC1: Marine and Coastal Health

The diversity of marine and coastal habitats and the biodiversity they support is critical for providing a range of ecosystem services. These habitats sustain stocks of fish and invertebrates that form the basis of important commercial and recreational fisheries, including aquaculture. Seagrasses, saltmarsh and mangroves stabilise soft sediments, prevent erosion and provide protection from storm surges.

Marine and coastal species process and recycle nutrients derived from terrestrial sources and also absorb large amounts of carbon, produce oxygen and help to regulate climate. In addition to these essential services, marine and coastal biodiversity creates recreational opportunities and contributes to Victoria's social and cultural amenity.

Strong links exist between many marine and coastal ecosystems, and so localised impacts on marine and coastal health can have wide-ranging implications, particularly for biodiversity. Many species are dependent on a range of different habitats, for example some fish species use estuaries, seagrass and kelp beds as well as open-water habitats; throughout their life cycles. Some species of fish and waterbirds can also depend on freshwater habitats. Consequently, the status of such species can be affected by impacts on any of the habitats they depend on. Furthermore, coastal environments are directly affected by activities in adjacent catchments.

Freshwater inputs into estuaries and bays affect water quality, habitat, and community dynamics of marine and coastal systems.

Condition of marine and coastal ecosystems

Victoria's marine and coastal ecosystems are not comprehensively monitored, making it difficult to evaluate their condition, the dynamics of marine communities, and how they change in response to environmental pressures.

Parks Victoria undertakes monitoring surveys in 11 marine national parks and 11 marine sanctuaries, mainly for subtidal and intertidal habitats.[7] This work collects baseline biological information to understand long-term changes in populations, abundances, community structures and ecological processes. This is complemented by scientifically rigorous community monitoring undertaken for the Sea Search and the Reef Life Survey programs, which partner with Deakin University and the University of Tasmania. These programs are discussed in Foundation Paper One, *Climate Change Victoria: The Science, Our People, and Our State of Play*.[6]

At this stage, results from these monitoring programs cannot be used to assess the status and trends in marine and coastal ecosystem health. However, they have revealed changes to marine and coastal communities, including:

- indications of positive changes in marine and coastal communities, such as increased fish size and abundance, in response to implementation of marine parks
- the decline of a key habitat-forming seaweed in Port Phillip Heads Marine National Park
- presence of pests like the Long-spined Sea Urchin, *Centrostephanus rodgersii*, which has extended its southern range from New South Wales to eastern Tasmania (being a voracious grazer, the urchin has consumed vegetation, such as kelp forests, leaving behind bare rock)
- decline of the Southern Rock Lobster population
- range extension of northern fish species into southern waters
- a decline in Broad-leaf Seagrass (*Posidonia australis*).

Detailed discussion of the general features of Victoria's marine and coastal habitats and a qualitative assessment of condition is provided in the 2008 State of the Environment report.[8] Main findings include the following.

- Victorian subtidal rocky reef communities generally appear to be in good condition, except in the far east of the state where some urchin barrens (areas that have been denuded of seaweed) occur. These may have been caused by over-fishing of top predators that prey on sea urchins, as well as southward movement of species of urchin that are native to NSW, possibly as a result of climate change.
- Victoria's bays and inlets are under substantial environmental pressure, and so are vulnerable to environmental changes.
- Little is known of the dynamics of subtidal reef communities in Victoria. However, the known presence of pressures (water-quality impacts, pest species, etc.) that impact on reef communities globally would indicate the potential for impacts to occur.
- Very few surveyed intertidal reefs are dominated by simplified states.
- In eastern Victoria, there are large areas of urchin barrens (*Centrostephanus rodgersii*) at Cape Howe, Gabo Island and Tullaberga Island. These have significant impacts on habitat and biodiversity.
- Port Phillip Bay is exposed to increased levels of sedimentation and nutrients because of their proximity to the entrance of the Yarra River and other freshwater drainages.
- Intertidal reefs in Port Phillip Bay may be degraded. While these reefs support relatively diverse intertidal assemblages, they tend to show more consistent signs of environmental degradation, including consistently low coverage of brown macroalgae, effects of shellfish harvesting and invasion by introduced species.
- Some reefs in northern Port Phillip Bay have also been invaded by the large brown Japanese kelp *Undaria pinnatifida*. There would appear to be strong potential for *U. pinnatifida* to expand its current range to the southern parts of Port Phillip Bay and to reefs in Western Port.
- Highly localised degradation has occurred from Boags Rocks Eastern Treatment outfall (near Gunnamatta), including substantially changed community structure on the nearby intertidal reef and soft sediment communities.
- Seagrass habitats in Victoria have shown large, shorter-term (5–10 year) fluctuations in area and also show some signs of stability over longer periods of time (over 50 years). Fluctuations in seagrass coverage observed in Victoria are difficult to interpret because changes can be caused by both human activities and natural disturbances.

Estuary condition

Data on the condition of estuaries has not been updated since the 2008 State of the Environment report. 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.[9]

Victoria's most modified estuaries occur around the more populated and developed coastal centres such as Lakes Entrance, Warrnambool and around Laverton and Altona in Melbourne (Laverton Creek and Kororoit Creek). Port Phillip Bay and Western Port, two large, permanently open estuaries, are considered highly modified. The Gippsland Lakes are also considered extensively modified. The west and east coasts are characterised by many small estuaries that can be closed for much of the time.

Smaller estuaries are the dominant estuary types in Victoria and are more prone to the effects of catchment modification such as land-use change and streamflow change.

Victoria's only near-pristine estuaries are located in the far east, where there is minimal modification and development, and where the catchments retain a good cover of native vegetation. Other largely unmodified estuaries occur around South Gippsland, along the Great Ocean Road and along the south-west coast.

Case Study: Channel Deepening Project

Dredging involves the removal of sediment, rocks and other material to maintain or deepen navigable shipping channels. It is undertaken periodically in most ports on the Victorian coast, but mainly in Port Phillip Bay and at the artificial opening of Lakes Entrance in the Gippsland Lakes.

Dredging can have implications for marine ecological processes when it directly disturbs species that live in sediments. Also of concern is the impact that dredging can have on turbidity and the settling of suspended solids onto marine plants and seaweed. These impacts can result in changes in species composition, loss of biodiversity and reductions in commercial and recreational fisheries catches.

Dredging activities adjacent to urbanised or industrialised areas are also likely to mobilise contaminated substances that can degrade water quality and may be toxic to aquatic species.

Other impacts of dredging can include changes in circulation patterns, coastal zone dynamics and coastal morphology from modified coastlines and/or seabeds.

In 2008, a significant dredging program was commenced in Port Phillip Bay to provide access for larger shipping and to meet the predicted demand for increased shipping. Works started in February 2008 and ended in November 2009. Because of the potential for environmental degradation, and community concern, the Office of the Environmental Monitor was established by the Victorian Government to scrutinise the environmental performance of the project.

Monitoring (which continued for the two years after the project's completion) found that there was comprehensive compliance with all environmental approval conditions and that the health of Port Phillip Bay remains consistent with levels seen prior to the dredging work.[10, 11] Specific findings included the following.

- While increased turbidity levels were found during some of the dredging works, the effects of the project were smaller than the changes observed in response to high-rainfall events and associated catchment inputs in 2010 and 2011.
- Water quality, plants and animals, fish stocks and contaminants in fish during and for the two years following project works were within the range of natural variability.
- Some degradation of deep-reef communities were affected by rock fall but are recovering.
- Changes to tidal sea levels, currents and waves inside the bay were consistent with predictions and are minor in terms of natural variability.
- Assessment of phenomena such as fish kills, foreshore flooding and erosion, and spider crab moulting events during and following dredging were found not to be related to the project works.

The long-term impacts of the Channel Deepening Project are thought to be minimal. However, ongoing monitoring is required to confirm this. The effects of climatic influences such as rainfall and temperature variations had much larger and more widespread effects on many environmental indictors than the dredging itself. Impacts caused by dredging operations, although often highly visible, were short-lived, with no ongoing implications for critical processes and features of Port Phillip Bay such as nutrient cycling or seagrass beds.

Indicator MC2: Conservation of Marine and Coastal Areas

Conservation of marine and coastal areas is critical for the protection of ecosystems, biodiversity, and for ensuring the resilience of marine systems into the future. Fishing and other extractive industries are not permitted in marine national parks and sanctuaries.

However, the existence of protected areas alone does not ensure the effective conservation of marine and coastal ecosystems, because these areas can be compromised by a range of external pressures.

For example, sea urchins have been linked to significant damage to protected areas such as Beware Reef on the south-eastern coast. Therefore the management of pressures outside of protected areas is required.

This includes the use of quotas and controls on fishing equipment to ensure the sustainability of fisheries, and the control of invasive species, particularly through the protection and restoration of natural predators.

Coastal waters protected in marine parks

Victoria has 13 marine national parks and 11 smaller marine sanctuaries covering some 123,000 hectares. Currently these protected areas cover only 5.3% of Victoria's coastal waters, compared to the protection of 18% of Victoria's land in parks and reserves. The area protected in marine parks has remained unchanged since 2002.

Of the 81 listed rare and threatened marine fauna species recorded in Victoria (including species listed on the DEPI Advisory List, under the Victorian *Flora and Fauna Guarantee Act 1988*, and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*), 78 (96%) were recorded in Victoria's marine parks network.

In addition to the marine parks described above, six of the 11 Victorian wetlands listed under the international convention on wetlands (the Ramsar Convention), are located on or near the coast – providing habitat for many marine and coastal bird species.

Coastal lands in protected area system

As at 2010, there were some 75,000 hectares of coastal parks and reserves in Victoria. The vast majority of coastal land (96%) is on public land, with one-third reserved as national park, coastal park, marine national park or marine sanctuary under the *National Parks Act 1975*. Despite this, Victoria's coastlines are still under threat from development, particularly urbanisation.

Development modifies the natural coastal environment with significant impacts on both marine and coastal ecosystems. Much of the development of Victoria's coast occurred prior to 1980. However, between 1980 and 2004 a further 41 km of the Victorian coastline was urbanised – an increase of 15%.[12] Many coastal urban areas, particularly those around and within a few hours drive of Melbourne, are experiencing unprecedented levels of development. Victoria has consistently had the second-highest percentage of urbanised coastline after New South Wales.[8]

Indicator MC3: Marine and Coastal Biodiversity

Marine fauna

Victorian marine ecosystems encompass a wide range of physical environments, and support representatives of more taxonomic groups than all Victorian terrestrial and freshwater habitats combined.

The true extent of Victoria's marine biodiversity is largely unknown, but southern Australia is recognised as a diversity hotspot for several taxa, including red and brown algae, lace corals, crustaceans and ascidians (sea squirts).

In addition, Victorian marine environments support diverse fish assemblages and provide critical habitat for marine mammals and seabirds, many of which are endangered.

A lack of knowledge and understanding of marine systems is a major hindrance to our ability to protect marine biodiversity and to report on its current condition. Assessment of threatened communities and species in marine environments is poor compared to terrestrial environments, particularly for marine flora, invertebrates and fish.

There is generally very little known about the population status of marine species or their response to key environmental threats, so lists of threatened species are not always a true reflection of the number or vulnerability of marine species.

It should be noted that many species of fish and waterbirds depend on a range of freshwater, estuarine and marine habitats. The status of such species can be affected by impacts on any of these habitats.

Marine communities and species listed as threatened

The Department of Environment and Primary Industries (DEPI) maintains threatened species Advisory Lists, which document the threat status for various species.[13] Information about the Advisory Lists is provided in Part A: 2 Biodiversity and Land.

As at 2013, six species of marine and coastal vertebrate fauna were critically endangered, nine endangered, 19 vulnerable, 13 near-threatened, and data was found to be deficient for four species (Figure A.4.1).

Some three-quarters of the total listed species were birds (40 species), with eight mammals, three fish, and one reptile – the critically endangered Leathery Turtle (*Dermochelys coriacea*). Other critically endangered species include the Blue Whale (*Balaenoptera musculus*), Southern Right Whale (*Eubalaena australis*), Greater Sand Plover (*Charadrius leschenaultii*), Grey-tailed Tattler (*Heteroscelus brevipes*), and the Lesser Sand Plover (*Charadrius mongolus*).

Between 2007 and 2013, six marine and coastal bird species declined in status and two bird species were added to the Advisory List because of decreasing populations. Only one species improved its threatened status over the period.

The Advisory List for threatened invertebrate fauna contains many marine and coastal species, including sea anemones, jellyfish, shellfish, squids, crustaceans, starfish and sea cucumbers.[14] The number of invertebrate species in Victorian marine and coastal systems is unknown, but it is estimated to greatly exceed the diversity of vertebrate fauna. Consequently, the knowledge of conservation status also remains poor and the current number of threatened species is likely to be vastly under-reported.

In addition, two of Victoria's marine communities are listed as threatened under the *Flora and Fauna Guarantee Act 1988* – these are the Port Phillip Bay Entrance Deep Canyon Marine Community and the San Remo Marine Community.

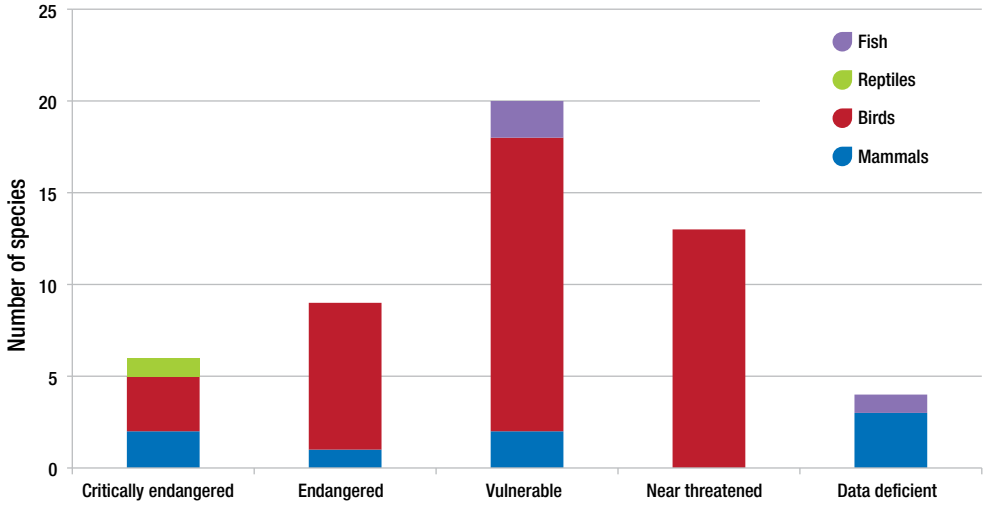


Figure A.4.1: Number of Victorian marine and coastal vertebrate species listed on the *Advisory List of Threatened Vertebrate Fauna in Victoria, 2013*

Number of introduced species in Victorian marine environments

Introduced species are a major threat to the integrity of marine ecosystems in Victoria. While the effects of many introduced species are relatively benign, some invasive species have the potential to drastically alter the structure and dynamics of marine ecological communities.

Impacts of introduced species include displacement of native species, increased competition for resources, altered nutrient cycling, changes to marine food chains, and changes to habitat structure. These changes can significantly impact on fisheries and aquaculture production.

Most introduced species are transported into and within Victorian waters via ships' ballast water or from biofouling (the accumulation of organisms on vessel hulls and internal spaces, maritime equipment and mobile marine infrastructure). Since 2004, Victoria has required vessels travelling from outside Victoria – or between Port Phillip Bay and other Victorian locations – to manage high-risk ballast water to prevent the spread of invasive species. However, Victoria has no controls over hull biofouling, which may be the main cause of the introduction of marine pests to Australia, and has been implicated in the spread of species within Victoria. Invasive species are also entering Victorian waters because of increases in sea temperatures (see Part A: 1 Climate Change and Air Quality). Other species, such as the Northern Pacific seastar (*Asterias amurensis*), may be spreading through the movement of larvae on naturally occurring eastward currents after initial translocation to Victoria via ballast water.

The source of most new incursions within Victoria is likely to be Port Phillip Bay. 'Secondary invasions', particularly those originating in Port Phillip Bay, are increasingly recognised as a significant threat to Victorian marine assets.

Monitoring of introduced species

Surveys for introduced marine pests have been undertaken in Victoria's commercial ports and harbours. Few, if any, formal surveys have been done outside these locations. There have been no formal surveys undertaken in Port Phillip Bay (including Port of Melbourne and Geelong Port) or Western Port (including Port of Hastings) since 2008.

As reported in the 2008 State of the Environment report, some of Victoria's bays and inlets, and particularly Port Phillip Bay, have been heavily invaded by introduced species.

> Port Phillip Bay is considered to be one the most invaded marine ecosystems in the Southern Hemisphere, with 161 introduced species (including 61 cryptogenic, or origin-unknown species) representing up to 13% of all benthic sediment and encrusting species recorded in the bay.[15]

Without further formal surveys in Port Phillip Bay or Western Port it is unclear whether additional undetected invasive species are present.

Although formal surveys have been limited, DEPI maintains a database of detected invasive species. Since 2008, invasive species found in Victorian waters have included the following.

- *Grateloupia turuturu* (a red seaweed) has been detected in Port Phillip Bay.
- Japanese kelp (*Undaria pinnatifida*), which was reported as being confined to the north-eastern side of Port Phillip Bay in 2008, has since spread further throughout the bay and beyond (see below).
- The Northern Pacific seastar (*Asterias amurensis*) was detected in Western Port for the first time in 2011. A small population was detected in the north of the bay near San Remo. That population is believed to have been eradicated, but larvae have since been detected in the waters of Western Port. It is likely that they are transported there naturally from Port Phillip Bay.
- A formal survey was undertaken in Port of Portland in 2011. Previously unrecorded species were detected including the European fanworm (*Sabella spallanzanii*), green seaweeds (*Caulerpa racemosa var cylindracea* and *Codium fragile fragile*), various cryptogenic bryozoans (invertebrates) and red seaweed.

Outside the commercial Victorian ports, a number of invasive species have been detected in local ports and other environments, including the following.

- Japanese kelp (*Undaria pinnatifida*) was detected in Apollo Bay harbour in 2009. It quickly became established in the harbour despite efforts to eradicate it.
- The Northern Pacific seastar (*Asterias amurensis*) and Pacific oyster (*Crassostrea gigas*) have been detected at Tidal River, Wilsons Promontory National Park, possibly due to larvae being transported eastward from established populations.
- There is a high potential for existing introduced species to extend their distribution within Victoria. This is particularly the case for Japanese kelp (*Undaria pinnatifida*) and the Northern Pacific seastar (*Asterias amurensis*).

Impacts of introduced species

While the impacts of few invasive species have been measured in Victoria, species such as the Northern Pacific seastar, Japanese kelp, European shore crab (*Carcinus maenas*) and the European fanworm (all found in Port Phillip Bay), are known to have had significant impacts in other parts of the world.

The extent of ecological impacts of introduced species in Port Phillip Bay is largely unknown. While Port Phillip Bay is considered one of the most invaded habitats in the Southern Hemisphere, most of the recorded introduced species have little demonstrable impact on the already highly modified environment of the bay.

Some introduced species are now influential components of the ecology of Port Phillip Bay. For example, the introduced East Asian bivalve (*Theora lubrica*) and the introduced crab (*Pyromaia tuberculata*) are dominant components in the diet of many bottom-dwelling fish species in the bay.[16]

Given the numbers and wide distribution of introduced species in the Victorian marine environment, their impacts on marine and coastal health are likely to be substantial, particularly on less modified systems.

Impacts of aquatic harvesting

There are several important commercial and recreational fisheries in Victoria. Commercial and recreational fishing can have widespread effects on marine ecosystems.

Fishing can directly remove large numbers of individuals of targeted species from marine environments and has the potential to impact large numbers of unwanted species (by-catch).

Removing biomass from marine habitats can also substantially alter numbers of remaining species, and the removal of adult (reproductive age) fish can lead to a decline in future generations. Regulated fishing at appropriate (sustainable) levels allows species to be harvested without impacting the ability of the species to maintain or increase population size through reproduction. Over-fishing occurs when high levels of fishing pressure reduce the ability of a targeted population to replenish itself, and so its population declines. Unregulated commercial and recreational fishing has the potential to significantly impact on species populations and ecosystem health through over-fishing.

In addition to catching targeted species, a large number of by-catch species (i.e. non-target fish species, marine invertebrates and other species such as birds and marine mammals) can be potentially caught in fishing operations. By-catch is primarily managed through a range of controls such as equipment restrictions and seasonal closures, and is considered a minor issue in most Victorian fisheries. However, by-catch can be a problem for trawl, gillnet and long-line fisheries in Victorian waters, and can sometimes represent up to 40% of the total catch.[17] There is limited information on the ecological impacts of by-catch on marine ecosystems in Victorian marine systems. Furthermore, discarded fishing gear drifts on ocean currents and can continue to catch marine species (ghostfishing). Both seabird by-catch and marine debris from fishing and other sources are listed as threatening processes under the *Flora and Fauna Guarantee Act 1998*.

Some fishing methods such as trawling and scallop dredging can directly disturb benthic habitats because the fishing gear is in direct contact with the seafloor. Deep-reef and soft-sediment habitats are most vulnerable to this impact, which is more likely to be an issue in areas of higher fishing intensity such as in far eastern and western Victoria.

Victoria also produces seafood through aquaculture industries. The potential impact of aquaculture on marine and coastal biodiversity depends on the species, management practices and legislative framework under which each facility must operate. Physical disturbance of the site can occur with the construction and maintenance of infrastructure. Other potential impacts include risk of disease from the farmed species and food supply, introduction of non-endemic species or genetically different individuals to wild populations, and increased nutrient load to water and sediment.

Aquaculture production does not harvest wild populations and is therefore not discussed further here. Information on Victoria's aquaculture production can be found on the DEPI website.

Commercial fisheries

Historically, commercial fishing has resulted in a decline in the stocks of certain key species. Today, quotas and a range of other management controls are currently in place to ensure the sustainability of fishing activities. In general, all major Victorian fisheries are currently considered to be sustainable, but either close to full exploitation or are already fully exploited – particularly those of economic importance such as the Southern Rock Lobster.[18]

This means that further exploitation or an increase in other pressures (e.g. by marine pests) may constitute a threat to the continuity of the fishery. In addition, illegal harvesting of some species is a problem, particularly for high-value species such as abalone and rock lobster.

Between 2002–03 and 2010–11, Victoria's annual total fisheries production ranged between 4,600 and 6,400 tonnes with no trends evident over the period (Figure A.4.2). Victoria's annual commercial fishing effort has decreased significantly since the 1980s resulting in a general decline in fisheries production by approximately two-thirds. This was mainly to ensure that fisheries resources were harvested sustainably, and to enhance recreational fishing opportunities. Habitat degradation in bays, inlets and harbours has also affected fisheries production by reducing populations of commercial and recreational species.

Assessments of the sustainability of commercial fish stocks have been undertaken by the Australian Government.[19] Of the 20 commercially wild-caught stocks assessed across Victoria, 15 were considered sustainable and only one (school shark) was considered to be over-fished. However, five wild-caught stocks did not have enough information to determine stock status.

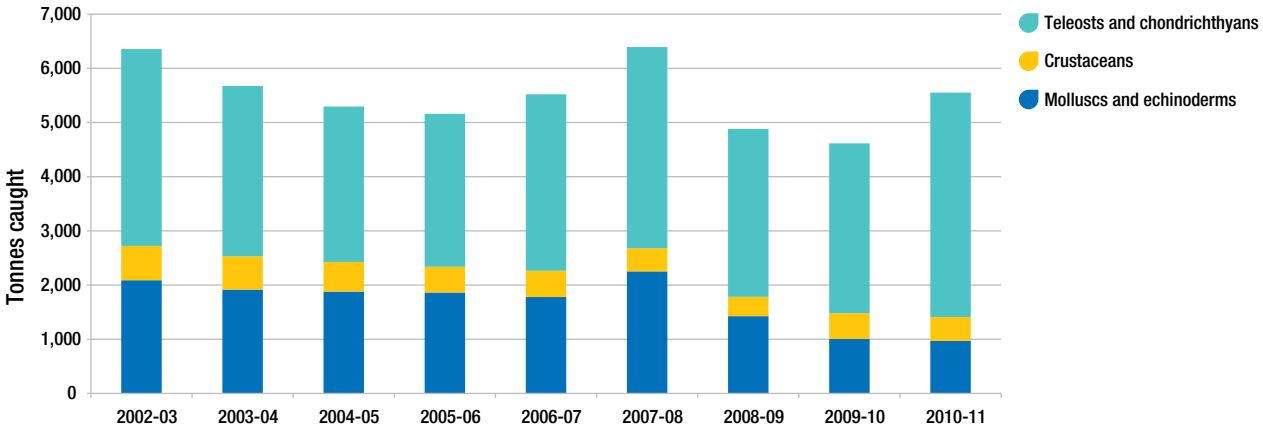


Figure A.4.2: Victorian annual fisheries production, 2002–03 to 2010–11, by type

Source: DEPI.

Indicator MC4: Marine and Coastal Water Quality

Reduced water quality in marine and coastal environments can impact on biodiversity and ecosystem health. It can also negatively affect activities such as swimming, boating, and recreational and commercial fishing.

The quality of Victoria's marine water is strongly dependent upon the activities that occur in the adjacent catchments. A large and growing proportion of Victorians live on or close to the coast. This has implications for estuarine and marine water quality, principally due to urban stormwater runoff and treated effluent discharge.

Port Phillip Bay and Western Port are the two largest and most densely populated areas of Victoria's coastline and are home to many industries. The location of these heavily urbanised centres in close proximity to the marine and estuarine environment means that activities that occur within the catchments can also have implications for the adjacent marine and coastal environment. Other settlements along the Victorian coast are also associated with local water-quality issues, particularly those on the Gippsland Lakes.

Impacts on water quality

Potentially polluting discharges from terrestrial-based urban and industrial systems are classified as 'point' and 'diffuse'.

Point-source discharges are direct discharges into the receiving environment from the pipes of industrial facilities and municipal sewage treatment plants. Point-source discharges usually introduce water from the source into a single location, are close to large population centres, and most are licensed by the EPA.

Diffuse-source pollution is often delivered to the marine environment after storms as water moves across the land. Agricultural and urban stormwater runoff that reaches the marine environment via streams and rivers is the major component of diffuse pollution, and constitutes the greatest proportion of pollution to marine and estuarine systems.

Industrial point-source discharges introduce chemical loads such as nutrients, various metals, petroleum hydrocarbons and other contaminants into the marine waters surrounding the discharge point. Victoria has 29 EPA licensed point-source discharges that enter marine environments, with the majority located within Port Phillip Bay and Western Port.

The licences set enforceable limits for pollutants that must be maintained to achieve environmental protection. Of the 29 point-source discharges, 76% of the total volume of water comes from three sources – a Shell industrial site in Corio Bay, and the two treated effluent discharges from the Western Treatment Plant (Werribee) and the Eastern Treatment Plant (near Gunnamatta).

As a result of these, areas of concern in Victoria's marine and estuarine environments include Long Reef (adjacent to Werribee) and Boags Rocks (near Gunnamatta) on the Mornington Peninsula. The point-source discharges at these two sites contribute greater than 75% of the point-source inputs of nitrogen, phosphorous and suspended solids into Victoria's marine environment. The Eastern Treatment Plant is currently undergoing an upgrade that will reduce nutrient discharges.

The desalinisation plant at Wonthaggi will constitute an additional point source of potentially polluting substances when in use. It is estimated that up to 280 GL per year of hypersaline water will be pumped back into the sea. However, the impact of this discharge on water quality is not expected to extend beyond the mixing zone (100 metres from the outlet).

Nutrients

Elevated nutrient levels can result in algal blooms (eutrophication), fluctuations in dissolved oxygen, loss of sensitive species (e.g. kelp), decreases in dissolved oxygen, and subsequent die-off of susceptible fish and invertebrates.

Some species of phytoplankton may produce toxins in water, with implications for the health of fish, other animals and humans that come into contact with the water.

Anthropogenic nitrogen loads are introduced to the marine environment via point and non-point sources. Two significant point sources of nitrogen into Victoria's waters are the outfalls associated with the Western Treatment Plant in Port Phillip Bay and the Eastern Treatment Plant at Boags Rocks near Gunnamatta Beach on the Mornington Peninsula.

The concentration of chlorophyll-a is commonly used as a measure of eutrophication because it provides an indication of the abundance of phytoplankton in the marine environment. Increases in chlorophyll-a concentrations within a marine environment are usually due to seasonal increase in temperature, increased nutrient levels and decreased flushing of bays, and can be influenced by a reduction in nitrogen cycling (denitrification efficiency).

Suspended solids

Water clarity (turbidity) is affected by the amount of particulate matter in the water column including suspended solids such as clay and silt particles, and planktonic organisms such as algae and zooplankton. In most marine and coastal ecosystems, a small amount of suspended solids in the form of nutrients is essential to the survival of microscopic plants and animals. However, high levels of suspended solids can impact on marine and coastal ecosystems by reducing light levels and making it difficult for marine plants to grow, and by smothering plants and seaweeds that grow on the sea floor. Increases in suspended solids also reduces the aesthetic value of estuaries and beaches, making them less attractive for recreational activities.

Suspended solids in marine waters can increase when there is a large inflow of suspended solids from rivers (for example, during a storm event), during tidal and seasonal variation such as strong winds, and during activities such as dredging. Shallow waters are more susceptible to increased suspended solids because of the ease with which sediments are resuspended in the water.

Salinity

Salinity concentrations in bays and estuaries reflect changes in the volume of freshwater inputs, stratification, evaporative fluxes, water circulation and exchange with adjacent ocean waters. Salinity concentrations in Victoria's bays are mainly the result of the prevailing weather and climatic variables including rainfall, wind, temperature and solar radiation. Changes in salinity have important implications for ecosystem health, as well as the transport and mixing characteristics of marine and coastal systems.

Changes in salinity can influence the distribution, abundance and composition of biological communities, as well as the breeding and hatching success of some fish, squid and prawn species.

Toxic pollutants

There are a number of potentially toxic substances from industrial and urban processes that can affect water quality and the health of animals and humans that use the marine environment. Substances include heavy metals such as copper, arsenic, mercury, lead and cadmium; and organic compounds such as pesticides and polychlorinated biphenyls (PCBs). Some pollutants can accumulate within the tissues of individual animals (bioaccumulation) and/or increase in concentration in higher trophic levels (biomagnification), both of which can lead to chronic poisoning, even if absolute levels of a toxin in the environment are low.

The influx of industrial contamination can be particularly harmful in estuarine environments where flushing is limited, and when historic deposits containing such substances are resuspended during storms or dredging.

In most cases, the presence of industrial toxins in the marine environment is the result of activities that occur, or historically occurred, upstream within catchments. Runoff from intensive uses, such as industrial and urban activities, is responsible for many substances, although in many cases substances move through the air and surface or groundwater before reaching the marine environment. Toxic substances can also enter marine environments as a result of maritime activities such as spills. Anti-fouling paints used to prevent the growth of organisms on ships and the spread of marine pests can also be a source of marine toxicity.

Heavy metal contamination from non-point sources has historically been largely confined to Port Phillip Bay.[8] Monitoring of metals in Port Phillip Bay by the EPA has shown that concentrations are typically low (below the limit of reporting) and peaks in concentrations are below levels known to be toxic to humans and biota.[20] Concentrations of metals in the bay have gradually decreased over the years, although it is likely that the Yarra continues to be a source. This decrease is due to reduced inputs of metals as awareness about their toxicity has increased and industrial processes are improved.

Victoria's marine and coastal water quality

To monitor the condition of waters in Victoria's bays and estuaries, the EPA measures water quality in Port Phillip Bay (11 sites), Western Port (three sites) and in the Gippsland Lakes at Lake Wellington, Lake Victoria, Lake King (two sites) and Shaving Point.

Monitoring by EPA Victoria indicates that Victoria generally has good marine and coastal water quality, although this varies around the state. Water quality is better in the open waters of the continental shelf of Bass Strait, although it is rarely monitored.

Poor water quality in the open ocean is usually the result of sediment plumes from rivers after storm events. Such local effects are usually rapidly dispersed, only briefly affecting recreational and commercial fisheries.

In contrast, Victorian estuarine and bay systems – such as Port Phillip Bay, Western Port and the Gippsland Lakes – are subject to reduced water quality. This is due to the high level of human activity in and around Victorian bays and estuaries and the lower rates of water mixing with open waters. Poor water quality usually occurs after episodic storm events when high pollutant levels are discharged from rivers and drains. Water quality is also reduced during periods when reduced mixing and flushing of water occurs.

Victoria's most sensitive marine systems are monitored monthly by the EPA for a range of water-quality parameters including salinity, nutrients, suspended sediments and chlorophyll-a. The main water-quality observations for Victoria's marine and coastal waters over the reporting period include the following.

Port Phillip Bay and Westernport

- During the 1996–2009 Millennium Drought (see Part A: Climate Change and Air Quality), salinity concentrations in Port Phillip Bay exceeded neighbouring ocean levels in Bass Strait. The high rainfall in 2010–11 greatly increased freshwater inflows, which returned salinity levels to that recorded during the 1990s (Figure A.4.3).
- Nutrient loads from the Yarra and Maribyrnong Rivers and Western Treatment Plant increased in 2010–11 as a result of increased rainfall and associated catchment inputs.
- The increase in nutrient input to the bay resulted in an increase in phytoplankton and corresponding chlorophyll-a levels. There was an increase in the dominance of diatom phytoplankton, with few incidents of potentially harmful phytoplankton species.
- On 25 December 2011, areas of Melbourne experienced a severe storm event, which triggered a large flow of stormwater into the rivers and tributaries of the Melbourne catchment, eventually impacting on Port Phillip Bay. Over 32,000 ML of fresh water flowed into the bay in the six days following the storm, leading to an unprecedented drop in salinity in Hobson's Bay. Resulting water-quality impacts led to the highest ever plankton (a form of algae) levels, algal blooms, associated fish deaths and elevated bacteria levels.

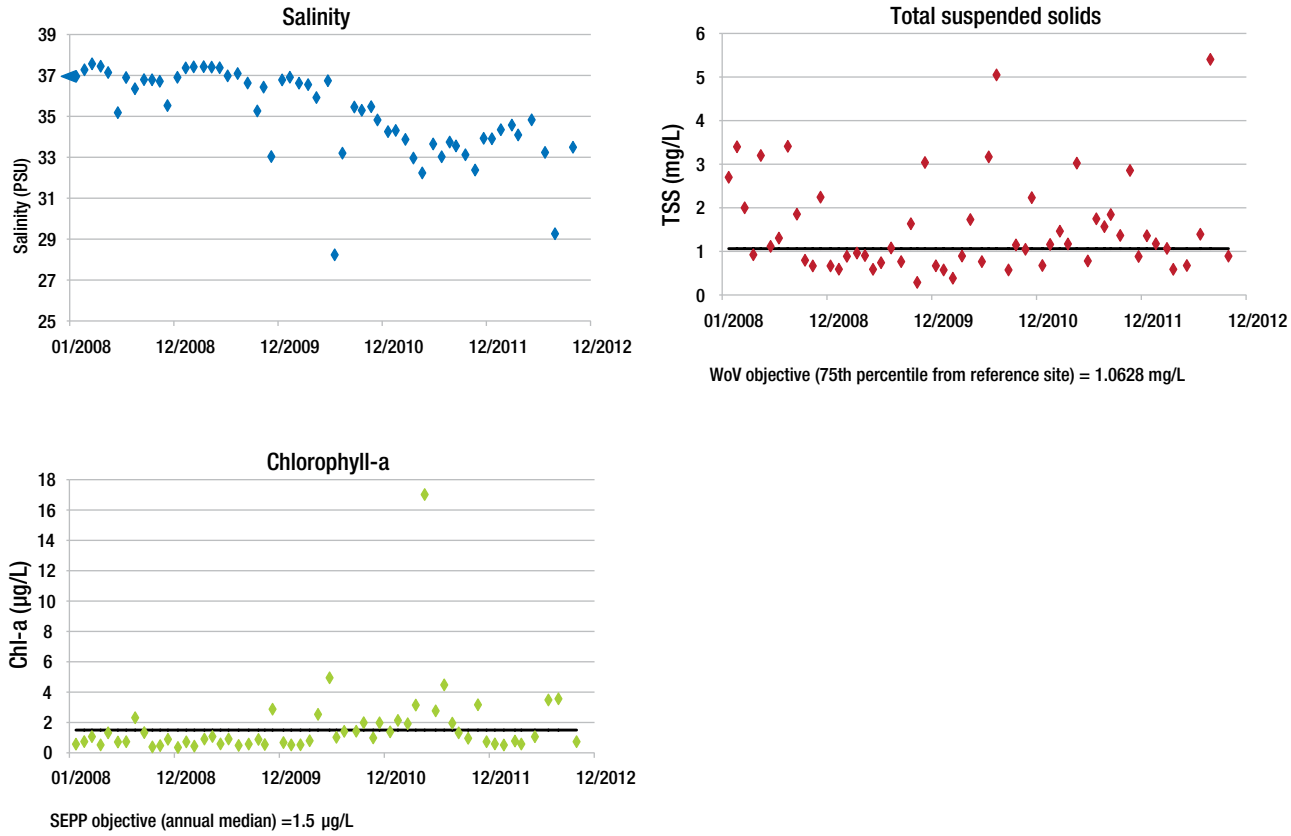


Figure A.4.3: Water-quality results off Patterson River in Port Phillip Bay 2008–2012

Source: EPA.

Western Port

- Water quality experienced in Western Port reflects recovery from drought conditions that had prevailed since 1996. A long-term trend of increasing salinity to 2009 was halted in 2010 by a return of average to above-average rainfall in the catchment.
- Overall water quality in Western Port was generally good with no algal bloom events detected.

Gippsland Lakes

- The water quality experienced in the Gippsland Lakes was generally good during the dry 2009 period but degraded slightly in 2010, and further in 2011 and 2012 when higher rainfall increased pollutant inflows (Figure A.4.4). The worst water quality was experienced at Lake Wellington where chlorophyll-a levels exceeded the annual median objective through the 2008 to 2012 period (Figure A.4.5).
- Pollutant loads increased in response to greater river inflows and resulted in exceedences of water quality objectives at all sites from 2009 to 2012. Poor water quality clearly reflects the negative influence of catchment inflows on the Gippsland Lakes.
- Climatic variation led to major variation in river inflows to the Gippsland Lakes. The total annual inflow was 1012 GL for the 2009 year. This doubled in 2010 and more than tripled in 2011.
- The increased freshwater inflows reduced salinity levels in the lakes. Salinity had increased during the 2008–09 period as a result of drought conditions.

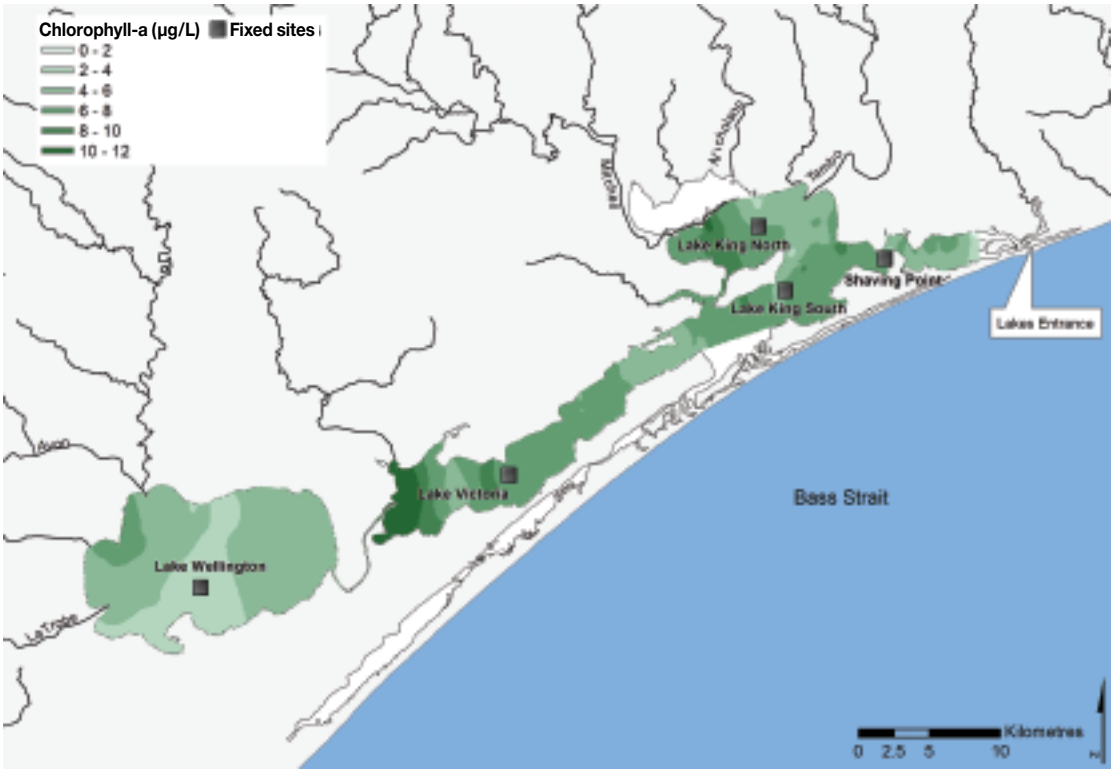


Figure A.4.5: Mapped chlorophyll-a across Gippsland Lakes in February 2012

Source: EPA.

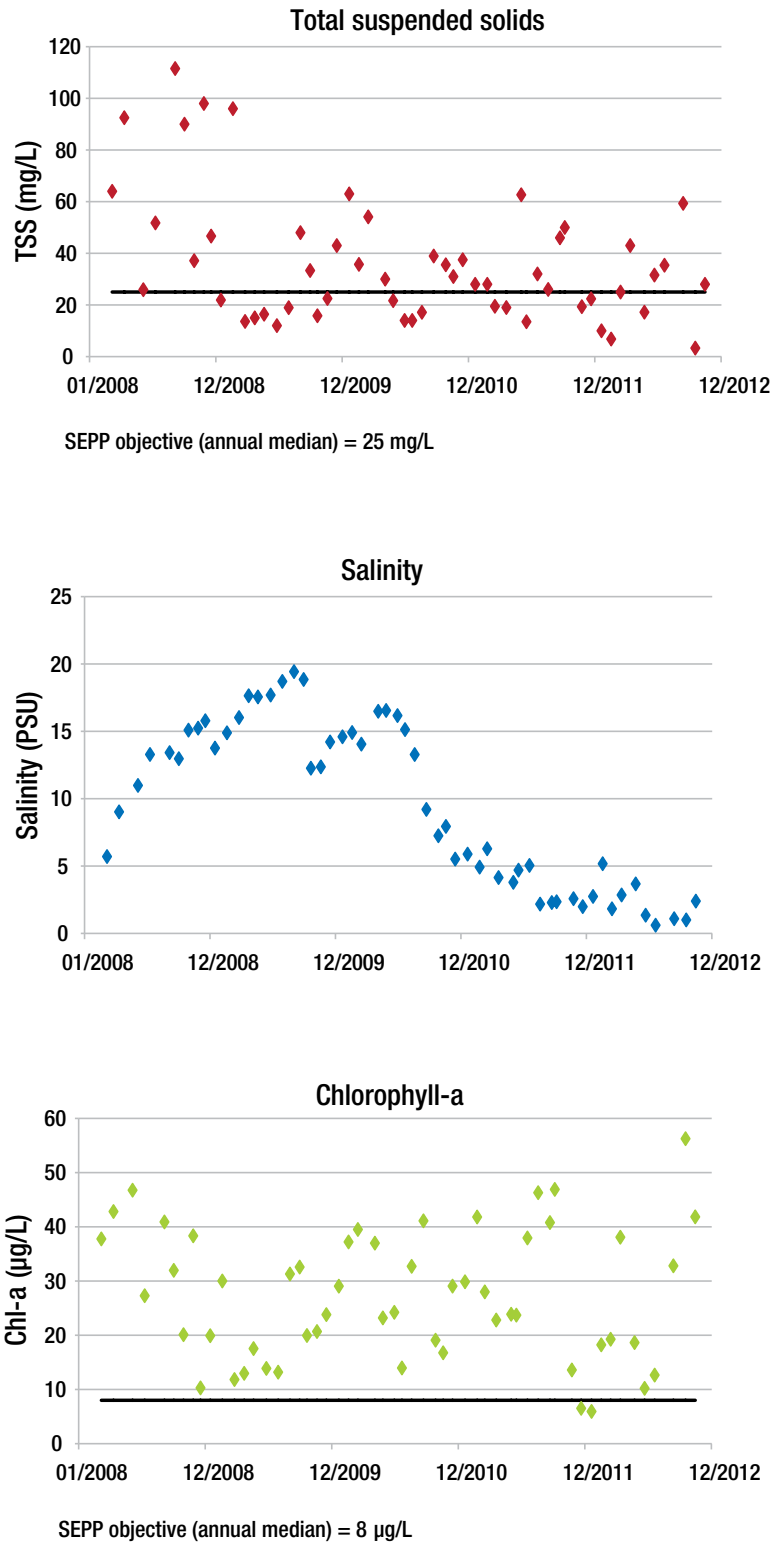


Figure A.4.4: Water-quality results from the Lake Wellington site in Gippsland Lakes 2008–2012

Source: EPA.

Case Study: Keeping an 'eye' on Port Phillip Bay [21]

In 2008, EPA engaged with the national Integrated Marine Observing System to develop and sustain continuous water-quality measurements across Port Phillip Bay. This was done using an automated monitoring system located on board the *Spirit of Tasmania I*.

Daily 80 km transects through the bay provide an ongoing window into the impact and recovery of events and activities such as floods, algal blooms, dredging in the bay, and exchange processes with Bass Strait. The data has been used to inform environmental managers and port authorities, aid fisheries research, integrate with numerical models, and investigate climate change studies.

The data obtained has highlighted Port Phillip Bay as a significantly climate-modified marine system, where reduced coastal discharges and higher evaporation causes elevated salinities higher than the adjoining ocean.

Data also shows algal bloom response to catchment nutrient inputs after storm events (see Figure A.4.6).

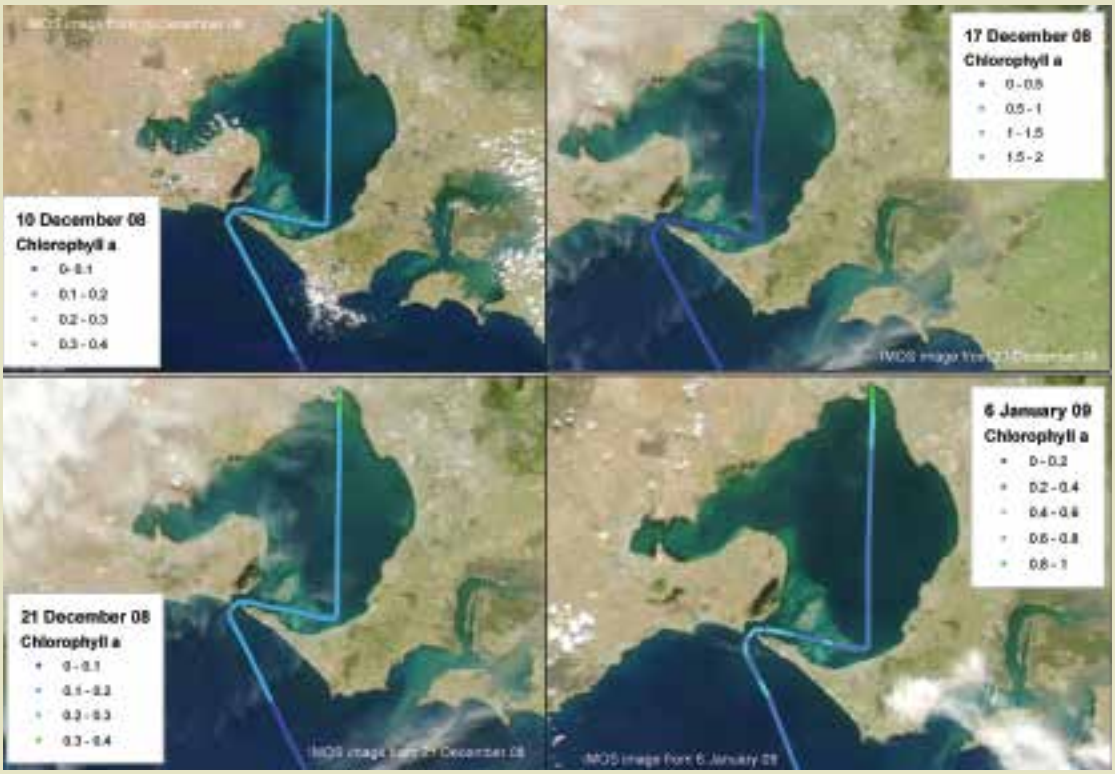


Figure A.4.6: Algal bloom response and recovery from December 2008 storm

Source: EPA.

Beach recreational water quality

Recreational water quality refers to the suitability of water for swimming and other activities that involve direct contact with the water. Recreational water quality is assessed by testing for the presence of *Enterococci* bacteria. This bacteria is commonly found in the gastrointestinal tracts of warm-blooded animals and may be present in marine waters. Animal faeces washed into the sea via rivers and stormwater drains after rain events is thought to be the principal source of *Enterococci*. Poorly managed sewage is also a source. Ingestion of these bacterial pathogens can lead to gastrointestinal illnesses such as diarrhoea.

EPA Victoria monitors the health of 36 beaches in Port Phillip Bay. Elevated levels of *Enterococci* are likely to be due to both point and non-point sources, particularly stormwater drains that discharge water at these sites on Port Phillip Bay. These stormwater inputs contribute to reduced recreational water quality at times of elevated input loadings.

Between 2007–08 and 2011–12, recreational water quality was generally good during fine weather (Figure A.4.7). However, stormwater runoff and river flows after rain resulted in an increase in the number of swim advisories (water quality deemed unsuitable for swimming) in 2010–11 and 2011–12 (Figure A.4.8). Elevated bacterial levels were usually short-lived, with bacterial levels returning to low levels within 24–48 hours after rain.

The increases in rainfall across the Port Phillip Bay catchment from 2010–11 have impacted on short-term water quality, particularly at beaches in close proximity to rivers, creeks and stormwater drains that flush out into the bay.

Of particular note was the Sunday 25 December 2011 storms, when large areas of Melbourne experienced a severe storm event. This triggered a large flow of stormwater into the rivers and tributaries of the Melbourne catchment, impacting on Port Phillip Bay. Beaches closer to the mouth of the Yarra had elevated bacterial levels after the Christmas Day storm. For Sandridge beach, the closest beach to the Yarra, a swim advisory was issued due to bacterial levels remaining high for up to 72 hours following the storm.

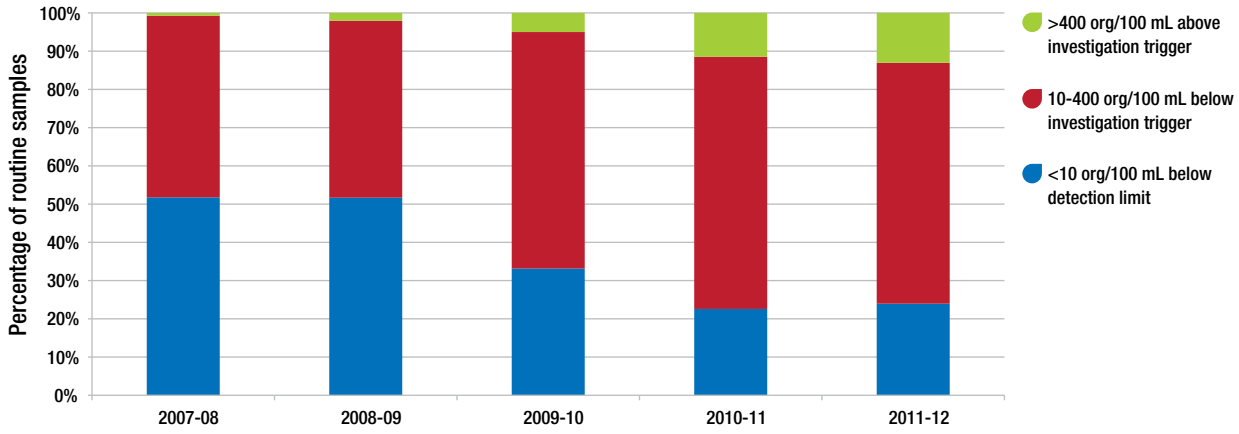


Figure A.4.7: Summary of routine *Enterococci* sampling results for Port Phillip Bay, 2007–08 to 2011–12

Source EPA.

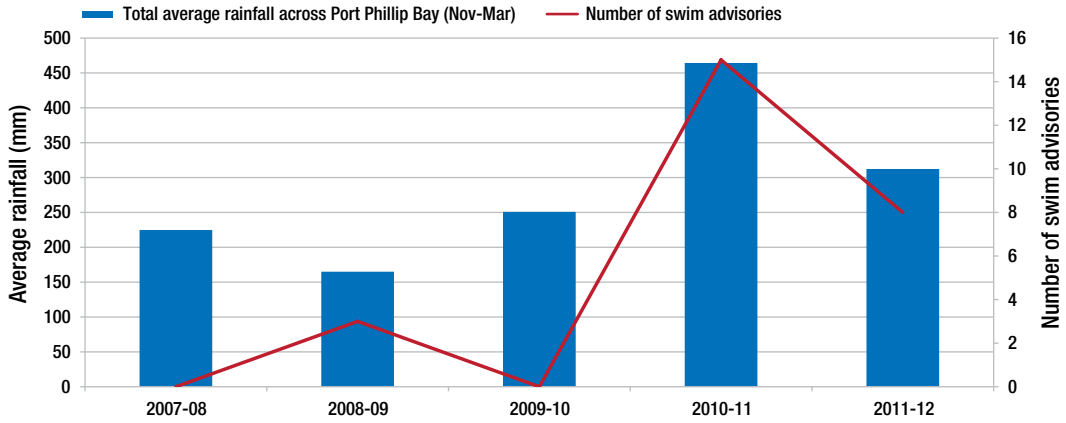


Figure A.4.8: The number of swim advisories compared to rainfall, Port Phillip Bay, 2007–08 to 2011–12

Source EPA.

The EPA no longer monitors recreational water quality outside of Port Phillip Bay. Previous data suggest that recreational water quality in Western Port is generally better than in Port Phillip Bay and this is likely to be because of the smaller population and lower density of impervious surfaces in this catchment.[8]

For beaches along the western coastline of Victoria, recreational water quality has been found to be very good, with the exception of some estuarine sites such as Wye River and Kennett River. Elevated bacterial levels in these estuaries appeared to be associated with localised stressors on river catchments partly as a result of the increased population, pressures on the townships' septic and sewerage infrastructure, and stormwater drainage.

Maritime activities and pollution incidents

Victorian marine waters are subject to pressures from a number of maritime industrial activities, including shipping, fishing, and oil and gas extraction, as well as recreational boating. Maritime activities have the potential to cause pollution in the coastal and marine environment through oil spills (including from recreational craft) and the discharge of ballast water. Maritime activity, particularly in terms of the size of ships calling into Victorian ports, has increased since 2002 and is projected to increase further. Dredging is undertaken periodically in most ports on the Victorian coast to maintain shipping channels. Dredging can have implications for marine processes, water quality and marine biodiversity (see Indicator MC1: Marine and Coastal Health).

A marine pollution incident is defined as any event that results in a chemical, oil or oily mixture, sewage or garbage entering the marine environment. Most of these occur in or around ports, but some are also of terrestrial origin. Maritime pollution spills can result in heavy metals and other toxic substances and chemicals entering the marine environment. These can have drastic impacts on freshwater and marine ecosystems. The effects may vary in severity from reducing growth and reproduction to directly killing plants and animals. The results can be particularly destructive in coastal wetlands and bays where flushing is limited.

Most incidents reported in Victoria are for small spills, less than 20 litres.

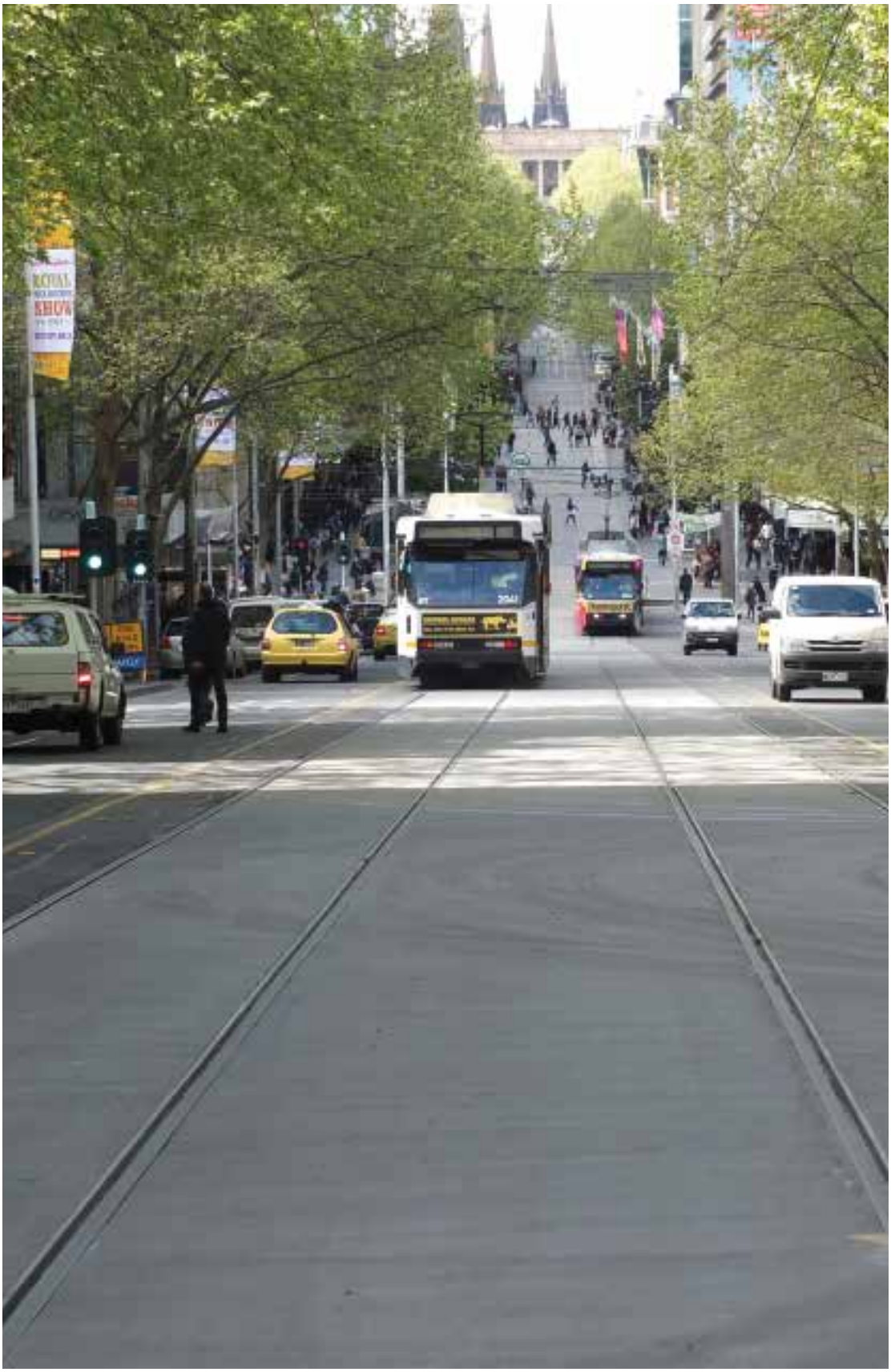
The greatest number of marine pollution incidents reported each year is in Port Phillip Bay.[8] This is probably due to the higher level of activity associated with the bay and the greater potential for sighting and reporting incidents due to the larger number of people using the area. Gippsland has the next highest number of reported incidents.

Data gaps

There is a lack of suitable data to adequately measure the condition and trends of Victoria's marine and coastal environments and the key resources they support. Despite the value of the marine and coastal environment, our knowledge and understanding – especially in regard to marine environments – is less developed than for terrestrial areas.

Marine and coastal data gaps include the following.

- Data on the condition of coastal land and marine and coastal ecosystems is not gathered in a comprehensive manner, making assessment of the condition of coastal and marine systems difficult.
- Assessment of threatened communities and species in marine environments is poor compared to terrestrial environments, particularly for marine flora, invertebrates and fish. There is generally very little known about the population status of marine species or their response to key environmental threats.
- Knowledge of the conservation status of marine and coastal invertebrates remains poor and the current number of threatened species is likely to be under-reported.
- Information about the condition of marine plants and animals is predominantly gathered in the context of maritime industries that depend on them, or in response to activities with likely impacts such as dredging.
- A lack of knowledge and understanding of marine systems is a major hindrance to protection of marine biodiversity and reporting on its current condition. For example, the large natural, spatial and temporal variability in marine and coastal ecosystems and species limits the ability to detect changes in response to known environmental threats (e.g. for seagrass and intertidal reef communities).
- While research has been conducted within Port Phillip Bay and Western Port in the last 30 years, it has only been in the past decade that larger-scale and (in some cases) longer-term monitoring programs have been established for marine and coastal systems (e.g. by Parks Victoria). Data from these programs are providing essential information about marine biodiversity in Victoria, and will become more valuable over time.
- Many studies of marine systems in Victoria are limited in spatial and temporal coverage, have collected different types of data for different requirements, and provide little information about the dynamics of marine communities and how these communities change in response to environmental pressures.
- Water quality monitoring outside the main estuaries is uncoordinated and disparate.
- Surveys for introduced marine pests are not done on a regular basis and are mainly limited to commercial ports and harbours. Few, if any, formal surveys have been done outside these locations.



Bourke Street, spring time

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CHAPTER FIVE HUMAN SETTLEMENTS

BACKGROUND

This chapter examines some of the key environmental pressures resulting from the everyday lives of Victorians. Population growth, the use of energy and water, and consumption and waste, are the overarching drivers of environmental degradation.

Energy use (including transport energy) is the major source of Victoria's greenhouse gas emissions, and is responsible for a range of pollutants that affect air quality (see Part A: 1 Climate Change and Air Quality). Water use is also a key issue for Victoria, with cycles of drought and significantly reduced river flows a threat to water resources and aquatic health (see Part A: 3 Inland Waters).

Waste generation reflects the level of consumption of material resources and manufactured goods. Increased consumption places pressure on the natural environment through the demand for resources (including water) and energy needed to produce and transport goods.

As consumption increases, so does the amount of waste generated, placing greater pressure on waste management systems, All of these pressures are exacerbated by a growing population, which increases demand for energy and resources, as well as land for development.

When the goods are manufactured outside of Victoria, consumption choices can also put pressure on interstate and international ecosystems and resources.

Current patterns of resource use in Victoria are unsustainable, placing enormous stress on natural ecosystems. In 2008, Victoria's annual ecological footprint was three times larger than the world average and one and a half times the land area of Victoria.[1] Energy generation and consumption was the single biggest impact on the state's ecological footprint.

It is clear that Victorians need to reduce their ecological footprint. If everyone lived like us, almost four planets would be needed to sustain the current global population.

Climate change

Climate change will have significant consequences for water resources and energy use in Victoria.

Reduced rainfall and increased evapotranspiration are likely to increase the frequency and severity of drought, and permanently reduce the availability of water resources. Under climate change, streamflow is projected to decrease by up to 50% across much of Victoria by 2070 (see Part A: 1 Climate Change and Air Quality).[2] This will result in less water in storages and groundwater resources, putting pressure on water supply for cities and towns, industry and agriculture. Reduced water resources will have important consequences for the supply and use of water in the future.

A warmer climate will lead to rising temperatures in Victoria with hotter summers and the increased occurrence of heatwaves. This will result in increased energy use for cooling during such periods. Consequently, hotter periods will place energy infrastructure under enormous strain, possibly leading to power cuts, which have already occurred in Victoria during the 2009 heatwaves. Increased energy use will also lead to more greenhouse gas emissions given Victoria's use of brown coal as its main fuel for electricity generation.

The impacts of climate change on Victoria is discussed in detail in Foundation Paper One, *Climate Change Victoria: The Science, Our People, and Our State of Play*.[3]

MAIN FINDINGS

Victoria's population

- In 2011, the population of Victoria was 5.53 million people, with the Greater Melbourne area accounting for 75% of the total population.
- Between 2001 and 2011, Victoria's population increased by 15%, or 730,000 people. The population of Greater Melbourne increased by 18%, or nearly 650,000 people, accounting for 89% of the total population growth in Victoria.
- For regional Victoria, the population grew by 83,000 people, an increase of only 6% between 2001 and 2011.
- Regional Victoria's share of the state's population decreased from 27% to 25% over the period, reflecting the relatively high growth in Greater Melbourne.
- Most of the population growth in Greater Melbourne and the regional centres occurred in the outer suburbs, generally as a result of greenfield or peri-urban development activity. Coastal towns also recorded strong population growth rates, particularly in areas close to Melbourne.
- Development in peri-urban and coastal regions is resulting in the loss of natural habitat and biodiversity, as well as agricultural land. Coastal development is a major pressure on coastal and marine ecosystems.
- Victoria's population is projected to increase to around 8.3 million by 2051 (2.7 million more people than in 2011).

Energy use

- Victoria's electricity consumption more than doubled between 1980–81 and 2010–11, although population grew by only 40% over the same period.
- Electricity consumption per capita increased by 45% since 1980–81.
- Victoria's electricity generation continues to be dominated by non-renewable sources, which accounted for 94.5% of the total electricity generated in 2010–11. Brown coal produced 97% of the electricity generated from non-renewable sources.
- Only 5.5% of Victoria's electricity was generated from renewable sources. Wind and hydro accounted for the majority of renewable sources (48% and 37% respectively).
- Victoria's net energy consumption nearly doubled between 1973–74 and 2010–11.
- Victoria's final energy consumption is dominated by petroleum products which accounted for 46% of the energy use in 2010–11.
- Between 1973–74 and 2010–11, the consumption of petroleum products only increased by 17%, whereas electricity consumption nearly trebled.

Water resources and consumption

- The drought conditions between 1996 and 2010 severely reduced Victoria's water resources across many catchments, particularly in central and western Victoria.
- In 2010–11, record-breaking rainfall and flooding greatly increased surface water, groundwater and water storage resources across much of the state.
- In 2006–07, total surface water resources were only 7,000 gigalitres (GL) – only 26% of the long-term average. In contrast, the high rainfall in 2010–11 resulted in surface water resources 175% greater than the long-term average.
- Melbourne's water storage levels declined to a record low of only 26% of the total storage capacity in 2009. For the major regional water storages, drought conditions led to levels of just 15% of the total storage capacity in 2009.
- Wastewater recycling has remained stable at around 25% (approximately 95,000 ML) of the total wastewater produced.
- The loss of harvested water is a significant problem in Victoria. In 2010–11, 17% of total water supply was lost during water distribution, the second-highest level in Australia.
- The percentage of the available surface water extracted was nearly 50% in 2006–07 compared to only 6% in post-drought 2010–11. In times of low water availability, large proportions of total flows are extracted for water supply, placing enormous pressure on river systems.
- About three-quarters of surface water harvested in Victoria is typically used for irrigation. The urban and commercial sector accounts for between 20% and 28% of water usage.
- The percentage of the available groundwater extracted ranged from 50% in 2006–07 to 22% in post-drought 2010–11. Irrigation, commercial and salinity control uses account for most of the groundwater consumption in Victoria. While groundwater supply is important for many regions of Victoria, it only accounted for 7% to 13% of the total water used.
- Melbourne accounts for about 10% of the total water harvested for consumption in Victoria.
- The power generation sector is a significant water user, accounting for 16% of total urban and commercial metered water use – nearly a third of Melbourne's total water use.
- Victoria's per capita water use was 192 L/person/day in 2010–11. Melbourne's per capita consumption has continued to decrease from 253 L/person/day in 1996–97 to 147 L/person/day in 2010–11, a reduction of 42%.

Trends in solid waste generation and management

- Between 2002–03 and 2010–11, Victoria's per capita waste generation increased from 1.7 tonnes per year to 2.1 tonnes per year, an increase of 23% over the period.
- Waste generation increased from 8.6 million tonnes in 2002–03 to 12 million tonnes in 2010–11, an increase of nearly 40%.
- Recycling increased from 4.4 million tonnes to 8 million tonnes between 2002–03 and 2010–11, raising the annual recycling rate from 51% to 68%.
- In 2010–11, the majority of waste produced in Victoria was from the construction and demolition sector, which accounted for 41% of the total waste produced.
- Recycling rates improved for all sectors. The biggest rise was for the construction and demolition sector, which increased from 54% in 2002–03 to 83% in 2010–11.
- Despite the improvement in the overall recycling rate, the increase in waste generation means that Victoria is becoming more waste-intensive.

INDICATOR ASSESSMENT

Indicator Summary

Indicator	Summary	Status and trends (Good | Fair | Poor | Unknown)	Data quality
HS1 Victoria's population	Victoria's population is rapidly growing, with most of the increase in Greater Melbourne. Population growth is increasing pressure on Victoria's environment and natural resources, especially in terms of land-use change.	NA	
HS2 Energy use	Victoria total and per capita energy use continues to increase. Victoria's electricity generation continues to be dominated by non-renewable sources, with only 5.5% of Victoria's electricity generated from renewable sources.		
HS3 Water resources and consumption	Victoria's water resources fell to record lows during the 1996 to 2010 drought period. While per capita water consumption is improving, the level of overall demand and use of water resources continues to impact on the environment. Inefficiencies in the distribution system continue to result in high water loss.		
HS4 Trends in solid waste generation and management	Waste generation: Victoria's total and per capita waste generation is increasing.		
	Waste management: Victorians are recycling more, with the annual recycling rate increasing from 51% to 68% between 2002–03 and 2010–11.		

Indicator Assessment Legend

Status

- Pressure likely to have negligible impact on environmental condition.
- Pressure likely to have limited impact on environmental condition.
- Pressure likely to have significant impact on environmental condition.
- Data is insufficient to make an assessment of status and trends.

Data Quality

- Good — Adequate high-quality evidence and high level of consensus
- Fair — Limited evidence or limited consensus
- Poor — Evidence and consensus too low to make an assessment

Trends

NA Assessments of status, trends and data quality are not appropriate for the indicator.

Indicator HS1: Victoria's Population

The Millennium Ecosystem Assessment reports that over the past 50 years humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history – largely to meet the needs of a rapidly growing population. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth and the degradation of many ecosystem services.[4]

Population growth increases the demand for land, energy, water and other resources, food, housing and other infrastructure, transport, and a range of goods and services. Growing populations can lead to direct environmental impacts through:

- changes in land use from conservation and agriculture to built environments resulting in the loss of vegetation and biodiversity, increases in introduced species and impacts on water quality.
- increased harvesting and diversion of water resources, altering river flows and impacting on ecosystem health – greater demand for water is particularly problematic during periods of drought and is likely to be a significant issue in the future with the predicted decrease in rainfall as a result of climate change.
- increased air pollution, including greenhouse gas emissions.
- increased disposal of solid wastes and discharge of human and industrial wastes to water bodies.

Population trends in Victoria

In 2011, the population of Victoria was 5.53 million people, with the Greater Melbourne area accounting for 75% of the total population (Figure A.5.1). Between 2001 and 2011, Victoria's population increased by 15%, or 730,000 people.[5]

This was mostly due to the population growth in Greater Melbourne, which increased by 18% (or nearly 650,000 people) over the period. Greater Melbourne accounted for 89% of the total population growth in Victoria. Victoria's population growth was the second-largest in Australia, after Queensland. Melbourne's growth is faster than that of the average of Australia's capital cities.

For regional Victoria, the population grew by 83,000 people, an increase of only 6% between 2001 and 2011.[5] Regional Victoria's share of the state's population decreased from 27% to 25% over the period, reflecting the relatively high growth in Greater Melbourne. The highest regional growth was in Geelong, with a 13% increase in population between 2001 and 2011. Other large increases occurred in Bendigo, where the population grew by 9.5% and Ballarat by 9%. These increases were higher than the overall growth for regional Victoria.

The population of some 40% of regional Victoria's Statistical Area Level 2 divisions (officially gazetted state suburbs and localities) declined between 2001 and 2011, with around half of these declining by more than 5% (Figure A.5.2). Eight of the 10 fastest declining divisions were in the state's north-west.

Peri-urban and coastal development

Most of the population growth in Greater Melbourne and the regional centres occurred in the outer suburbs, generally as a result of greenfield, or peri-urban development activity (Figure A.5.2).[5]

Coastal towns recorded strong population growth rates, particularly in areas close to Melbourne (e.g. Bass Coast, Cardinia, Casey, Surf Coast and Wyndham). Much of this is related to the growth of Melbourne and Geelong and the subsequent expansion of the commuter belt, as well as lifestyle factors, such as demand for more space and larger homes, the rising cost of city living and retirement migration.

Development in peri-urban and coastal regions is resulting in the loss of natural habitat and biodiversity, as well as agricultural land. Coastal development is a major pressure on coastal and marine ecosystems (see Part A: 4 Marine and Coastal, Indicator MC2: Conservation of Marine and Coastal Areas).

In the Urban Melbourne reporting area of the Port Phillip and Westernport Catchment Management Authority, only 5% of original vegetation remains.[6] This is a significant concern in Wyndham and Melton, where urbanisation is driving a reduction in the extent of native grasslands on Victoria's volcanic plains – the most cleared vegetation classes and one of the most cleared regions in the state (see Part A: 2 Biodiversity and Land).

Urban expansion has also driven increased demand for transport infrastructure, such as freeways, ring-roads, and public transport. In addition, climate change is becoming a consideration in planning decisions on the coast, with some areas predicted to be subject to inundation more frequently.[3]

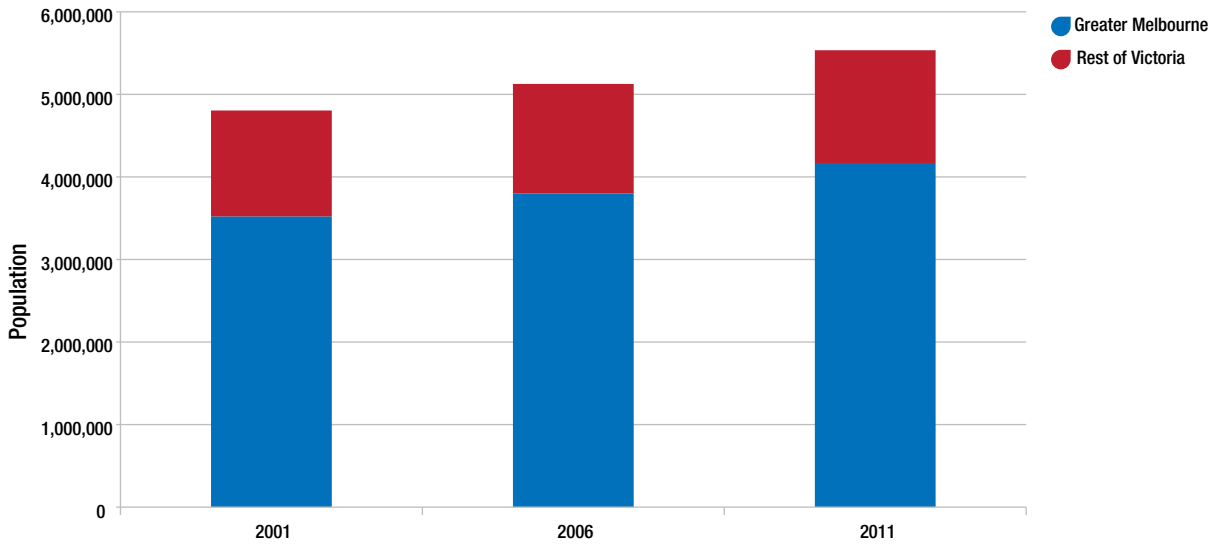


Figure A.5.1: Victoria's population growth, 2001 to 2011

Source: ABS

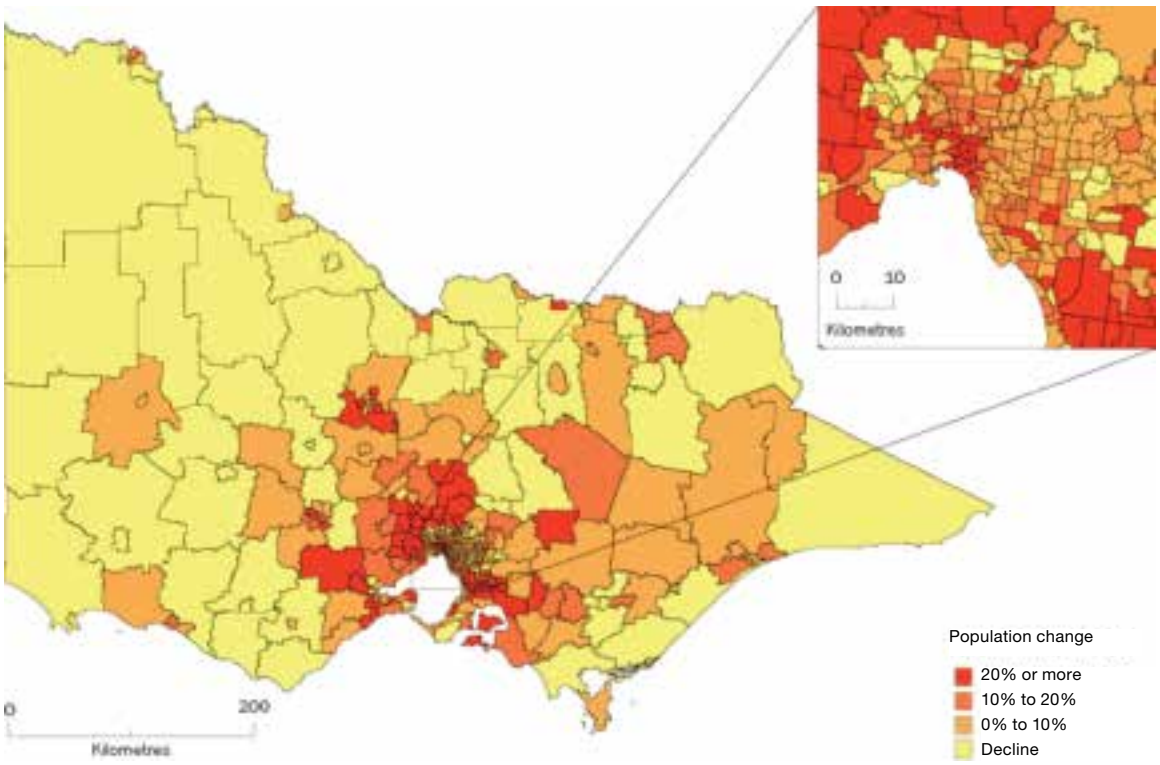


Figure A.5.2: Population change in Victoria, 2001 to 2011

Source: ABS.

Note: This map shows SA2 divisions, which are based on officially gazetted suburbs and localities.

Victoria's future population

Victoria's population is projected to increase to around 8.3 million by 2051, some 2.7 million more people than in 2011 (Figure A.5.3).[7] The majority of this rise will be in Greater Melbourne, which will increase by 2.3 million, accounting for 86% of the total projected population increase. Regional Victoria's population is projected to increase by 375,000 people between 2011 and 2051.

Victoria's projected population rise will increase the demand for peri-urban and coastal development, particularly around the Melbourne and Geelong areas. It will also increase the demand and consumption of water and other resources, energy, food production and a range of products and services. This will have severe consequences for Victoria's environment.

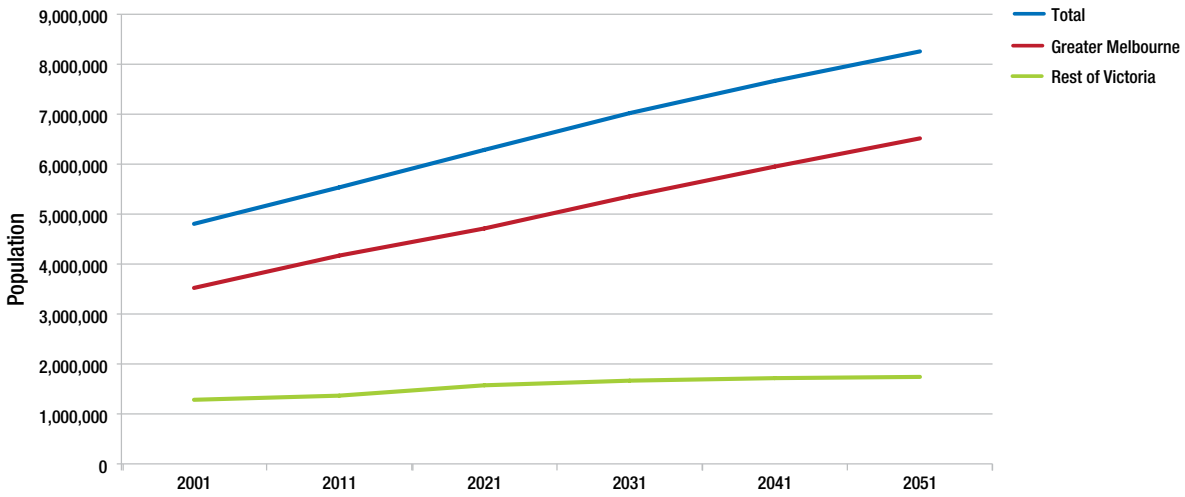


Figure A.5.3: Victoria's population growth 2001 to 2051

Source: ABS.

Note: Population growth from 2011 to 2051 are Australia Bureau of Statistics projections.

Indicator HS2: Energy Use

This indicator assesses Victoria's energy use. For greenhouse gas emissions and air pollution resulting from energy generation and use, including transport, see Part A: 1 Climate Change and Air Quality.

Energy generation and consumption is fundamental to everyday life and underpins social and economic activity. However, the reliance on fossil fuels for energy creates significant pressures on the environment.

In Victoria, energy use (particularly electricity generation and use) has the single biggest impact on the state's ecological footprint[1] and presents a range of environmental pressures, including the emission of greenhouse gases and other air pollutants, water consumption (see Indicator HS3: Water Resources and Consumption) and land use. Many of these environmental impacts will be exacerbated by climate change and will continue into the future unless there are significant changes to the way energy is generated and consumed.

Victoria's energy system is principally based on fossil fuels from the Gippsland Basin and imported oil. Brown coal is the most abundant of non-renewable energy resources in Victoria, and is the main fuel used to generate the state's electricity.

Energy generation and use is a major issue in Victoria because of the reliance on energy supplied from brown coal – the most greenhouse-intensive energy source in Australia. Electricity generated from brown coal is 30% more polluting than black coal, and almost six times as polluting compared to that generated from natural gas. The use of brown coal also impacts on air quality in the Latrobe Valley.

Energy consumption is driven by a range of factors. These include the structure and activity of the economy and changes in fuel mix resulting from government policies and initiatives, as well as consumer demand for cleaner energy. Greater uptake of energy efficiency and renewable energy will play a key role in decreasing consumption of fossil fuels in the future. Victoria has great potential for renewable energy – including wind, solar, wave and geothermal – yet very little has so far been exploited.

Consumption and generation of electricity

Victoria's electricity consumption more than doubled between 1980–81 and 2010–11. This is despite the population growing by only 40% over the same period (Figure A.5.4). The rise can be attributed to the electricity consumption per capita, which has increased by 45% since 1980–81, although this rate has declined slightly since 2006–07.

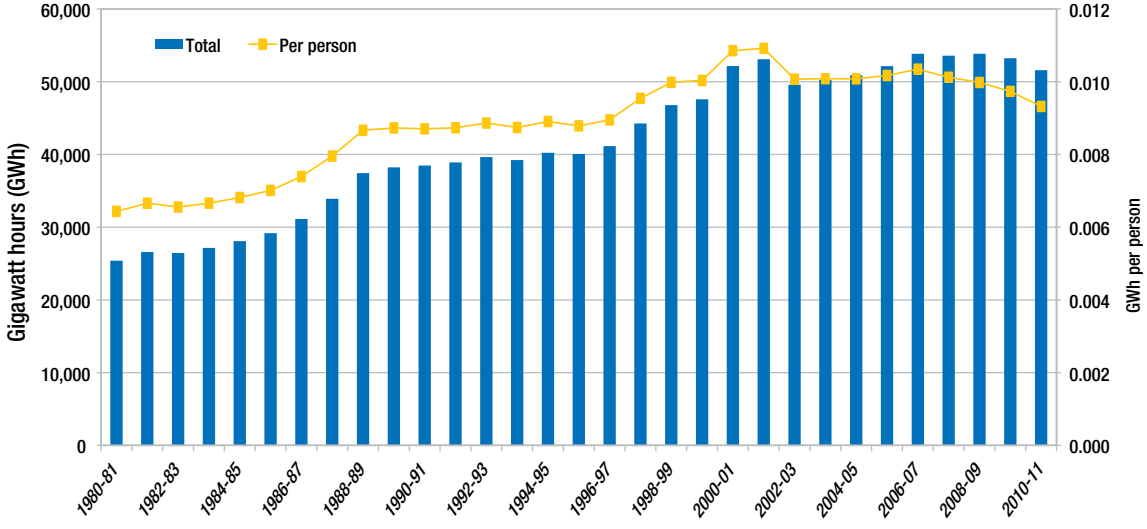


Figure A.5.4: Victorian consumption of electricity, 1980–81 to 2010–11

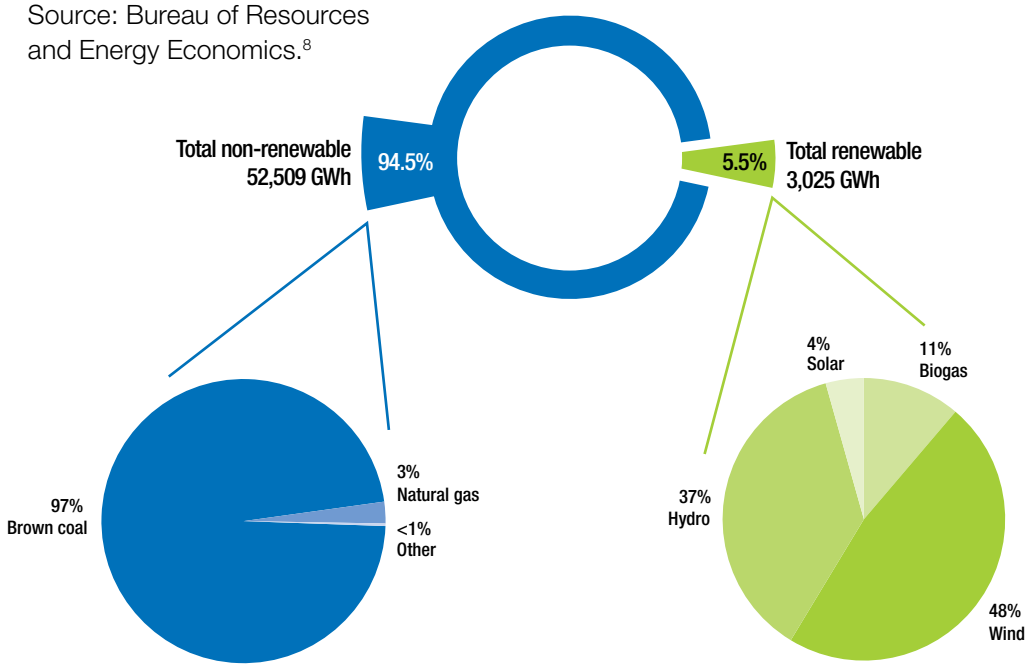
Source: Bureau of Resources and Energy Economics.[8]

Only 5.5% of Victoria's electricity was generated from renewable sources. Wind and hydro accounted for the majority of renewable sources with 48% and 37% respectively. Solar electricity generation only accounted for 4% of renewable electricity generation.

Electricity generation from renewable sources has been steadily increasing in Victoria. Installed capacity of renewable generation technologies has increased by nearly two and half times since 2000, with the wind sector significantly expanding over the period. Wind now accounts for over 25% of installed renewable electricity generation capacity in Victoria. Solar capacity has also significantly increased since 2000.[9]

Figure A.5.5: Electricity generation in Victoria, by fuel type, 2010–11

Source: Bureau of Resources and Energy Economics.[8]



Energy consumption

Electricity generation accounted for the majority of Victoria's net energy consumption (total energy used within the economy, including conversion, transmission and distribution) in 2010–11 with 39% of the total energy used (Figure A.5.6). Transport was the next highest sector with 21% of the total, followed by manufacturing (17%), residential (12%), and commercial (7%). Victoria's net energy consumption nearly doubled between 1973–74 and 2010–11, with energy consumed by electricity generation nearly trebling, residential energy increasing by 81%, transport by 60%, and manufacturing by 42%. However, the biggest increase was for the commercial sector, which more than trebled, although it accounts for only a small percentage of the total energy consumed.

Energy consumption has outpaced the increase in population growth in Victoria.

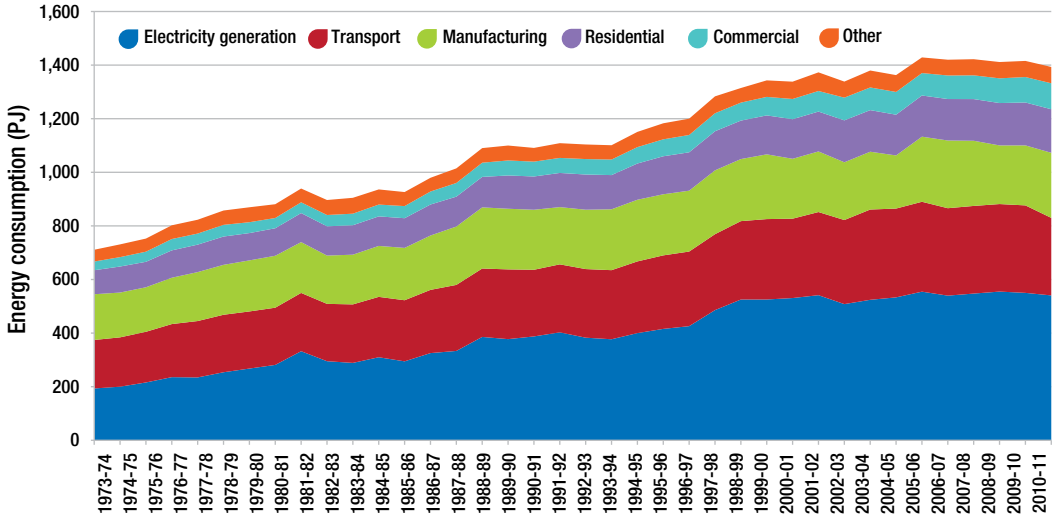


Figure A.5.6: Total net energy consumption in Victoria, by sector, 1973–74 to 2010–11

Source: Bureau of Resources and Energy Economics.[8]

Victoria's final energy consumption (total energy consumed – does not include the conversion, transmission and distribution of energy – is dominated by petroleum products (Figure A.5.7). In 2010–11, petroleum products accounted for 46% of the energy use – compared to 31% for natural gas, and 21% for electricity. These fuels supply over 97% of primary energy in Victoria.

Wood and wood waste combusted for space heating continue to dominate consumption from renewable sources. Between 1973–74 and 2010–11, the consumption of petroleum products only increased by 17%, whereas electricity consumption nearly trebled.

Consumption of natural gas increased rapidly in the early 1970s with the installation of Victoria's reticulated natural gas network, but has slowed since.

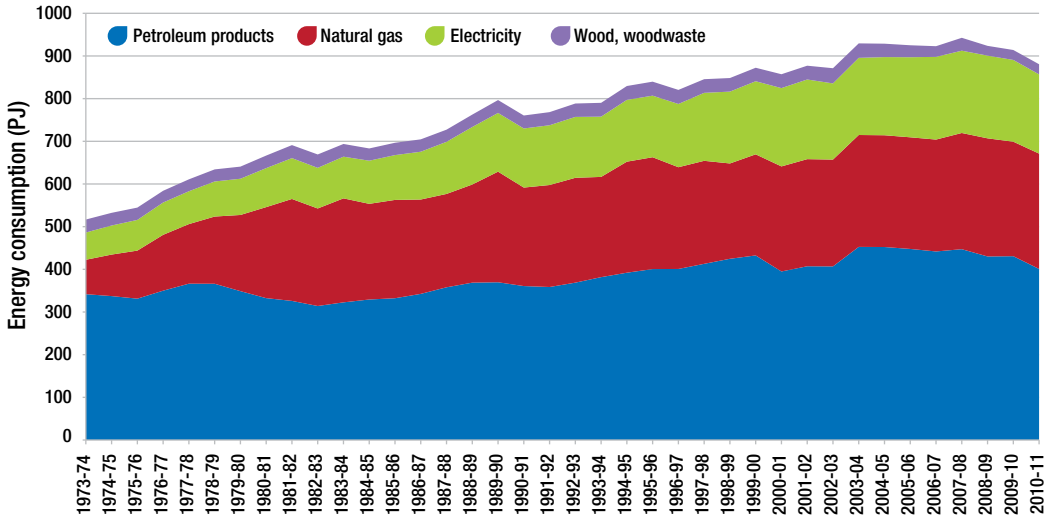


Figure A.5.7: Final energy consumption in Victoria, by fuel, 1973–74 to 2010–11

Source: Bureau of Resources and Energy Economics.[8]

Note: Data concerning refinery input and output, consumption of brown coal, production of petroleum products, and production and consumption of coke and coal by-products have not been included due to confidentiality.

Indicator HS3: Water Resources and Consumption

This indicator examines the availability and consumption of water resources in Victoria. For information on trends in river flows and groundwater levels, including the impacts of water extraction from these systems, see Chapter A: 3 Inland Waters.

The management of water in metropolitan and regional urban settings is discussed in Foundation Paper Three: *Water Victoria: The Science, Our Urban Communities and Our Water Futures*.[10]

Water is used for a variety of purposes, including residential supply, primary production (particularly for irrigation), power generation and industry. Water resources are vital for human health and wellbeing and for accommodating population growth.

The availability of water is also key for economic prosperity, especially for primary production industries. Victoria's water consumption increased over the last century, peaking in the 1990s, but dropped in response to water restrictions caused by long-term drought between 1996 and 2010. The severity of the water shortages has been particularly marked in central and western Victoria, where some storages were more than 90% empty at the end of the drought.

The availability of surface and groundwater resources is mainly determined by streamflow and rainfall, as well as impacts of land use on catchment hydrology. Streamflow in Victoria is highly variable, with most basins receiving only a fraction of their average flow in most years. The generally dry conditions are punctuated by wet years with flows well in excess of the average, which replenish storages and river systems. Surface water is more readily available in the eastern half of Victoria, which generates up to 80% of the state's streamflow.

In response to Victoria's highly variable streamflow, inland waters have been transformed into a complex and extensive system for harvesting, transporting and controlling the movement of water. There are 134 declared water supply catchments across Victoria and about 70 major storages, with at least one major on-stream storage constructed in 19 of Victoria's 29 river basins. In addition, there are over 455,000 farm dams in Victoria.[11] As a result, many river systems in Victoria are now environmentally degraded because of impacts on natural flow regimes (see Chapter A: 3 Inland Waters).

As demand for water has increased in Victoria, the use of groundwater to complement surface water sources has increased. Groundwater is now an important resource for agriculture, industry and domestic use.

Although useable groundwater resources are small compared to surface water (approximately 10% of surface water resources), it is widely used in more than 80 cities and towns in Victoria. In some regional areas, groundwater is the sole source of water.

During the Millennium Drought, the reduced surface water flows in Victoria were some of the lowest on record (see Chapter A: 3 Inland Waters). This focused attention on the management and use of water in Victoria. During drought periods, the state struggles to meet demand for water and there were are few opportunities to divert more water from rivers.[12]

To increase water capacity, the Victorian Government has embarked on two large infrastructure projects: the Bass Coast desalinisation plant and the pipeline to move water from the Goulburn River to Melbourne's Sugarloaf Reservoir. These will be used during times of severe drought and will provide more water security for Melbourne's growing population – particularly the desalinisation plant, which does not rely on rainfall.

The loss of harvested water is a significant problem in Victoria. Water is lost in the distribution network through evaporation and leakage. In 2010–11, 17% of total water supply was lost during water distribution, the second-highest level in Australia.[13] The majority of losses were from irrigation and rural water suppliers.

Water resources

Trends in Victoria's stream flows and groundwater levels are discussed in Chapter A: 4 Inland Waters.

The drought conditions between 1996 and 2010 severely reduced Victoria's water resources across many catchments, particularly in central and western Victoria. Many catchments experienced some of the lowest stream flows on record, with 2006–07 and 2008–09 volumes 27% and 32% of the long-term average respectively. Groundwater levels generally declined from the late 1990s to 2010 due to a combination of increased groundwater use and reduced recharge from both surface water irrigation and rainfall.

In 2010–11, the long-term drought ended in much of Victoria with high – and in some regions record-breaking – rainfall and flooding. This greatly increased surface water resources across much of Victoria and led to a rise or stabilisation of groundwater levels.

Victoria's total water resources between 2006–07 to 2010–11 are shown in Figure A.5.8. The impact of drought is clearly evident with total surface water resources in 2006–07 falling to 7,000 gigalitres (GL), only 26% of the long-term average. In contrast, the high rainfall in 2010–11 increased surface water resources to 175% of the long-term average. Victoria is heavily reliant on surface water, which accounted for most of the total water resources over the period – ranging from 87% in 2006–07 to 98% in 2010–11.

Groundwater resources showed little variation, remaining around 1 GL over the period. It is important to note that, while total groundwater resources remained relatively stable, the levels of some individual groundwater areas declined during drought conditions (see Chapter A: 3 Inland Waters).

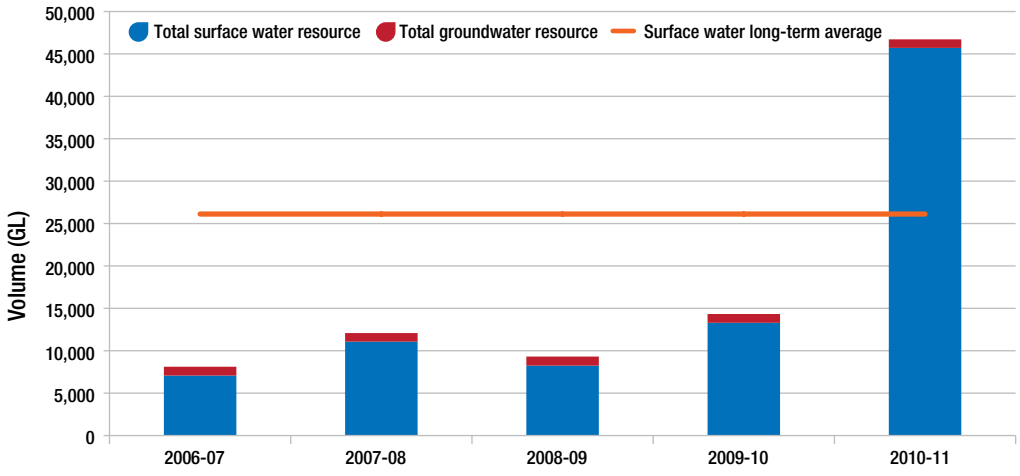


Figure A.5.8: Victoria's surface and groundwater resources 2006–07 to 2010–11, and long-term surface water average

Source: DEPI.

The impact of drought is evident for Victoria's water storages. Melbourne's water storage levels declined to a record low of only 26% of the total storage capacity in 2009 (Figure A.5.9). This was a result of historically low inflows.

The long-term average (1913–2011) inflow for Melbourne's water storages was 580,900 megalitres (ML) per year. However, during the drought (1996 to 2010) the average inflow dropped to 376,000 ML per year. In 2010–11, Melbourne's storage levels more than doubled – compared to the previous year to 56% of capacity – as a result of increased rainfall.

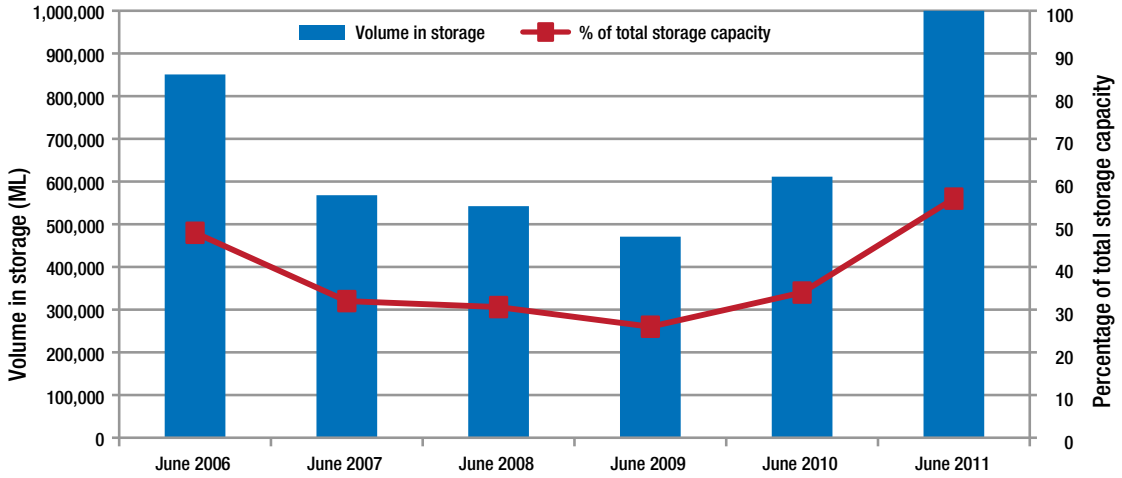


Figure A.5.9: Melbourne storage volumes, 2006 to 2011

Source: DEPI.

For the major regional water storages, drought conditions led to levels of just 15% of the total storage capacity in 2009 (Figure A.5.10). Storages most affected were in the Campaspe, Glenelg, Wimmera, Loddon, Maribyrnong and Werribee basins, which were less than 10% capacity at the end of June 2009. Storages in the Ballarat, Bendigo, Broken, Geelong, Goulburn and Murray systems were also extremely low with levels between 10% and 20% of total capacity.[14] The increased rainfall in 2010 and 2011 replenished regional storage levels to 84% of capacity.

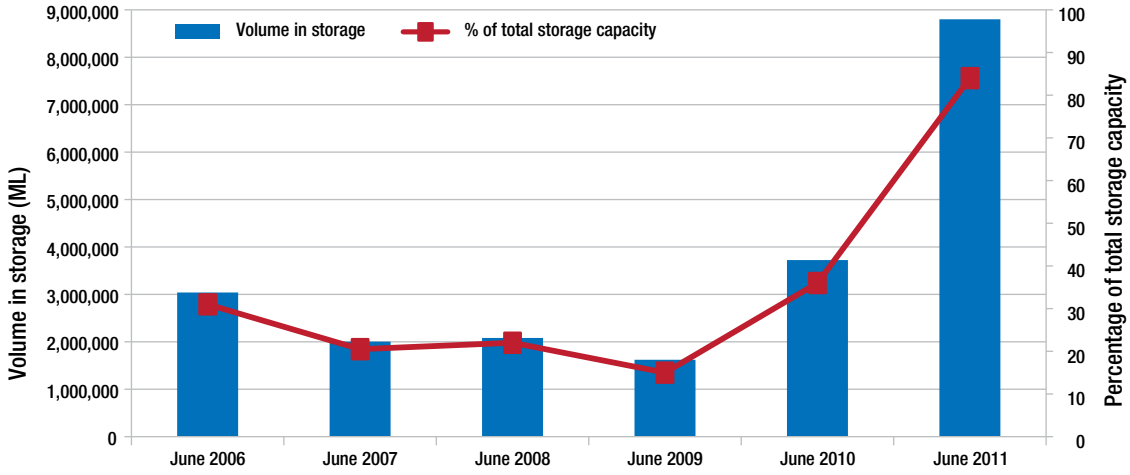


Figure A.5.10: Victorian major regional storage volumes, 2006 to 2011

Source: DEPI.

Wastewater recycling

Recycling wastewater has the potential to reduce the impact of wastewater discharges on the environment, reduce water harvesting from the natural environment, and potentially increase environmental flows. The volume of wastewater that the community produces is relatively stable, so recycling provides a reliable source of water.

Consumption of recycled wastewater is proportionally larger in regional areas due to the smaller volumes produced and proximity to fit-for-purpose uses.

Between 1996-97 and 2006–07, Victoria's wastewater recycling increased six-fold due to reduced water availability from other sources and greater investment in recycled water infrastructure.[1] However, from 2006–07 to 2009–10 wastewater recycling remained stable at around 25% (approximately 95,000 ML) of the total wastewater produced (Figure A.5.11). In 2010–11, wastewater recycling fell to 11% (approximately 55,000 ML) of the total wastewater produced. This was due to high rainfall increasing wastewater production and reducing the need for recycled water.

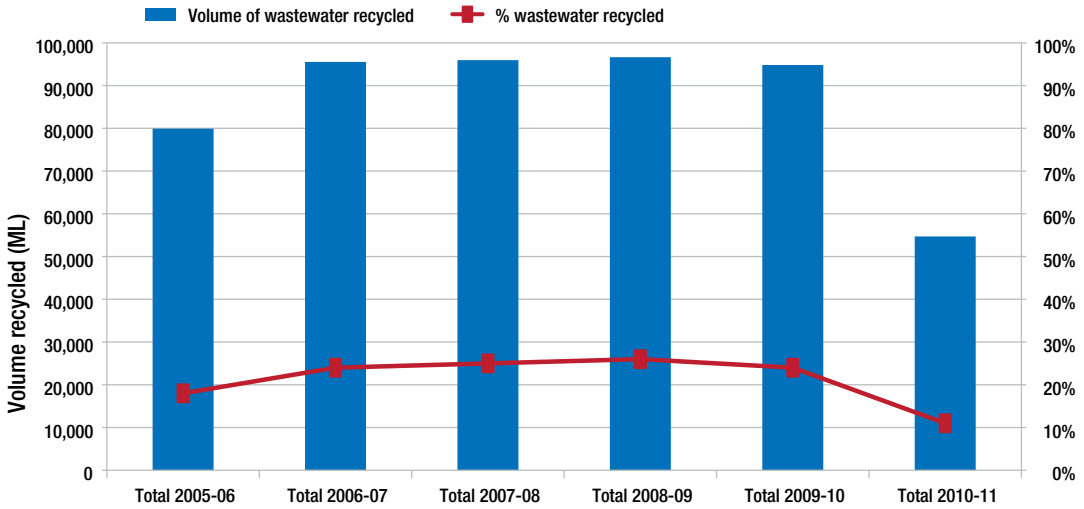


Figure A.5.11: Wastewater recycling in Victoria, 2005–06 to 2010–11

Source: DEPI.

Water consumption

Water consumption is determined by a range of factors, including population, consumptive entitlements, restrictions due to water availability, changes in need due to rainfall, and the water demand of primary industry.

It should be noted that while under the Victorian Government water allocation framework water users have set entitlements, this does not guarantee that the entitlement volume will always be available for use.[15] In times of low water availability, restrictions are applied to ensure resources are available for other users and the environment. However, the allocation system reduces water available to the environment more than for consumptive uses (see Part B: 1.3 Effective Protection and Delivery of Environmental Water). Consequently, during times of drought the overall demand and use of water resources impacts on the aquatic environment as the amount of water available decreases.

Surface water consumption

Between 2006–07 and 2010–11, the consumption of surface water ranged from a high of 3,456 GL in 2006–07 to a low of 2,822 GL in 2010–11 (Figure A.5.12). Consumption was influenced by drought conditions between 2006–07 and 2009–10, with severe water restrictions in place due to reduced water resources. In contrast, consumption in 2010–11 was influenced by the high rainfall, which reduced the need for water.[15]

The percentage of the available surface water extracted was nearly 50% in 2006–07 compared to only 6% in post-drought 2010–11. This shows the pressure placed on river systems in times of low water availability when large proportions of total flows are extracted for water supply.

Between 2006–07 and 2009–10, over 25% of Victoria's river basins had more than three-quarters of their annual streamflow harvested for consumption, and over 40% had more than half their streamflow harvested (see Chapter A: 3 Inland Waters).

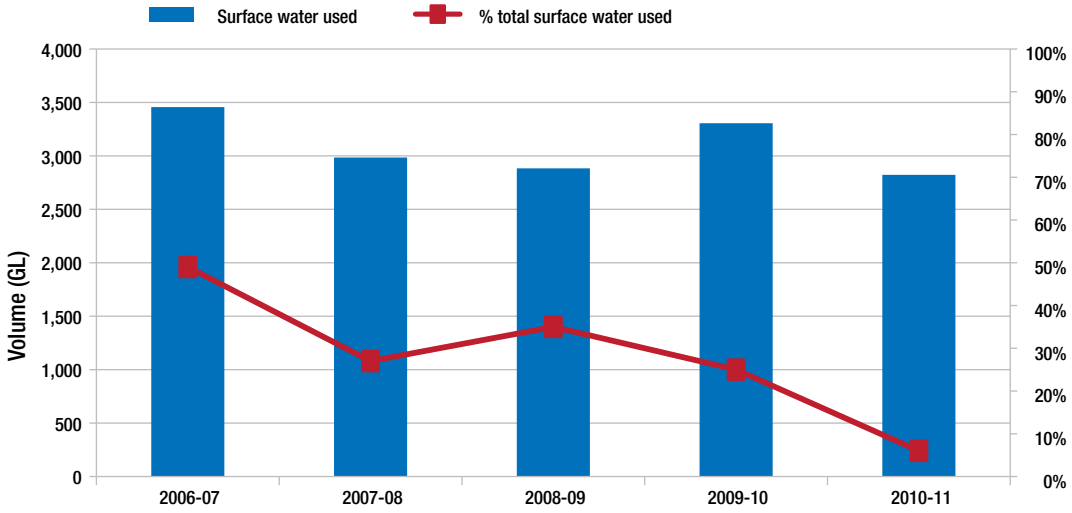


Figure A.5.12: Volume of surface water extracted and percentage of total resource extracted, 2006–07 to 2010–11

Source: DEPI.

About three-quarters of surface water harvested in Victoria was used for irrigation between 2006–07 and 2009–10 (Figure A.5.13). This decreased to 62% in 2010–11 because of the reduced need for water due to high rainfall. Over half of the water for irrigation is used for dairy production. Other significant uses include livestock, pasture and grains, and grapes and fruit. Most irrigation occurs in the Goulburn–Murray region.

The next biggest water user was the 'urban and commercial' sector, accounting for around 20% of water usage between 2006–07 and 2009–10. This rose to 28% in 2010–11 partly because of the reduction in irrigation use, but also because consumption for the sector increased by 138,000 ML compared to the previous year – possibly in response to the removal of some water restrictions. The 'domestic and stock' and 'power generation' sectors accounted for around 5% and 3% of the total surface water use respectively.

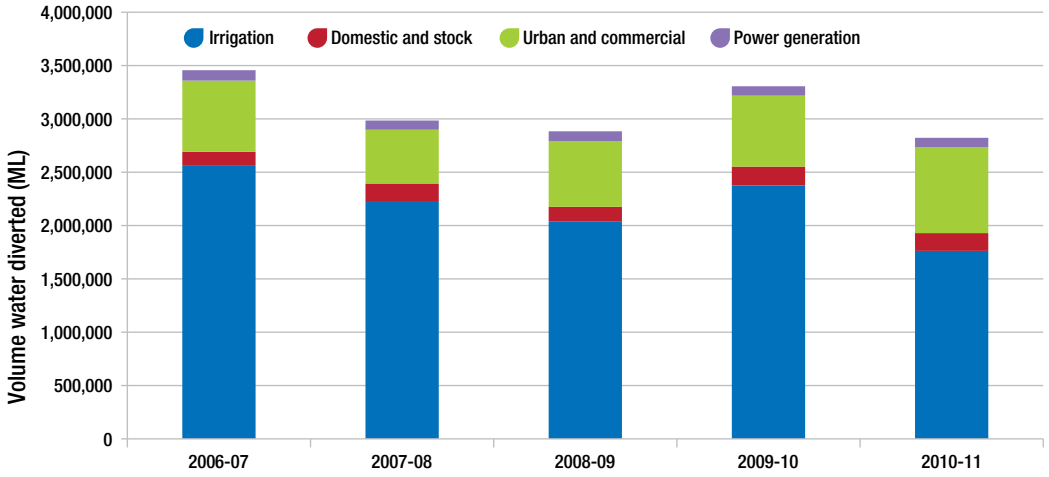


Figure A.5.13: Surface water diversions made under consumptive entitlements 2006–07 to 2010–11

Source: DSE.

Groundwater consumption

Between 2006–07 and 2010–11, groundwater extraction ranged from a high of 526,000 ML in 2006–07 to a low of 221,000 ML in 2010–11 (Figure A.5.14). The high rainfall in 2010–11 reduced groundwater extraction by approximately half due to reduced demand. The percentage of the available groundwater extracted ranged from 50% in 2006–07 to 22% in post-drought 2010–11. As with surface water resources, this shows the pressure placed on groundwater systems in times of low water availability, when large proportions of the total resource is extracted for water supply. While groundwater supply is important for many regions of Victoria, it only accounted for 7% to 13% of the total water used between 2006–07 and 2010–11.

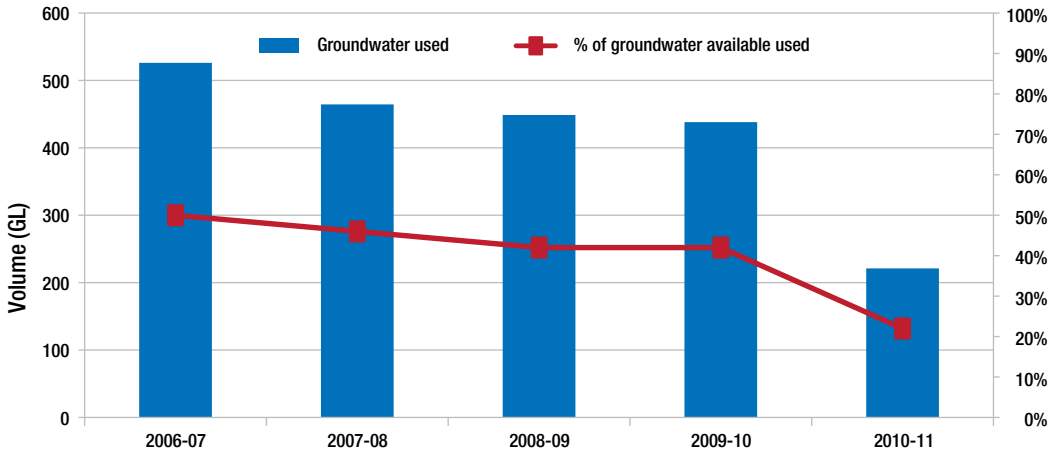


Figure A.5.14: Volume of groundwater extracted and percentage of total resource extracted, 2006–07 to 2010–11

Source: DEPI.

'Irrigation, commercial and salinity control' uses account for most of the groundwater consumption in Victoria (Figure A.5.15). Extraction for these purposes ranged from 75% during the drought period, to 55% in 2010–11, when the demand for water was reduced due to the high rainfall.

The 'stock and domestic' sector is another significant user, accounting for 27% of groundwater use in 2010–11. The Latrobe Valley coal mines can also extract high volumes of groundwater, accounting for 13% of total groundwater extraction in 2010–11. The Latrobe Valley coal mines and offshore oil and gas extraction has led to long-term declines in groundwater resources in Gippsland.

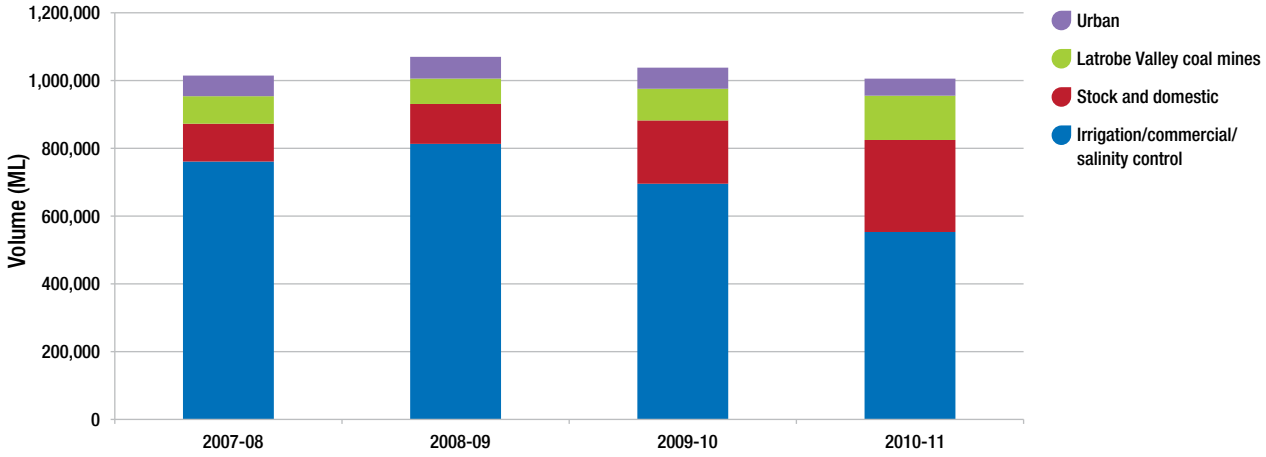


Figure A.5.15: Victorian groundwater extraction (Groundwater Management Areas and Water Supply Protection Areas) by use, 2007–08 to 2010–11

Source: DEPI.

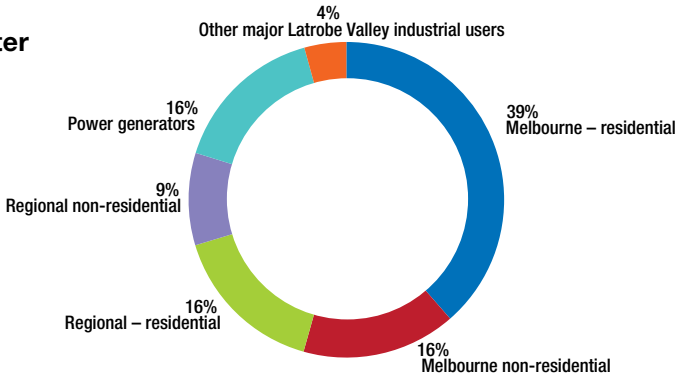
Urban water supply

Melbourne is home to 75% of the state's population and consequently is responsible for most of Victoria's urban water supply (Figure A.5.16). While Melbourne's residential use accounts for nearly 40% of the total Victorian metered urban supply, non-residential uses account for another 16%.

Melbourne accounts for about 10% of the total water harvested for consumption in Victoria. Regional Victoria accounts for 25% of the total urban water supply. The power generation sector is a significant water user, accounting for 16% of total urban water, nearly a third of Melbourne's total water use.

Figure A.5.16: Urban and commercial metered water consumption in Victoria, 2010–11

Source: DEPI.



Per capita water consumption

Victoria's per capita water use decreased from 229 L/person/day in 2008–09 to 192 L/person/day in 2010–11 (Figure A.5.17). While long-term consumption rates have been dropping due to water restrictions, this reduction is most likely due to the high rainfall in 2010–11 reducing demand for water.

Water usage across Victoria was variable, with Central Highlands having the lowest per capita use and Lower Murray the highest. However, it is difficult to compare regional per capita water usage as there are differences in levels of restrictions, climatic conditions driving demand for water, and different dwelling densities across the population centres.[15] Melbourne's per capita consumption has continued to decrease from 253 L/person/day in 1996–97 to 147 L/person/day in 2010–11 – a reduction of 42% (Figure A.5.18).

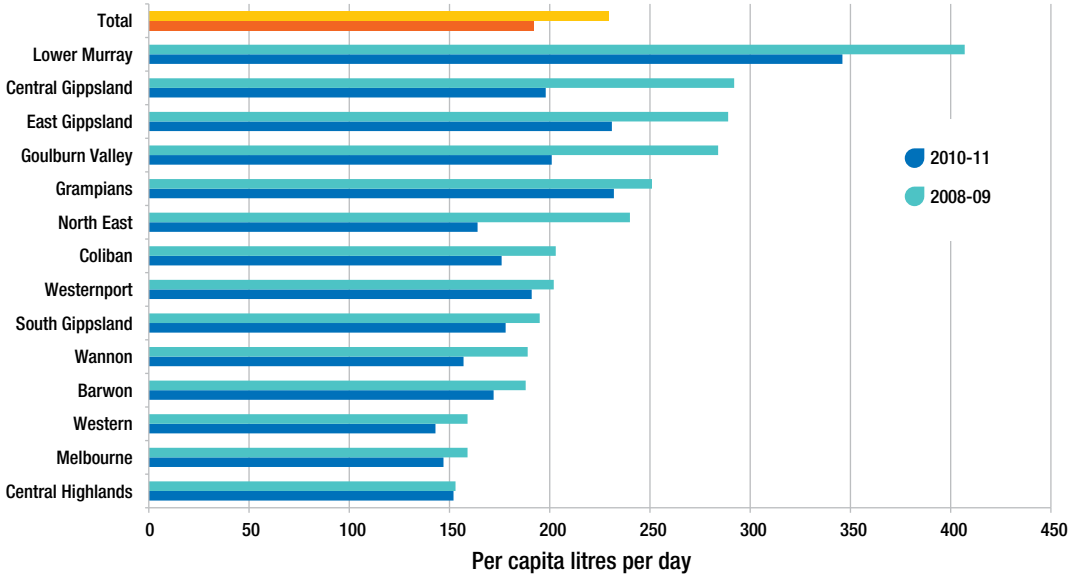


Figure A.5.17: Victoria's daily per capita water consumption, 2008–09 and 2010–11, by water corporation

Source: DEPI.

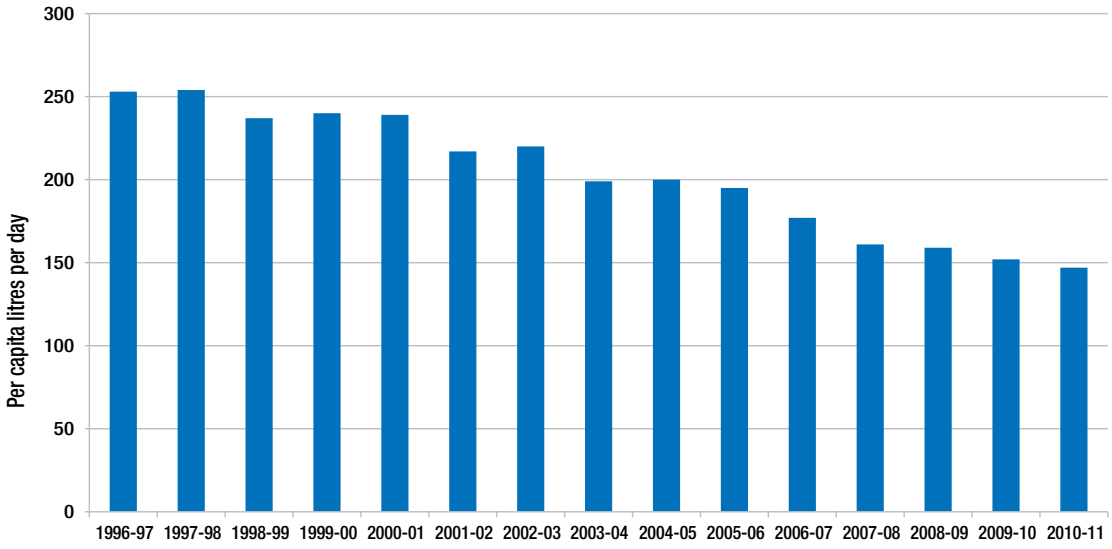


Figure A.5.18: Melbourne's per capita water consumption, 1996–97 to 2010–11

Source: DEPI.

Indicator HS4: Trends in Solid Waste Generation and Management

Waste is produced at all stages in the manufacture of products and services, as well as at the end of a product's lifecycle. Depending upon the way it is managed, waste can have a number of different environmental impacts, including:

- greenhouse gas emissions and pollution of groundwater from landfill
- the presence of hazardous and other waste and its impacts on amenity, ecosystems and human health
- conversion of land for waste disposal
- increased energy use to recycle products
- the effect of unmanaged outputs such as litter and dissipative wastes.

When waste is not reused, recycled or used efficiently, there is an opportunity lost, as the material can no longer be used to contribute to the economy.

Recycling waste not only makes such materials available to the economy, it also reduces the demand for resource extraction and conserves energy and water compared to manufacturing products from virgin materials. Further, due to the complex nature of material transformations, many of the substances that are produced are not able to be readily metabolised by the natural environment and may harm natural systems and biodiversity. Environmental management of waste, including landfills, recycling processes, management of prescribed waste and litter prevention, can greatly reduce these impacts. However, it is of great importance to reduce the amount of material requiring waste disposal.

A large proportion of waste comes from secondary industries, such as manufacturing and construction, some of which is potentially hazardous. Poor planning in design and assembly can lead to inefficient use of resources in manufacturing or construction, leading to unnecessary material waste. The management of such waste can be an economic burden, which is passed on down the supply chain of products, increasing the price to the consumer.

In the case of construction, poor design cannot only create unnecessary material waste, but also a legacy of inefficiency throughout a building's life.

Alternatively, waste products may be useful resources for other industries. For example, overburden material, such as soil, rock and gravel removed for construction and other activities, can become fill for landscaping, and manure can become fertiliser for agriculture (or even a bioenergy source for electricity generation). Similarly, wastes from households can be reused, recycled or composted, thus increasing their utility.

It is important to note that while waste policy can help to ensure that more waste is recycled, it is unlikely to reduce the amount of waste generated. This is because the total amount of waste generated is the result of consumption rates and other – social, cultural and economic – factors that are predominantly outside the influence of government waste policy.[16]

Waste generation and disposal in Victoria

Waste generation increased from 8.6 Mt in 2002–03 to 12 Mt in 2010–11, an increase of nearly 40% (Figure A.5.19). Recycling increased from 4.4 Mt to 8 Mt, raising the annual recycling rate from 51% to 68%. As a result of improved recycling, the amount of waste going to landfill decreased slightly over the period, from 4.2 Mt to 3.9 Mt.

Despite improvements in recycling, there are still valuable resources going to landfill. The marginal cost of increasing the recycling of all material types is currently prohibitive. However, a recent estimate found that if only high-commodity-value materials currently going to landfill (paper, cardboard, plastics and metal) were recycled, $172 million could be potentially made available to the Victorian economy.[16]

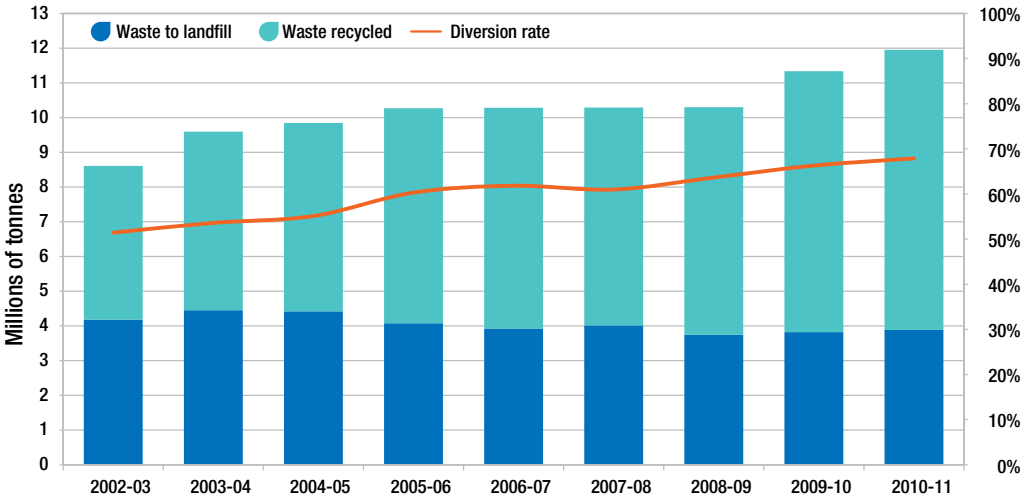


Figure A.5.19: Waste generation, landfill, recycling and the recycling (diversion) rate, Victoria 2002–03 to 2010–11

Source: DEPI.

In 2010–11, the majority of waste produced in Victoria was from the 'construction and demolition' sector, which accounted for 41% of the total waste produced (Figure A.5.20). The 'commercial and industrial' sector produced 34% of the total waste, with municipal solid waste accounting for 25%.

Between 2002–03 and 2010–11, the biggest rise in waste was for the 'commercial and industrial' sector, which increased by 47%. All sectors recorded significant waste increases over the period, with a 38% increase for 'construction and demolition' and 31% for municipal solid waste.

Recycling rates improved for all sectors. The biggest rise was for the 'construction and demolition' sector, which increased from 54% in 2002–03 to 83% in 2010–11 (Figure A.5.21). The recycling rate for municipal solid waste improved from 33% to 44%, whereas commercial and industrial only increased from 63% to 66%, a rise of only 3% over the period.

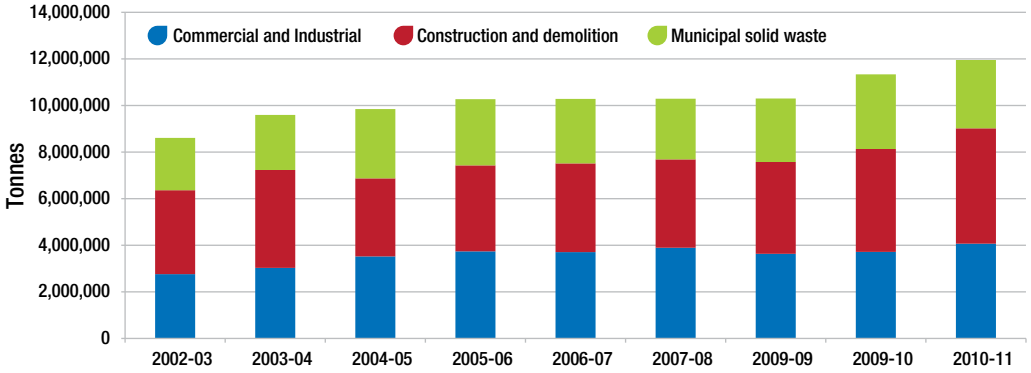


Figure A.5.20: Waste generation by sector, Victoria 2002–03 to 2010–11

Source: DEPI.

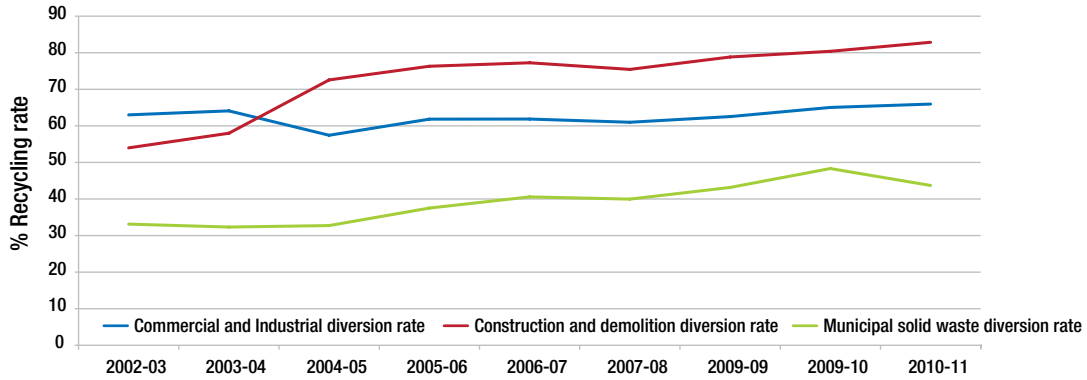


Figure A.5.21: Waste diversion rates by sector, Victoria, 2002–03 to 2010–11

Source: DEPI.

Despite the improvement in the overall recycling rate, the increase in waste generation means that Victoria is becoming more waste-intensive. Between 2002–03 and 2010–11, Victoria's per capita waste generation increased from 1.7 tonnes per year to 2.1 tonnes per year, an increase of 23% over the period (Figure A.5.22). This means that waste production is growing at a faster rate than population.

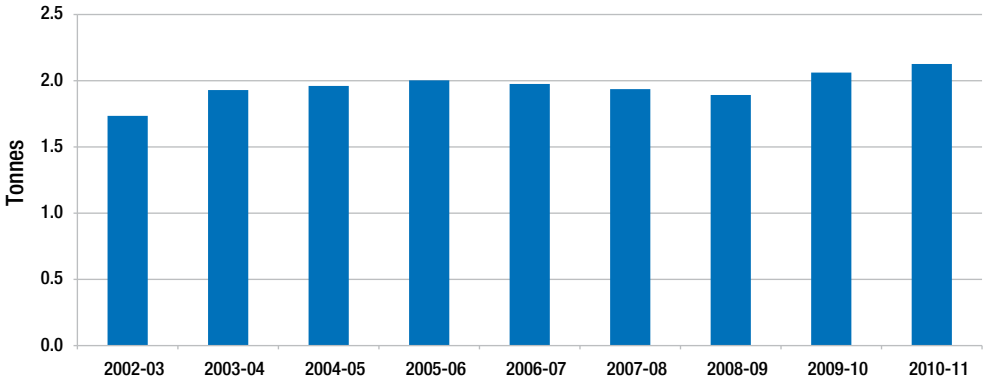


Figure A.5.22: Tonnes of waste per capita, Victoria, 2002–03 to 2010–11

Source: DEPI.

PART B

Victoria:
STATE OF THE
ENVIRONMENT
2013

GOALS AND RECOMMENDATIONS

INTRODUCTION PART B: GOALS AND RECOMMENDATIONS

Part B: Goals and Recommendations is underpinned by four key principles: ecosystem services, ecological resilience, social resilience and Strategic Adaptive Management. In this part we also propose recommendations for the Victorian Government's action.

Ecosystem Services

Our wellbeing as a society depends on the natural world. We depend on ecosystem services – the goods and services we receive from functioning ecosystems as a result of the biophysical processes that occur. The way we manage our natural environment needs to reflect the benefits we receive from ecosystem services. It is crucial that we understand Victoria's ecological processes[1] to ensure that we continue to benefit from ecosystem services in the long term. The long-term condition of environmental assets becomes much harder to maintain if the ecological processes that support those assets are not managed appropriately.[2] We do not, however, sufficiently understand whether our ecosystem services are improving or deteriorating, because the quality of our information on the trends of our environmental condition is inconsistent across scales, land tenures and ecological assets.[3]

Ecological and Social Resilience

'Resilience is the capacity of a system to absorb disturbance and still retain its basic function and structure.'[4]

Resilience can be broadly considered as the ability of natural and social systems to respond, and adapt to, external shocks while remaining within critical thresholds and retaining desired functions.[5]

Victorian ecosystems within the National Reserve System[6] appear to be relatively resilient, although natural hazards intensified by climate change, and invasive plants and animals are significant challenges. Furthermore, vulnerability assessments remain incomplete making our understanding of the ecological resilience of our ecosystems partial. Ecological resilience is much harder to establish in landscapes beyond the National Reserve System.

Over the coming decades, Victorian communities will need to adapt to the hazards of a changing climate. Climate hazards that are expected to increase in frequency and intensity will include bushfires, heatwaves, floods and seasonal drought. There are numerous complex elements that underpin social resilience and these are often unique to particular communities. These are factors that influence the vulnerability of populations to hazards, their social cohesion, and their capacity to adapt to repeated shocks. The challenge lies in identifying common factors that can be monitored over long time scales and then used to determine the relative resilience of communities.

Strategic Adaptive Management

In Part B, strategic adaptive management (SAM) is proposed in several sections as a critical principle in developing policy interventions and responses, particularly in relation to target setting.

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GOAL **ONE** RESILIENT ECOSYSTEMS

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GOAL ONE RESILIENT ECOSYSTEMS

1.1 Managing the Landscape for Ecosystem Services

Proposition

In Victoria we do not have a comprehensive understanding of the condition of our ecosystem services; whether they are improving or deteriorating. As demonstrated in Part A of this report, we can claim with some certainty the condition of some ecosystem services, but that certainty does not extend across the whole state or all of our natural assets. In many instances we cannot demonstrate that our investment in environmental programs is in fact delivering environmental outcomes.

The critical reforms required to enhance our current management regime are:

(a) integrated priority setting that places ecological processes and ecosystem services at the centre of the decision making process

(b) better implementation of key conservation tools

(c) improved data and monitoring regimes to inform decision making, adaptive management strategies and target setting.

Context

Our wellbeing as a society depends on the natural world. We depend on ecosystem services – the goods and services we receive from functioning ecosystems as a result of the biophysical processes that occur.

1.1.1 The importance of ecosystem services

The definitions of these ecosystem services were formalised by the 2005 Millennium Ecosystem Assessment, which was coordinated by the UN Environment Program. The services we receive, from both natural and modified ecosystems, include:

- provision of food, fresh water, fuel and fibre
- benefits from the regulation of ecosystem processes, such as climate regulation, waste decomposition, crop pollination, pest control and air purification
- basic ecological processes such as nutrient cycling and seed dispersal
- cultural services, such as recreational opportunities and aesthetic enjoyment.

The Millennium Ecosystem Assessment also examined the way in which ecosystem services contribute to 'constituents of wellbeing', which include:

- security
- basic material for a good life
- health
- good social relations
- freedom of choice and action.

The way we manage our natural environment needs to reflect the benefits we receive from ecosystem services. It is crucial that we understand Victoria's ecological processes[1] to ensure that we continue to benefit from ecosystem services in the long term.

We understand, as analysed in Part A, that the main drivers of change that impact our natural assets and ecosystem resilience are:

- climate change
- human population growth
- loss of biodiversity
- land-use change
- loss or fragmentation of habitat
- invasive species
- over-exploitation of natural resources
- pollution.

The long-term condition of environmental assets becomes much harder to maintain if the ecological processes that support those assets are not managed appropriately.[2]

We do not, however, sufficiently understand whether our ecosystem services are improving or deteriorating, because the quality of our information on the trends of our environmental condition is inconsistent across scales, land tenures and ecological assets (see Part A).[3]

1.1.2 Incorporating ecosystem services into decision making

There is a growing body of theory and practice that considers how ecosystem services can underpin decision making and improve socioeconomic, cultural and environmental outcomes.

Such an approach would also improve data and information collection. It would provide a clear outcomes framework – to sustain and improve ecosystem services that contribute to constituents of wellbeing – and thus the leadership required to prioritise research and monitoring to inform decision making.

1.1.2.1 Valuing ecosystem services

In order to base decision making on ecosystem services, an evaluation of each ecosystem service is required.[4]

A legitimate concern over attempting to value ecosystem services is that this will effectively put a price on nature. Quantification can be helpful in determining Natural Resource Management targets, but explicit monetisation can be a double-edged sword.

One perspective[5] is that applying financial values to a service is a way of ensuring ecosystems are included in cost-benefit analyses – such that, hypothetically, the potential loss of $50 million worth of natural water purification might be cited as evidence for not allowing development of a hotel that might only produce $30 million of economic value.

There are, however, significant concerns around such an approach. Can all ecosystem services be fully valued? If a price is put on an ecosystem service, it suggests it can be traded. But who has the right to sell the service? And who might be buying it?[6]

Community consultation is required to answer these and other questions because it is the community who ultimately receive the benefits of the ecosystem services, who suffer the loss of an ecosystem service, and to whom the constituents of wellbeing apply.

5.3 Community Awareness addresses the need to engage people with the concept of ecosystem services, which can then help inform community participants in this process.

1.1.2.2 Trade-offs

Another key aspect of ecosystem-services-based decision making is the need to appreciate the trade-offs that are involved. There may be trade-offs between different services, and these trade-offs may occur at different scales.

For example, boosting food production may decrease drinking water quality. More timber harvesting in one area might diminish the recreational opportunities of others. These trade-offs can occur over time (i.e. benefit now, loss later), geographically (i.e. benefit here, loss there), or across different spatial scales (i.e. reduce benefit locally to increase broader benefit).

Research is being undertaken into the understanding and management of these trade-offs.[7] There is also potential for identifying positive synergies between some ecosystem services: improvements to one service might also lead to greater provision of another service.[8]

1.1.2.3 Recent examples

A recent project in the South East Queensland (SEQ) Catchment has developed a pathway for establishing an ecosystem services framework for decision making.

The project followed these steps:

1. Identify the ecosystems in terms of the Millennium Ecosystem Assessment reporting categories.
2. Map the ecosystems.
3. Identify and describe the ecosystem processes occurring in those ecosystems.
4. Determine the link between ecosystems and ecosystem processes.
5. Relate ecosystem processes to data and then map those ecosystem functions.
6. Identify and describe the ecosystem services provided by those processes.
7. Determine the link between ecosystem processes and the services they provide.
8. Explore the linkages between ecosystem services and the constituents of wellbeing that they support.[9]

A key attribute of this process is the prioritisation of the constituents of wellbeing (the aspects of human wellbeing that are derived from ecosystem services – see above 1.1.1). While focusing on this creates an anthropocentric assessment of nature and its values, it also helps to make explicit precisely how dependent we are on the environment for our wellbeing.

On the topic of valuing ecosystem services, the participants in the SEQ Catchment project (a wide range of stakeholders, including community members) unanimously agreed that 'attempting to seek monetary values of ecosystem services was not a meaningful or achievable task'.[9] Instead, the process attempted only to prioritise and identify the relative value of the various ecosystem services and constituents of wellbeing.[9]

There is also evidence that management of natural resources in Victoria is starting to shift to an ecosystem-services-based approach. The Soil Health Strategy is explicitly aimed at treating soils 'as complex systems that produce services that we benefit from'.[10]

1.1.3 Current Victorian NRM programs by theme

The following is a brief overview of management of Victoria's ecosystems. Terrestrial ecosystems is considered in 1.2 Improved Protection, Connectivity and Extent of Native Vegetation.

For detailed analysis, data and trends pertaining to these ecosystems see Part A.

1.1.3.1 Marine and Coastal Environments

The health of Victoria's marine ecosystems is partly dependent on activities in adjacent catchments. They are significantly impacted by the inflow of pollutants and nutrients. Marine ecosystem health is also compromised by invasive species and over-fishing of some species.

Marine biodiversity – and the underlying processes that affect biodiversity – is not consistently and comprehensively monitored across the state leading to gaps in analysis and understanding. See Part A: Marine and Coastal Ecosystems for a detailed discussion of these issues.

As on land, management of the public reserve system is vital for sustaining ecosystem services. The Victorian Auditor-General has found the management of marine protected areas (MPAs) could not be shown to be effective.[11] Parks Victoria had a plan for management of MPAs, but it had not been fully implemented when it ceased in 2010, largely because funding intended for MPA management was used on other activities.[11]

VEAC is currently conducting an investigation of MPAs and their effectiveness. A discussion paper has been released, and the final report is due in February 2014. The report is expected to focus on improving management effectiveness and on assessing environmental threats.[12]

Bays and ports are monitored relatively well, chiefly for water quality by the EPA and for pests by DEPI. Most other monitoring, however, is in response to events such as algal blooms and pest incursions, rather than as part of any ongoing data collection. Specifically, a strategic, fit-for-purpose, cross-agency monitoring, evaluation and reporting program for marine ecosystems is required to deliver the data necessary for a focused and effective management intervention.

Pelican, Gippsland

A key weakness in the management of our marine environment, outside protected areas, is the absence of a strategic plan. While some aspects of the marine environment are covered in other documents (e.g. Victorian Coastal Strategy 2008, policies for water quality), and RCSs provide for regional risk-based management, 80% of Victoria's marine waters fall outside the boundaries of existing statewide planning policies or management strategies.[11] Such a marine management plan was also a key recommendation of the 2009 Land and Biodiversity White Paper,[13] *Securing Our Natural Future*, receiving broad support among the community and academia.

Proper integration of policy and planning frameworks that affect the marine environment is also needed.

1.1.3.2 Inland waters

Freshwater aquatic ecosystems are impacted by, among other things, loss of in-stream habitat, runoff of agricultural chemicals from farms, barriers (such as dams), and extraction of water for consumptive uses. Unfortunately, only limited data exists for statewide water quality. See Part A: Inland Waters for a detailed discussion of these issues.

As the point of intersection between terrestrial and aquatic ecosystems, riparian vegetation plays a critical role in providing ecosystem services. It supports a wide range of flora and fauna, provides breeding habitat, generates organic matter for in-stream biota, acts as drought refugia, adds stability to river banks, prevents erosion, and helps to filter nutrients, sediment and pesticides from catchment runoff, thus improving water quality.[14]

Riparian vegetation is also often the only remaining vegetation in some areas.[15]

Snowy River

The degradation of native riparian vegetation is therefore considered to be a 'threatening process' under the FFG Act.

Despite its acknowledged importance to ecosystems and their resilience (e.g. as drought refugia), and despite a decade of active management,[15] riparian vegetation is still in poor condition in most parts of the state, with the exception of East Gippsland.

Recent policy is attempting to address this. The 2 Million Trees program is partially designed to address this problem, with 500,000 trees to be planted along waterways in regional Victoria.[16]

The draft Victorian Waterways Management Strategy lists proposed changes in management to improve the condition of riparian vegetation. This includes progressively introducing voluntary agreements for fencing, weed management and revegetation, as well as reviewing and clarifying governance arrangements over riparian zones.[15] The Victorian Waterway Management Program provides an example of how adaptive management is being used to improve outcomes.[17]

Water quality in the Yarra and Port Phillip Bay is addressed in a new strategy (A Cleaner Yarra and Port Phillip Bay), which focuses on more effective coordination between agencies and the prevention of pollution.[18] The strategy also tries to improve the link between monitoring and reporting efforts and management action – as well as recognising the importance of engaging with community.

Estuarine and bay systems such as Port Phillip Bay, Western Port and the Gippsland Lakes are subject to reduced water quality. Poor water quality usually occurs after episodic storm events when high pollutant levels are discharged from rivers and drains. Water quality is also reduced during periods when reduced mixing and flushing of water occurs.

There is limited data available on the ecological condition of estuaries, although it is evident that most of Victoria's estuaries have been degraded.[19]

1.1.3.3 Soils

Monitoring for land health and soil condition has been very limited. See Part A: Biodiversity and Land for a detailed discussion of available soil data.

A report by the Auditor-General concluded that soil health programs across the state have generally been implemented effectively. However, the report says that individual programs have focused on 'delivery of outputs rather than achievement of outcomes', with the consequence that it cannot be demonstrated that soil health in Victoria has actually improved as a result of these programs.[20]

In response to recommendations in that report, the government released a Soil Health Strategy in 2012.[10] The strategy recognises that soils are the fundamental support system for Victoria's $9 billion worth of agricultural productivity, and explicitly addresses the role of soil in providing ecosystem services.[10]

Soil health is generally more of a problem on private land, and is related to how we use land for agriculture. Issues specifically related to soil ecosystems are dealt with in Part B: 2.1 Sustainable Food Systems.

No till farming north west Victoria

1.1.3.4 Pest plants and animals

Ecosystem disturbances, such as human settlement and agricultural production, often facilitate the spread of invasive species between landscapes and habitats. Colonisation by pest species is believed to cause loss of biological diversity, even though cause and effect can be difficult to determine.[21]

Agriculture is vulnerable to introduced species given its dependence upon the ecosystem services provided by biological diversity.

Once the habitat of natural predators is removed, 'population explosions of pest species can colonise productive as well as reserved landscape.[22]

There is considerable literature and research on the issue of eradication of pest species and their impact on biodiversity and the ecosystem services that biodiversity provides,[23] but this research is labour intensive, can be expensive and will take time to produce clear longitudinal studies to inform decision making.

A major problem for management is the lack of understanding of the impacts caused by pest plants and animals (PPA). There is limited data for where pests occur from year to year, what the environmental and economic impacts are, and the extent of private landholder compliance with legislative requirements. There is also a paucity of social data that would help to better understand who does what with respect to PPA and why they do it. Finally, the impacts of invasive species on ecosystems do not occur in isolation: other drivers are commonly at play simultaneously.

See Part A: Biodiversity and Land for a discussion of available pests, plants and animals data.

Some good progress has been made in some terrestrial areas, but Parks Victoria is now forced to rely heavily on short-term funding to solve a long-term problem, with the result that efforts are often ineffective.[24]

New invasive species management legislation designed to improve the effectiveness of the policy framework is being developed by DEPI.

1.1.4 Challenges of the existing NRM framework

Healthy ecosystems are needed in order to receive all the benefits and services that Victoria's natural capital can provide.

Swamp wallaby, Strzelecki Ranges

Healthy ecosystems often have complex food webs, high levels of biodiversity and strong resilience to disturbances. These ecosystems have evolved under certain conditions and are capable of tolerating specific disturbances. Ecosystem services are likely to be diminished when the disturbance is outside the range or type that ecosystems can withstand.[25, 26]

The drivers that impact our ecosystem resilience and natural assets are outlined above, and in detail in Part A.

As all of these are largely, if not entirely, driven by human behaviour, it follows that we take an active role in managing these drivers and reducing the stressors acting on our ecosystems. Climate change exacerbates many existing stressors, and this combination significantly magnifies the pressures on Victoria's biodiversity – particularly threatened species.[27]

Climate change also influences the way in which conservation management is approached, since the key is not necessarily to maintain the status quo of ecosystems in all respects, but to facilitate changes – adaptations – that will preserve ecosystem processes.[28, 29]

As demonstrated in Part A (and elsewhere),[30] our terrestrial, aquatic and marine ecosystems are under stress.

Management changes are necessary for our ecosystems to become more resilient and continue to provide services that are the foundation of human wellbeing.

The critical reforms required to enhance our current management regime are:

(a) integrated priority setting that places ecological processes and ecosystem services at the centre of the decision making process

(b) better implementation of key conservation tools

(c) improved data and monitoring regimes to inform decision making, adaptive management strategies, and target setting.

1.1.4.1 Integrated priority setting that places ecological processes and ecosystem services at the centre of the decision making process

Victoria currently has a number of strategies and frameworks to manage environmental assets and respond to the impacts of the range of stressors outlined above.

Some of these interventions are issue-specific – such as the draft Victorian Waterway Management Strategy and the Native Vegetation Framework – while others are place-based – such as the Victorian Coastal Strategy and the regional catchment strategies (RCSs). The RCSs integrate environmental management by multiple stakeholders across issues at a regional level.

It is also important to note that these strategies and frameworks do not conform to a standard scope. They work across different land tenures and scales, often overlap, and may have competing objectives.

This matrix of statewide and regional strategies also intersects with federal policies in environmental management and investment, such as the Australian Biodiversity Conservation Strategy and the *Environment Protection and Biodiversity Conservation Act 1999*.

Alpine high country brumby

Case Study: South Australian NRM Plan

In 2004, the South Australian Government introduced legislation, the *Natural Resources Management Act 2004.*[31] The Act stipulates that the NRM Council must prepare and maintain a State Natural Resources Management Plan to:

- assess the state and condition of the natural resources of the state
- identify existing and future risks of damage to, or degradation of, the natural resources of the state
- provide for monitoring and evaluating the state and condition of the natural resources of the state on an ongoing basis
- identify goals, set priorities and identify strategies with respect to the management of the natural resources of the state
- set out or adopt policies with respect to the protection of the environment and the interests of the community through the operation of this Act, including through the control of pest species of animals and plants
- promote the integrated management of natural resources
- include or address other matters prescribed by the regulations or specified by the minister.

The first state NRM plan was released in February 2006 and the NRM Council must review the state NRM plan at least once in every five years. *Our Place. Our Future. State Natural Resources Management Plan South Australia 2012–2017* is the current document that sets a long-term vision, goals and priorities for the management of South Australia's natural assets.[32]

The plan is nested towards the top of the policy hierarchy, informing the regional NRM plans.

Lessons learnt and relevance to Victoria

The Government of South Australia undertakes ongoing evaluation through an implementation reporting project to assess the effectiveness of the previous NRM plan.

A similar plan in Victoria would provide a key link between the Victorian Government's Environmental Partnerships policy, statewide issues-based environmental strategies, and the CMAs regional catchment strategies.

Catchment condition and management reporting currently undertaken by the VCMC in Victoria could also be included.

The responsible agencies in Victoria for developing and implementing a state NRM plan would be:

- Department of Environment and Primary Industries
- Victorian Catchment Management Council
- catchment management authorities.

The critical gap in Victoria's current NRM policy landscape is leadership.

There is currently no clear articulation of statewide priorities and objectives for managing the state's natural resources as a whole* – a vision for future management that protects and enhances environmental services.

The State Government released its *Environmental Partnerships* document in 2012. This is described as 'a pathway for action by government, communities and businesses in Victoria to maintain a healthy environment'. Although it contains eight high-level priorities 'to help strengthen our environmental partnerships and achieve our vision of a healthy Victorian environment that supports our prosperity and wellbeing',[33] it lacks any detail on how the subset of natural resource management priorities are to be operationalised through the matrix of statewide and regional strategies.

A comprehensive statewide NRM plan has been advocated by the Victorian Catchment Management Council (VCMC) in each of its Catchment Condition Reports (2002, 2007, 2012).[30] In its latest report, the VCMC argues for an Integrated Catchment Management Plan, suggesting that its absence is a 'major weakness of our current approach'.[30]

The existence of a statewide NRM plan will also provide a clear indication of state priorities to the Federal Government, to maximise Victoria's advantage in federal processes such as Caring For Our Country.

It is envisaged that a statewide NRM plan would be designed to coordinate, rather than integrate, the existing issue- and place-based strategies by providing overarching goals and by establishing a process for determining how trade-offs will be made between competing priorities. These other strategies can continue to operate autonomously, but the rolling-out of programs will be integrated across the strategies by the overarching plan.

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* The Victorian Investment Framework (VIF) Statement of Priorities 2012/13 did provide an overview of the investment priorities for the six participating programs that worked together through VIF:
- Land health
- Victorian River and Wetland Management Program
- Sustainable Irrigation Program
- Biodiversity Program
- Victorian Landcare Program
- Natural Resources Investment Program.

VIF is no longer used by the government and has ceased as a program.

By its very nature, a statewide NRM plan would integrate management across private and public land, as well as include coastal and marine environments. Continuity of funding will be critical for the necessary long-term monitoring that allows continuous adaptive management of the plan.

Another important feature of a NRM plan would be standardised terminology and consistent language. This language could be developed and used in the preparation of the overarching plan, and then disseminated through all existing state and regional NRM strategies for the sake of clarity and comparison of objectives.

Ideally, the first iteration of a NRM plan would be completed in time to guide the development of the next round of regional catchment strategies. Also, once complete, a plan could guide development of the currently outstanding issue-specific strategies, such as for biodiversity and marine management.

Mount Arapiles via Halls Gap

RECOMMENDATION 1

It is recommended that the Victorian Government establish a statewide Ecological Processes Management (EPM) Plan.

ATTRIBUTES

The EPM Plan will integrate the natural resource management of Victoria to improve ecosystem services outcomes. The State Government will amend legislation to recognise the EPM Plan and the plan will be based on:

- **systematic environmental data collection**
- **statewide targets for ecological processes and ecosystem function**
- **broad-based community consultation to identify relative values of ecosystem services and constituents of wellbeing**
- **a sound scientific evidence-base and ground-truthing that includes linking ecological processes and ecosystem function with the services they provide.**

1.1.4.2 Better implementation of key conservation tools

An important piece of Victorian legislation to protect biodiversity is the *Flora and Fauna Guarantee Act 1988* (FFG Act). This Act, among other things, requires a list of threatened species to be maintained, requires management intervention 'action statements' for each of those species to be prepared, and provides for several management controls to prevent various threats to biodiversity.

The FFG Act also allows for the listing of 'threatened ecological communities' and 'threatening processes'. While not exhaustive in scope, the listed threatening processes[34] address, to some extent, each of the drivers impacting on our natural assets and ecosystem resilience listed above (1.1.1).

A report by the Victorian Auditor-General's Office (VAGO) into DEPI's administration of the FFG Act found, among other issues, there was too much emphasis on the listing of threatened species.[35]

An authorising environment for the proposed Ecological Processes Management (EPM) Plan is necessary.

The Commissioner for Environmental Sustainability notes the review undertaken by VAGO and regards it as authoritative and therefore endorses the recommendations of the Auditor-General regarding the more efficient implementation of the FFG Act.

It is critical that there is legislative reform to facilitate better implementation of key conservation tools.

Bush Stone Curlew, Horsham

The FFG Act threatened species list is similar to two other species lists – an advisory list maintained separately by DEPI, and a federal list under the *Environment and Biodiversity Conservation Act 1999*. Thus, VAGO suggests that Victoria's limited resources are not being used in the most efficient or effective way by maintaining multiple lists.

The Hawke review of the EPBC Act also recommended a single national list of threatened species and ecological communities.[148] Efforts towards this end are to be supported on the condition that the federally maintained list also makes allowance for the listing of species that are threatened regionally. Administrative efficiencies that do not compromise effectiveness could be found so that resources can be better directed towards implementing the Act in full.

These lists, while valuable for some purposes, can be poorly suited to setting management priorities – 'a high risk of extinction does not imply high priority for an action'.[36]

A report by the Environment Defenders Office published two years after the release of the VAGO report found that very little has changed at DEPI in response to the Auditor-General's recommendations.[37]

Furthermore, the preparation of action statements has not kept pace with the listing of new species. These action statements are also unenforceable – there is no way to compel DEPI to take the action that is identified by the action statement. There is also some evidence to suggest that recovery plans under the federal *Environment Protection and Biodiversity Conservation Act 1999* (comparable to FFG Act action statements) do not result in any statistically significant improvement in a species' status.[38]

VAGO recommended that the Victorian Government assess the extent to which existing State Government policy is inconsistent with listings of threatening processes and threatened communities, and then identify ways in which policy can be changed to be consistent with those listings and their associated action statements. For example, the current practice of riparian grazing is at odds with the listing of 'degradation of native riparian vegetation' as a threatening process.

Ultimately, parliament would amend the FFG Act to make mandatory the listing of all threatened ecological communities and all threatening processes that meet the listing criteria. This could be achieved by removing ministerial discretion from s. 10.

As part of this shift towards greater emphasis on whole ecosystems rather than individual species, existing and new action statements for threatened ecological communities and threatening processes require action.

If the above reforms are implemented, it is possible that some resources could be saved through a commensurate reduction in the need to list (and develop action statements for) every individual species.

Initially, DEPI needs to make a concerted effort to improve the efficiency of the listing process – through consultation with the Scientific Advisory Committee (legislated for in the FFG Act) – and then use the full suite of management tools available to government in the Act.

This process begins with making critical habitat determinations (CHDs) and management plans mandatory.

The more powerful elements of the FFG Act – CHDs, management plans, and interim conservation orders – have been underutilised, if used at all, according to the Auditor-General.[35]

The US *Endangered Species Act*, unlike the FFG Act, has mandatory CHDs. While these are not always completed within the required 12 months, a study has revealed that those species with critical habitat determinations are twice as likely to improve in status, and only half as likely to get worse.[39]

With the impact of climate change for individual species still to be determined, these CHDs provide a mechanism to include future habitat areas that are not within the current range for the species but that are expected to provide critical habitat to that species in the future.

It is critical that the policy framework for implementing CHDs addresses the likely consequences of developing management plans and interim conservation orders, and possibly consider, the need for limited compensation to private landholders where their land use would be restricted for the purposes of protecting biodiversity.[40]

Finally, the legislation needs to be amended to allow parties other than DEPI to bring legal action for breach of the terms of the FFG Act[41] in a similar form to third party enforcement of the federal *Environment Protection and Biodiversity Conservation Act 1999* (s. 475), which gives standing to 'an interested person' to apply for injunctions. Under an amended FFG Act, these third parties could then apply to VCAT for an enforcement order, which would compel DEPI to take action. In particular, third parties would be able to apply for enforcement orders to stop any activity that relates to a listed threatening process.

Similarly, there is currently no Victorian Biodiversity Strategy (a legislative requirement of the FFG Act). The previous state strategy has now lapsed, and initial efforts to produce a new one in 2010 were not completed. Without a guiding document for our biodiversity goals and targets, it is difficult to adequately direct limited resources in an efficient way.

1.1.4.3 Improved data and monitoring regimes to inform decision making, adaptive management strategies, and target setting

For a more detailed discussion of how data and monitoring regimes in the environmental disciplines require improvement see Part B: 5.1 Monitoring and Data Collection.

Environmental programs, like all other aspects of government activity, need to be effective, both in terms of costs and outcomes.

The absence of adequate data and monitoring regimes makes it difficult to produce clear evidence and evaluation that demonstrates a direct causality between NRM programs and their benefits to the environment.

Throughout the consultation in the development of this report, it was clear that – despite the efforts of a world-renowned scientific community, and very capable and active citizen science contributions - there are significant gaps in resourcing and our understanding of Victoria's natural environment (see Part A).

In addition to developing and implementing policies and programs, the government has a responsibility for the evidence base on which these interventions are built.

These responsibilities include more baseline monitoring, harmonised data frameworks and compliance with various legislated requirements. Another recent report by VAGO[43] found that DEPI 'cannot be sure that their compliance activities contribute to protecting natural resources, primary industries and the environment as the legislation intended'. In response, DEPI has established a compliance reform team and a whole-of-DEPI regulation and compliance transformation project, to improve its approach to compliance activities.

It is a three-part process to address this disconnect in the policy cycle – both between the evidence base and decision making, and evaluating that the interventions undertaken can be shown to have tangible and demonstrable benefits on Victoria's natural capital.

It is envisaged that this three-part process is formalised through the development of an EPM Plan.

Establish community priorities

Firstly, it is necessary to establish community priorities regarding the method of valuing ecosystem services through broad consultation with both scientific experts and local community representatives. From this engagement, the underlying ecological processes can be identified and prioritised, and then determination of intervention activities for specific natural assets and attendant environmental programs can be decided.

Map statewide data

Secondly, the development of these programs would be aligned with rigorous information requirements. All statewide environmental data would be aggregated and mapped.

Given that the budget available for environmental management programs is always limited, the government – and program managers – need to be able to demonstrate that the programs that do receive funding are actually delivering the outcomes they were designed to achieve.

Data collation and information retention are critical in this process.

To this end, a more systematic use of tools is required. One such tool is the Investment Framework for Environmental Resources (INFFER) – a framework developed in collaboration between DEPI and academia with extensive ground truthing in Victoria.

INFFER could help both the State Government and CMAs develop more effective and efficient programs. INFFER provides a step-by-step process for assessing the likely success of a project, its value for money, the strength of the scientific basis for the work, and other variables that inform, but are not always considered, when making decisions about environmental investments.[44]

Establish statewide targets

Thirdly, a key gap in Victoria's natural resource management is the absence of targets.

Victoria's catchment management authorities (CMAs) produce regular regional catchment strategies (RCSs) – initially in 1997, then in 2003–04, and most recently in 2013. One analysis found that only a minority of targets in the first two rounds of regional catchment strategies met the criteria of 'SMART' targets: specific, measurable, achievable, relevant and time-bound.[45]

The guidelines for preparation of the latest round of RCSs did direct CMAs to develop SMART targets 'where possible' for significant assets,[46] but the legal requirements of the *Catchment and Land Protection Act 1994* (CaLP Act) (s. 24) do not explicitly require this.

One approach to developing SMART program targets would be to frame targets using a Strategic Adaptive Management approach. A key component of this is planning in advance for how to respond to changing conditions of natural assets, their threats and drivers for change, or a change in the provision of ecosystem services.

Steps to be followed include:[47]

- Establish quantitative and/or qualitative baseline thresholds for ecosystem services (linked to scientific understanding of ecosystem processes and asset condition).
- Identify checkpoint levels on path towards baseline thresholds.
- Establish a series of high-level working groups, with representatives from government, academia and the community, to determine management actions that will be taken in the future if a given checkpoint level is reached (as the checkpoints become closer to the baseline thresholds, planned management actions will need to become more drastic to ensure the thresholds are not crossed).
- Implement those actions if the checkpoints are reached.
- Evaluate, learn from, and reassess management actions.

This would allow aspirational targets to be set, including intermediate checkpoints with agreed management responses to ensure that the immediacy of need for Victoria's natural assets is not eclipsed by long-term goals.[45]

The targets to be included within an EPM Plan need to be aligned with an ecosystem services framework to provide an easily understood, anthropocentric rationale for the protection of natural assets and the ecological processes that support them.[8, 9, 48]

Red tailed cockatoos
Courtesy of Bob McPherson and www.redtail.com.au

RECOMMENDATION 2

It is recommended that the Victorian Government establish targets for statewide ecological processes and ecosystem function and adopt Strategic Adaptive Management.

ATTRIBUTES

The Strategic Adaptive Management approach will deliver targets, threshold baseline levels and checkpoints by agreement between government, scientists, land-users and community stakeholders. These targets will:

- **be set at state, regional and local scales**
- **include predetermined management responses if intermediate checkpoints are crossed**
- **be assessed and reported against, regularly and publically.**

Plovers, Phillip Island

1.2 Improved Protection, Extent and Connectivity of Native Vegetation

Proposition

Importance of native vegetation

One of the most important aspects of land management is retention and restoration of native vegetation. It helps maintain ecosystem processes and leads to many ecosystem services – ecological as well as social, cultural and economic.[49]

To preserve these services, a number of issues need to be addressed:

- **Protecting what remains:** keeping national and state parks as large banks of high-quality native vegetation, and boosting protection of remnant vegetation on private land.
- **Increasing the extent:** ensuring an appropriate suite of regulations and incentives to rehabilitate land that has been cleared or degraded.
- **Improving connectivity:** targeting revegetation work to achieve landscape-scale strategic objectives of ecosystem services and resilience to climate change.

Foundation Paper Two, *Land and Biodiversity Victoria: The Science, Our Private Land Holders, Incentives and Connectivity* provides a detailed discussion on many of the issues presented in 1.2.

Context

Victoria is the most cleared state in Australia.[19] Since European settlement of Victoria, over half of the state's native vegetation has been removed, chiefly for the purposes of agriculture and urban development. Much of this clearing occurred before 1989, after which broad-scale clearing of land was banned. Indeed, up until the 1980s, farmers were even encouraged by the government to actively clear their land.[50]

1.2.1 Protection of areas of high natural capital

Preservation of protected areas is a fundamental component of biodiversity conservation,[51] and therefore of supporting ecosystem resilience. In Victoria, our National Parks and State Parks have typically been less exposed to the stressors that threaten ecosystems, which increases the likelihood that those areas are more resilient to other impending stressors like climate change.[52]

In that context, the National Reserve System is a good example of a 'climate-resilient' strategy for ecosystems. Climate change will, however, 'challenge the ability of the current reserve system to provide protection when the climate shifts so much that plants and animals no longer thrive where their current reserves are located'.[52]

Globally, even as protected areas are expanding, biodiversity continues to decline.[53] This is because protected areas generally prevent only direct impacts such as land clearing; not indirect impacts like pollution and climate change, which can originate from outside the park boundaries.[54] While setting aside areas for ecological purposes is important, it is not enough by itself. It is also important to ensure the quality of these ecosystems is maintained.

See 1.1, 1.3 and 1.4 for further discussion of these issues on public land. The remainder of 1.2 will focus on these issues pertaining to private land.

Wildflowers, central Victoria

1.2.2 Protection on private land: permitted clearing and landholder obligations

Almost two-thirds of land in Victoria is privately owned, and just 20% of this private land retains its native vegetation. Revegetation of farm land in southern Australia has been shown to yield great benefits for biodiversity and ecosystems.

For example, by increasing the amount of native vegetation on a property from 4% to just 8%, populations of woodland birds increased by about 25% over a period of eight years.[55]

Primary producers can benefit from improvements to their local ecosystems, such as those shown in Figure B.1.1.

Change[56]	Effect	Benefit
Encouraging more native fauna	Reduction in insect pests	Less need for chemical sprays
Establishing wind breaks	More sheltered crops and livestock	Greater yields
Establishing more shade	Cooler body temperature for stock	Greater yields of milk, wool, meat
Maintaining remnant vegetation	Improved property landscape and aesthetics	Potential for recreational opportunities and increased property values

Figure B.1.1: Benefits to primary producers from local ecosystem improvement

1.2.3 Permitted clearing: recent reforms to regulations

DEPI has recently reformed permitted clearing regulations.

In September 2012, DEPI undertook a public consultation process that received 182 submissions[149] from a variety of sources, including academic institutions, catchment management authorities, local government, community groups, peak industry bodies and individuals.

Significant changes to policy governing clearing of native vegetation were announced in May 2013. The reforms were scheduled to commence in September 2013 – when the Victorian Planning Provisions (VPP) and all planning schemes are amended – as this report was going to print.

The previous policy (Native Vegetation Management: A Framework for Action) had been reasonably effective at reducing the removal of native vegetation, although the ultimate goal of a net gain each year was not being met. DEPI reported an overall net loss of 4,090 (± 20%) habitat hectares per year (which accounts for both area and quality).[57]

The Second Approximation Report is due to be released late in 2013 and will provide a quantified measure of the effectiveness of native vegetation management since 2008.

Road to Nhill

1.2.3.1 Objectives of the reforms

The recent reforms have removed 'net gain in the extent and quality of native vegetation' as an overall objective of native vegetation management (State Planning Policy Framework (SPPF), clause 12.01-2). The new objective is 'to ensure that permitted clearing of native vegetation results in no net loss in the contribution made by native vegetation to Victoria's biodiversity' and that the reform 'creates the framework for permitted clearing to have a neutral impact on biodiversity'.[58]

There are serious objections raised in relation to this shift.[59, 60] Concerns from both academic institutions and CMAs are that the reforms focus too heavily on reducing cost, both to government and landowners, rather than focusing on maintaining and improving Victoria's biodiversity. Furthermore, the aims and actions of the review conflict with the underlying intent of Victoria's permitted clearing regulations to achieve 'no net loss'.

1.2.3.2 Contributions of native vegetation to broader environmental outcomes

The Victorian Government suggests that the changes help clarify the objective of the permitted clearing regulations and introduce 'a more stable, equitable, predictable and transparent system and has measurable benefits for both the environment and industry'.[61]

However, in doing so, it also overlooks the contributions of native vegetation to other environmental benefits – such as water quality, land protection and social and cultural values.

According to DEPI, the Biodiversity clause in the permitted clearing regulations is deliberately limited to the state's expectations regarding biodiversity to avoid confusion and duplication with objectives that are appropriately dealt with elsewhere within planning schemes. Other benefits from native vegetation (or disbenefits from its removal) remain in the VPP, including in the SPPF. This includes:

- elements of the SPPF relating to environmental risks (13-03-1 Soil degradation; 13-03-2 Erosion and landslips); natural resource management (14-02-2 Water quality); and Environmental and landscape values (12-04-3 Landscapes)
- other objectives within clauses 52.16 and 52.17, including land and water protection, identified landscape values and Indigenous cultural heritage.

While some of these other values of native vegetation are included in the Purpose of Clause 52.17 as DEPI asserts, these are not explicitly linked to the objectives of the permitted clearing regulations.

Government reference to 'relative biodiversity values'[58] affirms these concerns. The methods that will be used to assign 'biodiversity value' under the proposed changes are unclear.[60]

NaturePrint (see Foundation Paper Two, *Land and Biodiversity Victoria: The Science, Our Private Land Holders, Incentives and Connectivity*) is promoted as a key tool of the reforms. Although it is an innovative mapping and modelling tool with many benefits and of scientific merit, NaturePrint is purely biodiversity-based and does not include aspects such as the loss of visual amenity, cultural heritage, land protection and water quality objectives.[62]

1.2.3.3 Assessing sites before the removal of native vegetation

Changes to how sites are to be assessed are also potentially problematic. The reforms endeavoured to reduce the burden of the permitted clearing regulations by removing the need for on-site assessments in the case of low-risk removals of native vegetation. These assessments will now be done exclusively using mapped data (employing tools such as NaturePrint).

This presents two key issues:

- the criteria for determining 'low-risk' removals of native vegetation
- the danger of relying on mapped data alone without the verification of on-site inspections.

The criteria for determining low-risk

Firstly, areas that already have depleted biodiversity values may be determined to be low risk. However, the biodiversity values that remain may be very important for the local community and may in fact warrant a greater level of protection rather than a reduced level of protection. Studies have highlighted the importance of also conserving and improving the quality of smaller vegetation patches[63, 64] or individual trees.[65] Furthermore, individual acts of low-impact clearing can be collectively significant.[66] The reforms could result in incremental clearing of these 'low-risk' situations based on the development of a simplistic system.

Biodiversity is fundamental to ecosystem resilience. The Australian Institute of Landscape Architects present the considered view that 'Rather than allowing incremental clearing in all "low-risk" situations such as urban settings and putting all of our efforts into high risk/strategic areas such as conservation reserves, we should endeavour to protect and enhance a mosaic of quality and extent across the Victorian landscape which is far more likely to be developed through the rigour and imperfection of the current native vegetation permitted clearing regulations than the proposed reforms.'[67]

Glenelg Hopkins CMA also raised the concern that 'Much of the Victorian Volcanic Plain (VVP) has not been surveyed and many of the EVCs are inaccurate. There is a risk in classing this area as low-quality vegetation as more of the VVP grasslands will be lost despite the presence of significant species such as the Striped Legless Lizard.'[62]

There is a further complication in that key decision criteria are focused largely on threatened species and not biodiversity as a whole, and the importance of ensuring that 'common' species persist. Vegetation classified as 'low-quality' could be important habitat for local fauna.[60]

According to the Interdisciplinary Conservation Science Research Group (RMIT University): 'Small patches and corridors of vegetation not only provide habitat for a number of species persisting in highly fragmented landscapes, but have been found to compliment [sic] conservation objectives for large reserves.'[59] This can be achieved through a combination of providing connectivity[68] and keystone resources[69] for a number of species and ecological communities. Studies have also highlighted the importance of placing a high value on native vegetation irrespective of its size and of not biasing conservation objectives towards patches that are large in extent.[70, 71]

Grasses, western Victoria

Relying on mapped data without the verification of on-site inspections

Secondly, there is a risk that relying on mapped data alone will fail to account for small but important variations – for example, that one particular cluster of trees might provide habitat to a community of a threatened species when a similar nearby cluster does not. The metadata contained within these digital datasets is too coarse to be applied at the scale of individual properties. NaturePrint has a resolution of 75 m × 75 m, whereas much of the clearing and biodiversity values considered under the permitted clearing regulations operate at a finer scale than this.[60] Even the 'Introduction to NaturePrint: A blueprint for nature conservation' published by DEPI cautions that: 'care should be taken when using the maps at fine scales such as parcels, properties and paddocks'.[72]

In addition to the level of accuracy of the proposed mapping and modelling tools, the Australian Institute of Landscape Architects raised a number of additional questions and concerns regarding a shift to relying on mapped data:

> **Will the tools be available for use by the proposed date for assessment changes? Ecological systems are temporal, not static, and can change within a few years; therefore, how regularly will information be updated and how will the tools adapt to changes in environmental conditions and land uses? How will the data be populated and kept up to date? Furthermore, how are assessors (mainly Councils) meant to use these tools? It may be difficult for Councils to incorporate the local spatial data on indigenous vegetation into NaturePrint, due to the lack of standardised approaches to data collection. What funding will be available to facilitate this action?**[67]

At a minimum, a discretion available to decision makers inserted into the regulatory framework as to what kind of assessment process is sufficient and required would be advisable. That may include the use of digital data or on-ground ecological assessments or, further, some form of social or cultural assessment.

1.2.3.4 The importance of retaining the avoidance hierarchy

Administrative efficiency has been introduced through the new policy, which is likely to make it more user-friendly for those clearing land and those providing offsets. The regulations also remove the previously existing hierarchy of first avoiding the clearing of native vegetation, then minimising the clearing, and finally offsetting that which cannot be avoided.

The purpose of the avoidance hierarchy was to ensure a precautionary approach to proposals to clear native vegetation.

That was not always the case in practice. An analysis of applications under the previous system shows that only 3% of initial applications to remove vegetation were refused, and 70% of these refusals were then overturned at VCAT.[73]

A greater reliance on offsetting approach assumes that biodiversity restoration projects are adequate substitutes for avoiding the loss in the first place. There is no scientific evidence to support this, and indeed offset projects typically result in a loss of overall biodiversity.[74] At best, new plantings will only provide adequate habitat decades into the future when the ecosystem has matured, but even this overlooks the importance of population dynamics across shorter time scales.[75]

A perceived shift away from the principles of 'avoid' or 'minimise' provoked a great deal of concern among submissions in the public consultation process from both the community sector and scientists:

The North Central CMA region is significantly cleared and it is considered reasonable that efforts are made to avoid clearances, minimise impacts and/or contribute to a 'net gain'. Allowing the removal of native vegetation, in circumstances where it is deemed to have no significant impact on Victoria's biodiversity, does not reflect due consideration of the smaller isolated remnants that occur and are significant at a regional scale. These pockets of native vegetation may be important for connectivity, visual amenity or land protection.[76]

North central Victoria

The majority of clearances under the permitted clearing regulations opt not for replanting, but for protection of existing native vegetation. This means that rather than establishing new vegetated areas, the offset instead creates long-term protection for another piece of native vegetation, often several times larger than that being cleared. The consequence is that permitted clearing regulations inevitably lead to an overall loss of native vegetation.

It is critical that the risk factors used to calculate the area of offset required be reconsidered. A recent study[77] found that to ensure no net loss in the population of a single frog species that lived in an area being developed, a habitat offset 19 times larger than the original habitat was needed. While each clearing and each species will be different, the proposed risk factors of 1.5 and 2 (i.e. somewhat less than 19) may well be far too low to achieve effective biodiversity protection.

1.2.3.5 A purpose-built information system

It is important to acknowledge that DEPI has committed to improving the information system to support the reforms to the permitted clearing regulations: 'Proposed action 2.1: Develop a purpose built information system that measures biodiversity value and prioritises locations across the state for conservation. This system can inform application assessment pathways, decision making guidelines and offset requirements.'[58]

DEPI currently collects information on permits that are referred to DEPI (as a referral authority) and on all offsets that are recognised as credits by the native vegetation credit register. The new online Native Vegetation Information Management (NVIM) system, which will be rolled out to support the reforms will expand the collection of information to include the permits granted by local government that are not referred to DEPI. The supporting reforms, which form part of the reforms to Victoria's native vegetation permitted clearing regulations, include clear commitments regarding the collection and reporting of information regarding the reforms to Victoria's native vegetation permitted clearing regulations.

However, if this information system is based primarily on modelling, it is erroneous to state that it 'measures biodiversity value' – rather it estimates or models biodiversity value.[60] Furthermore, it is critical that complementary databases are aligned with the NVIM to maximise information sharing and analysis. For instance the Victorian Biodiversity Atlas (VBA) needs to be adequately resourced for all essential database management tasks such as data capture, quality control and assurance, maintenance and updating; and the extent of native vegetation that is cleared for the purpose of bushfire protection also needs to be analysed comparatively with the NVIM.

RECOMMENDATION 3

It is recommended that the Victorian Government protect native vegetation on public and private land by amending permitted clearing regulations.

ATTRIBUTES

The amendments will include:

- **recognising the contribution of native vegetation to all ecosystem services**
- **expanding the tools for clearing application assessments to include ground-truthing at all scales**
- **a requirement that all applications outline the steps that have been taken to avoid and minimise the extent of native vegetation that is proposed for clearing.**

1.2.4 Permitted clearing: an alternative to the current offsetting framework

Conventional offset schemes such as that prescribed by the State Planning Policy Framework are effectively a 'lending bank' where the loans are never fully repaid by developers, and the unaccounted for costs are borne by society as a whole through reduced ecosystem services.

An alternative to this conventional model is a type of scheme that has been described as a 'biodiversity savings bank'.[75]

The administrative efficiencies of the recent reforms could be maintained, but trades will only be allowed once the 'evidence for the expected environmental benefits is beyond reasonable doubt'.[75] Trades that adversely affect critical habitat for listed threatened species, or that add to an already high risk of extinction, will not be allowed.

The biodiversity savings bank could be linked to carbon bio-sequestration programs like the Federal Carbon Farming Initiative, with the added advantage that this would ensure bio-sequestration plantings are undertaken to maximise biodiversity as well as carbon capture – ensuring greater diversification rather than the current reliance on monoculture plantations.

There are international examples of viable biodiversity savings bank models. In the US, there are a broad range of systems implemented from conventional offsetting models to successful biodiversity or conservation savings banks.[78]

A key phase of establishing a biodiversity bank in Victoria will be to transition the existing BushBroker program to become a key platform for the new savings bank. BushBroker is the flagship mechanism of government for facilitating offset deals among buyers and sellers of native vegetation offsets. BushBroker is an innovative program that warrants its good reputation but could still be improved by consolidating the proliferation of separate schemes (within some individual councils and also individually brokered deals) that duplicate effort and defy tracking and coordination.

A new savings bank would require government leadership and the consolidation of schemes into an improved BushBroker program could then be expanded to become a one-stop shop for accreditation and monitoring of offset deals for native vegetation clearance.

BushBroker could be linked with the new online NVIM, enabling the tracking of all legal clearing of native vegetation where:

- planning authorities register all applications for clearing
- approved applications are listed
- clearings are detailed (locality, area to be cleared, vegetation type to be cleared, etc.) and the offsets that are required
- permitted clearings' accredited offset deals can be verified
- reporting at various geographic scales (council area, catchment management region, statewide) can occur to enhance future planning and policy development.[66]

Wattle Newstead

1.2.5 Additional requirements for native vegetation protection

Victorian landowners have duty-of-care requirements established by the *Catchment and Land Protection Act 1994*. Section 20(1) requires landowners to take all reasonable steps to:

- avoid causing or contributing to land degradation which causes or may cause damage to land of another landowner
- conserve soil
- protect water resources
- eradicate regionally prohibited weeds
- prevent the growth and spread of regionally controlled weeds
- prevent the spread of, and as far as possible eradicate, established pest animals.

What remains unclear is where action by land managers crosses the threshold from being something that meets these basic legal requirements and something that ought to be supported by government incentives.[13]

The vast majority of Victorian landowners are very conscious of their duty-of-care obligations and the impact that their actions have on local ecosystems. However, while many individual actions by landowners (and developers) may appear to have relatively minor impacts, collectively 'traditional' activities undertaken can have significant impact on our ecosystems. Some of these activities include:

1. Cattle grazing in national parks
2. Licences for crown river frontage grazing
3. Greenfields mineral and gas exploration
4. Uncontrolled prospecting in National Parks
5. Inappropriate tourism and development in National Parks.

There is much discussion among experts and the community about the impacts of these activities, and they need to be reconsidered, their management modified.

The final point (5) was recently the subject of an impassioned plea by some of Victoria's most esteemed scientists and academics, including Sir Gus Nossal AC, CBE, Professor Barry Jones AO and former chairman of the Victorian Environmental Assessment Council Duncan Malcolm AM, JP.[79] They express deep concerns about the National Parks Amendment (Leasing Powers and Other Matters) Bill before State Parliament: 'The most insidious of these intrusive uses are the proposals of the Victorian Government to lease areas within our national parks for up to 99 years to encourage commercial development by private corporations.'

The Office of the Victorian Government Archietect (OVGA) argues strongly that any built intervention must complement environmental, Aboriginal and historic cultural heritage and other values, and must be subject to design review by the OVGA's Victorian Design Review Panel during the project process to provide qualitative review.

1.2.6 Increasing native vegetation on private land

Beyond the duty-of-care obligations, DEPI has a number of programs that are designed to provide incentives to private landowners to increase the extent to which they manage their land for ecological outcomes.

The two key programs provide payments for taking measures that improve the quantity (extent) and quality of biodiversity, as well as its security:

- BushTender aims to improve high-priority native vegetation and biodiversity by providing a new source of income to landowners.
- EcoTender provides a broader framework and covers aspects of land and water management that result in environmental improvements, and is not limited to native vegetation. Outcomes can include, for example, improved hydrology or reduced levels of salinity.

These programs use an auction-based approach, wherein landowners offer to undertake specific activities for a specific price. They are established with the help of a site assessment by DEPI field officers. The government then selects the tenders that represent best ecological value for money.

The lack of funding for long-term monitoring of projects such as those funded under these schemes means that it is hard to assess the effectiveness of this investment (see 1.1 for further discussion).

Indeed, the lack of funding more generally is the primary limiting factor with programs like BushTender and EcoTender. There is currently no ongoing State Government funding, and the programs only operate cyclically as money becomes available. Generally, the schemes do not cover labour costs or opportunity costs associated with the conservation work undertaken. This means that, while cost-effective for the government, the schemes do not provide full compensation for the conservation value being provided in return by landowners. In the longer term, this failure to provide full compensation may result in diminished interest in the programs.

Although an economically efficient way of achieving incremental improvements in local biodiversity, as part of a new funding model it is critical that the government further explore ways in which the private sector can be encouraged to provide financial support to these schemes – in particular as they link to strategic landscape-scale projects such as wildlife corridors (see below).

While DEPI does make an effort to inform landowners of the incentives, and previous tenders have been fully subscribed, there is scope for more effective dissemination of information that is more readily understood.

Of course, promoting greater uptake is only of use if there is sufficient funding to enable that uptake. And while revegetation may not be as ideal as retaining vegetation in the first place, there are other activities that landowners can commit to under EcoTender that can make major contributions to ecosystem health. In addition to dealing with pest plants and animals, fencing off livestock from waterways (and allowing regrowth of native riparian vegetation) yields significant benefits to ecosystem services – especially to water quality (see 1.1).

Finally, these market-based mechanisms, which foster competition between landholders, often create tension with the community cooperative (e.g. Landcare) model of conservation, which relies on volunteerism, reciprocity and trust. Both approaches have merits, but the possible tension between the two needs to be managed to avoid 'crowding out' by the government:[80]

> '… environmental policy design should proceed with caution in the presence of intrinsic motivations. Weak regulations and small, competitive financial incentives have the greatest potential for negative effects. Recognising and supporting existing efforts can crowd in, rather than crowd out, voluntary contributions.'[81]

1.2.7 Improving connectivity

1.2.7.1 Strategic design of biolinks

Victoria has a highly modified and cleared landscape, and beyond protecting existing areas of high natural capital, we need to ensure these areas are well connected.

Biolinks, or wildlife corridors, can play an important role in allowing the migration of species and the mixing of genes, which in turn contributes to the resilience of the species[82] – in particular, resilience to the impacts of climate change.

Specifically, as temperatures rise, many species are expected to migrate south or to higher elevations. Obviously this is a major problem for many of our species – those that already live in our alpine areas cannot go much higher,[83] and those in southern coastal areas cannot move any further south.[84, 85, 86]

Excellent work is being done to establish wildlife corridors throughout Victoria, at both small and large scales. Much of this is on private land by volunteer groups,[87] with funding from both public and private sectors.

While individuals and community groups can and do play an important role in performing this work, the government's role of strategic leadership is critical in determining how and where biolinks are to be established.

While there are several schools of thought regarding the best structure of biolinks,[52] it is critical that projects that receive public funding comply with a broader strategic direction for connectivity throughout the state, and beyond state borders. To that end, the National Wildlife Corridor Plan sets out a number of guidelines for biolinks.[88]

- Building wildlife corridors across Australian landscapes is a cooperative endeavour.
- Corridors are to be designed and implemented in ways that benefit local communities.
- Healthy, functioning landscapes require connectivity at a variety of scales.
- Effective corridors connect the landscape across a mosaic of land tenures and land uses without affecting property rights.
- The design and location of corridors are to be based on the best available information derived from scientific research, traditional Indigenous knowledge and practitioner experience.
- Corridors are to be designed to assist native species' adaptation to the impacts of climate change.
- Corridor design recognises and manages for potential risks such as those posed by invasive species and fire.

Case Study: Gondwana Link[89]

Gondwana Link is a landscape-scale conservation project in the ecologically significant south-west corner of Western Australia. It extends for 1,000 km from the western edge of the Nullarbor Plain to the wet forests of the Margaret River region, consisting of 12 smaller area programs fitting together to produce a large landscape change.

Figure B.1.2: Gondwana Link[90]

The aim of the Gondwana Link project is to reconnect fragmented ecosystems, and to protect, restore and maintain the fundamental ecological processes that underpin these ecosystems.

The project commenced in 2002 as a collaboration of key groups before the small coordination unit became a not-for-profit company, Gondwana Link Ltd, in 2009. Lead groups in the project are Bush Heritage Australia, Greening Australia, the Wilderness Society, the Nature Conservancy, Fitzgerald Biosphere Group, Friends of the Fitzgerald River National Park and Green Skills.

The project is being achieved through a range of activities, including:

- developing the case for stronger protection of the public land estate
- providing incentives for better land management, such as fencing and restoring bush land
- purchasing bush land to protect and manage
- purchasing and revegetating large areas of cleared land
- developing ecologically supportive industries, such as commercial plantings of local species
- working to achieve social, cultural, and economic change where this strengthens support for ecological values.

Lessons learnt and challenges for Victoria

The following challenges were identified and addressed by the scientific and strategic planning undertaken in developing Gondwana Link:

- Fine-scale spatially explicit planning across complex landscapes
- Factoring in specific impacts of climate change and the potential synergistic effects of climate change and other land cover changes
- Accommodating unforeseen emerging opportunities.[91]

Foundation Paper Two, *Land and Biodiversity Victoria: The Science, Our Private Land Holders, Incentives and Connectivity* includes a chapter on biolinks (Chapter 6) and a case study on the Werribee River biolink with reference to other Victorian projects.

Gondwana Link is showcased here as an example of a landscape-scale initiative. A critical obstacle for Victoria in establishing a similar project is the significant fragmentation across the state in comparison to Western Australia. However, Habitat 141, which crosses the South Australian border with Victoria, is a good example of a successful, local north–south corridor initiative.

Establishing biolinks can also potentially result in adverse socioeconomic impacts – chiefly concerning land-use opportunities (such as loss of future opportunities for agricultural use or peri-urban development).[92] These impacts need to be addressed in the planning of large-scale connectivity projects, but the initial step is to identify the scientifically optimum biolinks and prioritise them before allowances are made for socioeconomic factors. Furthermore, these allowances need to be clearly stated and justified.

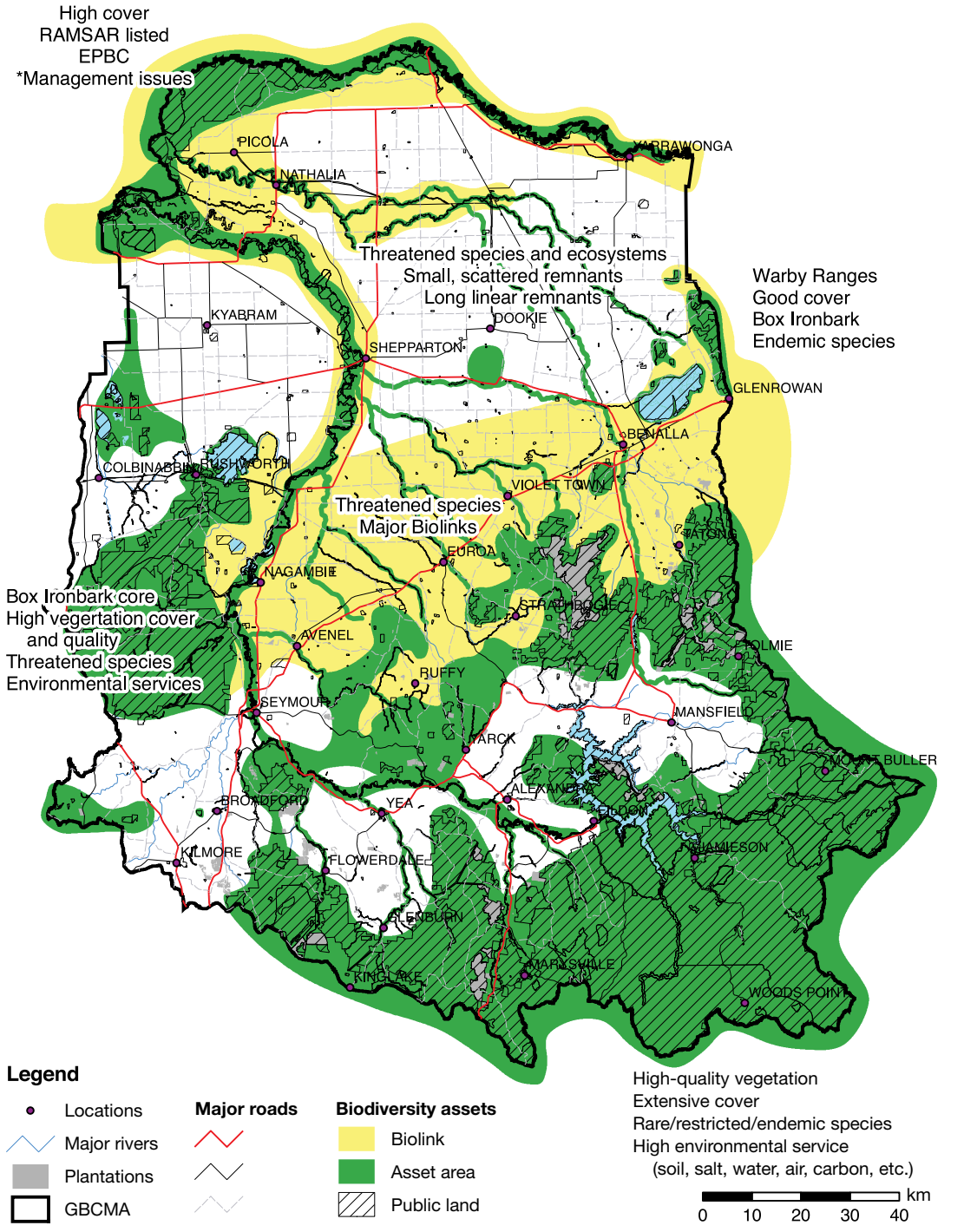

Figure B.1.3: Biodiversity assets for Goulburn Broken Catchment, Victoria, 2010–2015

Source: www.gbcma.vic.gov.au.

There has been a trend across Australia of governments increasingly relying on private individuals and groups to perform conservation work (explored further below). With that reliance in mind, maps that establish connectivity priorities can be seen as setting the broader framework within which community groups can operate – rather than perceived as government controlling, or centralising, conservation efforts.

It is also important that the community understands the overall objectives – including the need to collect data from these projects to assess the effectiveness of the efforts.

RECOMMENDATION 4

It is recommended that the Victorian Government integrate and sponsor efforts to develop biolinks at different scales.

ATTRIBUTES

To achieve this, the Government will need to ensure scientific oversight and community engagement to:

- **evaluate effectiveness of current private land funding models and programs to deliver ecosystem services**
- **publish all evaluations publically**
- **establish funding mechanisms (including market-based initiatives) based on this evaluation**
- **assist Victorians to access Federal funding opportunities**
- **provide logistical support to landowners and community (including ongoing monitoring).**

1.2.7.2 Delivery of biolinks and community involvement

Community consultation is a key element in the design, development and implementation of biolinks. Volunteer efforts are the bedrock of biodiversity conservation in the private sphere. It is critical that community groups are drawn into a meaningful collaborative ethic and that they retain a sense of 'ownership' of their work.

Community groups such as Landcare play a key role in supporting individual landowners, so it is important for projects to be locally owned and driven. Revegetation projects may be geographically isolated (such as a farmer planting a row of trees as a wind break), or they may be part of a large, strategic wildlife corridor.[93]

The government needs to facilitate and support this community involvement, and does so through state-funded Landcare facilitators.[94] There are also federally funded Landcare coordinators focusing on the Carbon Farming Initiative.

While these geographically based coordinators are critical, there is also a need for coordinators focusing on key themes, such as Indigenous participation, urban and coastal Landcare and youth involvement. Funding for these roles was a 2010 state election promise, but they are yet to be created.

In addition to Landcare groups, Victoria also has 13 Conservation Management Networks. These are intended to bring together private landowners, public authorities (such as CMAs) and the wider community. Typically, these networks focus on a local ecological community, and so far they have had success in achieving good biodiversity outcomes.[95]

In Victoria there are over 300 ‘Friends of’ organisations and many other small community groups such as field naturalist groups. Larger organisations such as the Victorian National Parks Association and Birdlife Australia also play a major role. This broad diversity of community volunteer efforts needs to be supported.

Hindmarsh planting day – Landcare from the bush to the city

The government can also work to consolidate, galvanise and harmonise these groups and promote collaboration where possible. Biolink projects present a great opportunity to bring together diverse community groups and harness their understanding of integrated NRM at a landscape scale.

Nationally, the Australian Biodiversity Conservation Strategy identifies engaging all Australians as a major priority. It aims to achieve this by mainstreaming biodiversity, increasing Indigenous engagement, and enhancing strategic investments and partnerships. The strategy has set a target of a 25% increase in participation in biodiversity conservation activities by 2015 (from 2010).

Government promotion of landscape renewal best practice is also critical. As the incentive programs have now been established and implemented for a decade, there are many examples of Victorian farms that can be showcased to demonstrate the environmental outcomes.

A key feature of this will be to demonstrate the advantages of retaining and/or restoring native vegetation. Partnerships with universities or other research organisations could be established to conduct experiments that look to test guidelines for how much land on a farm could be devoted to conservation.[96]

The techniques implemented by the farm would be selected based on their capacity to demonstrate a maximising of ecosystem function while maintaining productivity, also taking into account associated issues such as soil health and the impacts of conventional food production methods (see Part B: 2.1 Sustainable Food Systems).

1.3 Effective Protection and Delivery of Environmental Water

Proposition

As the global climate changes, environmental baselines will no longer be stationary but change over time with patterns of rainfall and drought in south-east Australia. At the same time, water demands will change as human settlements expand and many river systems will suffer from high levels of consumptive water use.

In creating the Environmental Water Reserve (EWR), Victoria has made great progress in defining and delivering water to ecosystems. However, the greatest portion of the EWR is also the most vulnerable to change. To protect waterways from the pressures of over-extraction we need to provide greater legal protection to the water already in the EWR, expand the EWR where appropriate and use effective water accounting to address problem areas.

Context

Healthy rivers and wetlands (referred to as waterways) support ecosystems and provide a home for species important to Victoria – such as river red gums and the Murray cod. Appropriate flows of water through waterways are essential to ensure proper ecosystem function. Water thus provides numerous ecosystem services that are essential to our society. It underpins critical elements of the economy: agricultural production, tourism and recreation.

1.3.1 The importance of environmental water in providing ecosystem services for all Victorians

Boosey Creek, north-east Victoria

Appropriate flows of environmental water carry out a number of functions:[97, 98]

- stimulate animals like native fish to feed and breed (to do this cod and yellowbelly fish need to be able to move on to floodplains)
- trigger plants to seed or germinate (river red gums need flooding for seeds to germinate)
- move carbon (important for food chains) between rivers, floodplains and estuaries
- allow fish and plants to move about the river system and colonise new areas
- help restore groundwater supplies
- stabilise river banks through better vegetation growth, reducing erosion into the river
- flush out the salt along river banks and floodplains
- prevent toxic blue–green algae blooms
- provide social and recreational uses such as boating and fishing.

The importance of environmental flows has been clearly demonstrated in the past decade. The Murray Hardyhead (a freshwater fish endemic to the lower Murray–Darling river system in South Australia, Victoria and New South Wales) is one of the most highly threatened fish in Australia. In 2008 the remaining populations were under threat from lack of water, driven by a decade of drought and greatly exacerbated by river regulation on the Murray, which was impairing breeding by severely disrupting connectivity between populations.[99]

In this case, a suite of actions were taken to enable breeding and protect the species, including provision of environmental water and significant earthworks. These responses were, however, beset by tensions between government and the irrigator community. Rather than environmental water being delivered to habitat areas as a matter of procedure, it required the intervention of the Victorian premier.[100]

1.3.2 Threats to environmental water

The threats to future water resources in Victoria are:

- reduced rainfall and inflow under a changing climate
- land-use changes (for example, forest plantations on previously unforrested land can reduce the amount of rainwater reaching waterways)
- declining groundwater and water-quality impacts, including pollution, bushfires and salination.

A changing climate in south-eastern Australia will increase the uncertainty of supply (see Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State Of Play*, Chapter 4) and compound the problems caused by over-extraction.

Recent projections of climate change impacts in the region estimate that for 1°C of warming, average annual rainfall is expected to decline by 0–9% – this reduction is expected to double with 2°C of warming.[101]

In many cases most of the Environmental Water Reserve is water left in rivers after other uses have been met. As a result, reduced flows caused by climate change disproportionately affect this water. For example, in the dry years of the Millennium Drought up to 95% of water was extracted from the Campaspe River system for towns and irrigation, greatly intensifying the pressures of drought on the environment.[97]

Modelling of the environmental flow components of the Campaspe led to the conclusion that, even under baseline conditions, there are many occasions when the minimum flows needed to sustain populations of Murray cod are not achieved.

If conditions of either moderate climate change or the low inflows of the drought years are assumed, then environmental flows become even lower. Without some form of intervention, it is unlikely that the river will be able to support natural populations of native fish.[102]

1.3.3 National Water Initiative

Action on environmental water has been led at the federal level by the National Water Initiative (NWI), guided by the National Water Commission (NWC), which oversees framework development and reports on implementation. The NWI seeks to improve productivity and efficiency while 'establishing clear pathways to return all systems to environmentally sustainable levels of extraction'.[103]

All states and territories were required to develop an implementation plan to meet commitments under the National Water Initiative (2004). Victoria's plan was accredited by the National Water Commission (NWC) in 2006.

In it, the government committed to:

- protect and where necessary repair stressed rivers and groundwater systems – the natural source of all our fresh water – by giving them legal water rights and conducting restoration works
- price water to encourage people to use it more wisely
- permanently save water in our towns and cities, through commonsense water-saving and recycling measures
- secure water for farms through pioneering water allocation and trading systems
- improve monitoring and reporting on the quantity and quality of the state's water resources.

1.3.4 Water rights

The agencies in Victoria responsible for allocating and delivering environmental water are:

- the minister for water, who has broader water allocation responsibilities under the Water Act
- the minister for environment and climate change, who is responsible for the environmental watering policy framework
- DEPI, which manages the water allocation and entitlements framework, develops state policy on the management of water resources, waterways and environmental water, and has oversight of the Victorian Environmental Water Holder (VEWH)
- VEWH, which decides on the most effective delivery of water and communicates those decisions; is responsible for public engagement; and commissions projects to demonstrate ecological outcomes; and drafts annual watering plans developed in consultation with, and delivered by, waterway managers
- waterway managers (Melbourne Water and catchment management authorities), which identify regional priorities; undertake local flow studies, monitoring and reporting; and propose annual environmental watering actions to VEWH
- water corporations, which provide infrastructure (dams and irrigation) to hold and deliver environmental water; and ensure all passing flow commitments are delivered.

There are four different types of 'rights' to take water in Victoria, these are issued as entitlements:

- bulk entitlements
- environmental entitlements
- water shares
- water licences.

In addition to issued entitlements, sections 8.1 and 8.4c of the *Water Act 1989* allow individuals to take water for domestic and stock purposes.[104]

In regulated rivers (where water is held in storage), rights to use water exist as bulk entitlements and are held by water corporations in perpetuity.

Within these bulk entitlements, water shares are allocated, urban customers are supplied and licences for irrigator usage are issued. Water-use licences do not specify a volume for use, only the conditions under which water can be used.

At present there are around 38,000 water shares in the state with a market value of over $4 billion.[105] In groundwater and unregulated rivers, consumption of water is limited by permissible consumptive volumes (PCV) and sustainable diversion limits (SDL) respectively. These aim to prevent extraction of water that will damage the environment. However, limits on use often reflect historical allocation rather than a sustainable level of use for that river.

In areas of the state that fall within the Murray–Darling Basin, water use is also limited by the Murray–Darling Cap – a limit that was set at the volume that was extracted in 1993–94. Any new water shares or water licences cannot exceed these limits. In 2019, this cap will be replaced by an SDL.

Barmah redgum flooding 2011

1.3.5 Sustainable water strategies

Management of water in Victoria is guided by the regional sustainable water strategies (SWSs). These documents, produced between 2006 and 2011, describe the water supplies and requirements of four regional areas (Central, Northern, Western and Gippsland), as well as outlining current policy and challenges for issues such as changing land use, future threats to water supply or balancing consumptive needs.

Where necessary, the SWSs identify unregulated systems that are designated Water Supply Protection Areas (WSPAs). These are areas that are highly flow-stressed and require a statutory management plan to address problems of over-use.

The Victorian Government has introduced measures to prevent future over-allocation of water systems (incorporated into the regional SWSs), and has made significant investment in recovering water for environmental use. There are, however, still problems with pressures from existing over-allocation.[106]

While Victoria does not issue new water licences that exceed the various allocation caps, it is a key feature of the state water allocation framework that the rights of existing water users be protected.[15] When addressing the sustainable use of water, government plans specifically state that interventions should not affect existing water users (e.g. Northern Region SWS).

This policy applies even in river systems that are potentially over-allocated, such as the Campaspe.[97, 102]

The present State Government position is that it does not explicitly identify systems as over-allocated. Instead, it manages the needs of the environment through the WSPA designation.

To date, the government has not provided data to the NWC on over-allocated systems in the state. However, the NWC identified 18 water systems in Victoria that are listed as WSPAs and, by implication, were over-allocated and/or overused in 2011 – rising from a total of nine in 2009.[107] This increase is a result of greater recognition of system stress as SWSs are implemented.

1.3.6 Defining environmental water

The *Australian Environmental Water Management Report 2010* (NWC 2010) uses a commonly agreed definition of environmental water: 'Environmental water is the water regime provided to achieve environmental objectives.'

The pressures on environmental water were brought acutely to the fore during the prolonged dry conditions that Victoria experienced between 1997 and 2009. The Millennium Drought served to exacerbate the stress that many water systems were under due to high levels of extraction for consumptive use.

In response, reforms to the *Victorian Water Act 1989* in 2005 established the existence of the Environmental Water Reserve.

The Environmental Water Reserve (EWR) is made up of three parts:

- **Environmental entitlements (or held water):** This water has the same legal status as other bulk entitlements (e.g. water rights held by water corporations). It is the only part of the EWR that can be stored and actively managed,
- **Obligations on bulk entitlements (or planned water):** Water that can be destined for consumptive use (some passing flows are primarily for environmental outcomes) but must provide minimum flows at determined points to meet environmental needs, and
- **Above-cap water:** Water that remains in excess of all other entitlements and cannot be kept in storage. Above-cap water comprises the largest portion of the EWR and is the most susceptible to natural variation and climate change.

Environmental entitlements have identical legal status to bulk entitlements for consumption and represent water that is effectively 'owned' by the environment. In 2009, this portion represented 6% of the total EWR[13] and is likely to have increased since then.

Some bulk entitlements specify that passing flows are reduced or stopped when inflows fall below a certain level.[102] These conditions are likely to become more common in a changing climate.

There is more protected water available for environmental flows than in the past. However, because of the relatively high vulnerability of most of the EWR and the possibility that, in future droughts, environmental water could be used to bolster consumptive requirements at the expense of waterway health, there have been calls for a greater protection of environmental water outside of environmental entitlements.[108]

In addition, a changing climate means that we can no longer rely on past trends of rainfall and drought to predict future conditions, and this is to be recognised when setting and reviewing targets for environmental flows.

Irrigation channel water wheel north-east Victoria

1.3.7 The Victorian water law review 2014

A review of the Victorian water law, due in 2014, intends to investigate the effectiveness of current water allocation and management arrangements. The review seeks to simplify the current framework 'without adversely impacting on current entitlements', suggesting that it is unlikely to recommend the reduction of existing consumptive entitlements.[109]

However, the potential exists to reclaim water from consumptive use through mechanisms such as the sustainable water strategies purchase. These can set targets for water to be recovered via purchase on the water market.

It is critical that the review explicitly assess the potential outcomes of reducing consumptive entitlements through purchase.

Non-entitlement water in the EWR does not have equal legal status to water managed by the VEWH. This water (planned and above-cap water) is the most vulnerable to decreased flows in a changing climate.

It is important that any planned water listed as part of an environmental entitlement remains a part of that entitlement.

Where planned water cannot be converted to environmental entitlements, legal protection could still be ensured so that, when they are reduced in dry years, the impact on the previous beneficiaries (including the environment, and downstream domestic and stock users) is offset by the water corporation that receives the extra water.

This approach was applied by the government during the drought and makes sure that any consumptive reduction to passing flows during drought is not cost-free to users of the extra water.

The State Water Accounts provide a good tool for monitoring how water has been delivered and compliance with passing flow requirements, The government could push for the rapid release of these accounts to identify any problem areas in a timely manner, and be prepared to take enforcement action for any breaches.

RECOMMENDATION 5

It is recommended that the Victorian Government improve the protection of the existing Environmental Water Reserve.

ATTRIBUTES

Protection would be improved by:

- **defining types of water outside environmental entitlements (e.g. planned water, conveyancing water, evaporation, flood) that cannot be managed**
- **identifying physical and policy barriers to efficient delivery of water options for managing non-entitlement water for environmental outcomes**
- **providing clear requirements to comply with terms and conditions of both bulk entitlements and environmental entitlements and include penalties for non-compliance**
- **including the conversion of non-entitlement water to environmental entitlements, with oversight of delivery passed to the VEWH where the conversion benefits the environment, water can be managed effectively and there is no impact on the reliability of water availability**
- **retaining any planned water listed as part of an environmental entitlement as part of that entitlement.**

Yarra River Parks Vic cleaning activities

1.3.8 Formation of the VEWH

Once environmental entitlement to water had been established, the need for an independent decision maker to guide the use of water drove the formation of the VEWH through an amendment to the Water Act. The VEWH began operation in 2011.

The VEWH was established to hold and manage environmental water entitlements and is not involved in defining water entitlements and allocations[110] (see 1.3.4 Water rights).

The purpose of the VEWH is to manage the environmental water holdings to:

- maintain the Environmental Water Reserve in accordance with the Environmental Water Reserve objective
- improve the environmental values and health of water ecosystems, including their biodiversity, ecological functioning and water quality, and other uses that depend on environmental conditions.[110]

The Victorian model has key differences to other existing water holding entities (such as the Commonwealth Environmental Water Holder):[100]

1. **Management focus:** The VEWH owns a large water portfolio and is responsible for efficient, accountable and effective management rather than further water recovery, making the VEWH unique among environmental water management organisations.
2. **Increased independence:** There is a limit on the power of the environment minister to direct the actions of the VEWH; and its corporate form provides the VEWH with legal standing and the ability to enter into contracts in its own right.
3. **Increased flexibility:** Under its legislation, the VEWH may be able to trade water more freely than other government-funded agencies.

1.3.8.1 Delivery of environmental water

The VEWH works closely with waterway managers (Melbourne Water and the catchment management authorities) to produce seasonal plans for water delivery, and is a unique statutory environmental water management body in that the environment minister cannot direct its actions in respect to delivery or trade in water.

In 2011–12 (the first full year of operation), 92% of planned priority watering actions were fully or partially achieved by the VEWH and waterway managers.[111] However, it should be noted that this was a year of particularly high rainfall.

Total delivery across the state was 516,000 ML of water to 35 river reaches and 10 wetlands. Some key outcomes from these deliveries include:

- The first environmental water release into the Yarra, which maintained water quality and improved habitat for fish. Sightings of Australia grayling suggests successful upstream migration (see Case Study: Yarra River Environmental Flow Management).
- Inundation of Lake Carpul (a northern wetland) – an event that has not occurred since 1993. The lake is dominated by a black box community that generally requires inundation every one in eight years. Without the 2,062 ML of environmental water the lake would have continued to decline. This water made sure the environmental values were maintained while the CMA investigated a works program to make future watering more efficient. Over 20 species of waterbirds were recorded.
- Provision of environmental water to the Wimmera–Mallee wetlands through the Wimmera–Mallee Pipeline. This action supported a local population of Australian painted snipe (a nationally vulnerable and state-listed threatened species) and a variety of locally significant animals.

Case Study: Yarra River Environmental Flow Management

The water holdings in the Yarra River consist of:

- 17,000 ML per year
- minimum passing flows at various points along the river
- 55 ML per year in the Yarra River downstream of the confluence with Olinda Creek.

Objectives

The water holdings are used to provide a range of specific flow events in the Yarra River. These flow events have been identified by the Yarra River Environmental Flow Study,[112] a scientific study that considers the stream-flow-dependent environmental values of the Yarra River and the water required to support them.

The environmental flow objectives identified for the Yarra River include:

- Maintain channel geometry throughout all reaches.
- Improve access to suitable habitats for fish and macroinvertebrates by providing flows that scour sediment from pool and benthic surfaces in riffles.
- Maintain longitudinal connectivity for fish passage.
- Increase the zone of flood-tolerant vegetation on banks by drowning terrestrial vegetation encroaching on banks.
- Ensure minimum flows do not cause flow related declines in water quality.
- Preserve inundation of wetlands and floodplains.

Actions

Each year Melbourne Water submits a Seasonal Watering Proposal for the Yarra River that outlines the priority watering actions for the upcoming year. Following inclusion in the Seasonal Water Plan by the VEWH, Melbourne Water is issued with a Seasonal Watering Statement that enables them to deliver the Yarra water holdings in accordance with the Seasonal Watering Plan.

Management of the water holdings includes actions such as:

- Releasing specific flow events into the Yarra River for environmental benefit.
- Placing a temporary ‘cease to harvest’ order on the Yering Gorge pumps to allow stream flow to pass through the system.
- Working with storage operators to maximise the environmental benefit of operational releases of water into the Yarra River.

In 2012–13 Melbourne Water released 12,693 ML of water into the river for various environmental flow events into the river including:

- A winter flow event targeted at scouring sediment from the bed of the stream to improve habitat for fish and macroinvertebrates.
- Two summer flow events aimed at improving water quality and providing connectivity between habitats for fish and macroinvertebrates.
- An autumn flow event targeted at the spawning of Australian grayling, a native threatened fish species.

Water Holdings throughout the state are managed adaptively, allowing the delivery of the entitlement to be tailored to the prevailing climatic conditions and new knowledge gained from the monitoring and evaluation of previous flow events.

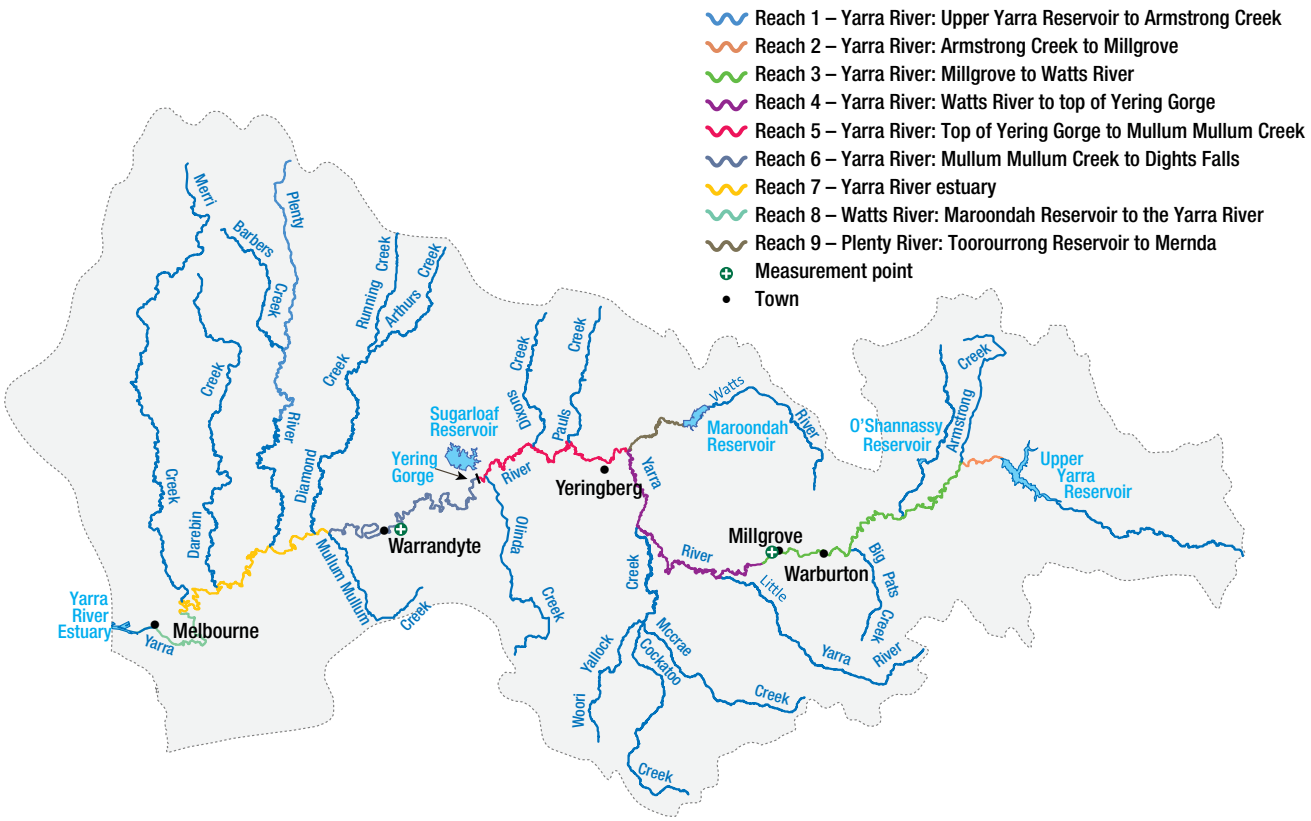

Figure B.1.4: The Yarra system showing the different 'reaches' of the river

The reaches are essentially the management units of the system, with each reach having specific flow recommendations.

Low flows	Low flows generally provide a continuous flow through the channel. This may either maintain the flow above a 'cease to flow', or provide habitat as a change from 'high flows'.	Connects in-stream habitats and can have benefits for other system users, such as providing water for livestock.
Freshes	Small or short-duration peak flow events. These are flows that exceed the base flow and last for at least several days. Freshes are a key contributor to the variability of flow regimes, providing short pulses in flow.	Helps to maintain or improve water quality and prevents algal blooms from occurring.
High flows	Persistent increases in the seasonal base flows that remain within the channel. High flows do not fill the channel to 'bankfull'.	Allows for fish migration and enhances recreational fishing opportunities.

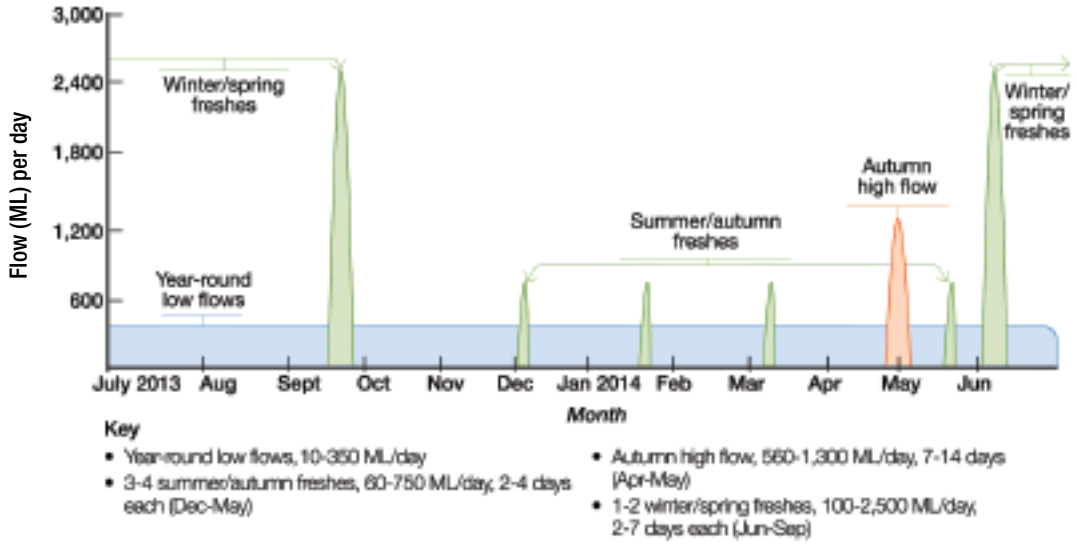

Figure B.1.5: Priority watering actions in the Yarra system 2012–13

This illustrates the range of watering events Melbourne Water could have supplied under the Seasonal Watering Plan.

1.3.8.2 VEWH activity in the water market

In managing its water holdings, the VEWH has access to the market in water shares and water allocations. It is able to engage in temporary trade of water holdings in order to meet its objectives.

In 2011–12, the VEWH sold 12,000 ML of allocation across several systems.[111] Proceeds from the sale of water are used for future watering priorities for waterways and direct environmental outcomes in rivers and wetlands. This may include funding the delivery of environmental watering actions, purchasing water allocation at a different time – or in a different system, or funding works and measures to improve water-use efficiency.

In this way, the VEWH can use trade to actively improve its overall objectives of improving environmental conditions. For example, the VEWH used sale funds to make a joint purchase – with Melbourne Water – of an additional water entitlement in the Werribee Basin, increasing the water available for priority watering actions in the winter of 2012.[113]

The need to achieve value for money in its management decisions creates an incentive for the VEWH to consider the marginal benefits of either using its water or using the funds generated by sale of the water. When the marginal benefit of selling the water and investing in an alternative activity is greater than using the water directly, it is reasonable to expect that the VEWH would sell. This capacity to sell water to achieve alternative benefits (such as infrastructure investment to improve efficiency of environmental watering, or investment in some of the many other elements of environmental health in aquatic ecosystems) extends the role of the VEWH beyond merely the provision of environmental water.

In time, this may lead to competition between the waterway managers for access to available water resulting in a de facto extension of the role of the VEWH into broader aquatic ecosystem management, by rewarding those waterway managers who best achieve efficient environmental watering through integrated catchment management.[100]

The most recent research in the Southern Murray–Darling Basin by the NWC[114] concluded that: 'Water markets are making a major contribution to the achievement of the [National Water Initiative]'s overall objective of optimising the economic, social and environmental values of scarce water resources.'

The VEWH is able to act in the state and interstate water markets to manage the EWR and there is scope for investigation on how water holdings can be best managed through those markets, particularly in dry years.

Research focusing on the Murray–Darling Basin has been undertaken by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) – investigating how sophisticated market transactions can be used to improve environmental outcomes.[115] CSIRO models the environmental flow outcomes of using time-limited products, such as entitlement leasing and options contracts.

Products of this type allow private entitlement holders a greater sense of security while still allowing water to be used for environmental purposes at optimal times. Indeed, trading by the VEWH is in allocations, which is temporary trade.

Further research will provide useful insights into the optimal balance between the various forms of water products and irrigator attitudes to using the water market in this way. This can inform the government's ability to develop sophisticated trading products, such as time-specific leasing, to manage environmental water.

1.3.9 Future challenges – monitoring and demonstration of outcomes

It can be difficult to determine the extent to which planned environmental water is being made available, as most reporting methodologies are established to monitor water managed through entitlement provisions.

In the long term, it is critical that the VEWH demonstrate the benefits of environmental watering, in terms of both the maintenance of healthy waterways and the benefits and services that we accrue from them.

Research

Outcomes for environmental water delivery are based on environmental objectives used to set delivery of volumes of water. Therefore operational plans for releases of water would best be guided by an extensive research program to maximise those outcomes. Targets would also incorporate input from community engagement to identify benefits taken from waterways and community-identified values that would be improved by investment.

Long-term research, guided by the VEWH, could be conducted into strategies for the most efficient delivery of water for the provision of ecosystem services.

It would also be advisable to assess strategies such as the creation of dedicated infrastructure and the use of sophisticated water market products.

Water landscape Murchison north-east Victoria

Monitoring

Maximising the efficiency of water delivery in providing outcomes will depend on demonstrating the effects of those deliveries. DEPI has a monitoring system for assessing the response of rivers to environmental watering and is developing a similar system for wetlands.[17] This can form the basis of long-term monitoring of the outcomes of environmental water delivery – the benefits generated, and the identification of problem areas.

Effective delivery, accounting, research and monitoring will ultimately identify systems where ecological outcomes are not being met. The VEWH and water managers can drive the process of improving outcomes either through investment in restoration or infrastructure, or securing additional water for these systems.

Target setting

Each site that is provided with environmental water has specified environmental objectives that are set annually. Examples of these outcomes that the VEWH are seeking from 2012–13 to 2015–16 include:

- increased fish, bird and bird breeding pairs
- improved water quality
- increased diversity of aquatic species
- regeneration of riparian vegetation.

Providing environmental flows will require considerable investment and it is crucial, therefore, that the benefits can be observed. This requires an effective ecological monitoring program that can demonstrate effective use of the water holdings and is supported by timely and transparent reporting.

To this end, the Victorian Government has developed and is undertaking the Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP),[116] and is developing a similar program to monitor wetland responses to watering.[15] These programs will provide a sound scientific basis for the link between particular flow components and the ecological response.

To further improve knowledge of ecosystem responses, waterway managers carry out targeted ecological monitoring following environmental water deliveries and provide the information to the VEWH (see Case Study: Yarra River Environmental Flow Management).[117]

Effective delivery, accounting, research and monitoring will ultimately identify systems where ecological outcomes are not being met and could be the focus of future investment.

Wimmera River

RECOMMENDATION 6

It is recommended that the Victorian Government use research and monitoring to protect environmental water and set targets.

ATTRIBUTES

Statewide water targets are best established through a consideration of ecosystem services benefits. Targets would be reviewed and updated regularly using a transparent framework.

Indicators to measure progress towards targets are:

- **environmental flows necessary to maintain services**
- **waterway health**
- **standard indices of water health**
- **social and recreational benefits.**

1.4 Review of Impacts on Ecosystems Due to Planned Burning

Proposition

Large bushfires in Victoria can have severe impacts on life, property, communities and ecosystems, and it is necessary that the government act to mitigate risks. Climate change is likely to increase the risk of fires.[118]

The fuel reduction target of a minimum annual rolling average of 5% of public land recommended by the Victorian Bushfire Royal Commission (VBRC) was largely intended to improve protection of life and property in the event of a very large fire. It is possible that this target will not provide the level of protection assumed by the public and it is ecologically inappropriate for many ecosystems, leading to substantial damage to biodiversity and ecosystem functions.

The rezoning of planned burning zones to elevate the priority of asset protection may act to compound environmental damage.

Ultimately, there would be a risk-based management approach to fire prevention. The use of planned burning for fuel reduction would be one tool among a wider set of options.

Context

The Victorian Bushfires Royal Commission (VBRC) was convened in the tragic aftermath of the 2009 Black Saturday bushfires. The Victorian community sought to learn from those experiences to minimise bushfire losses in the future.

1.4.1 A future bushfire regime that protects life, property and ecosystem services

Alongside a focus on preparedness, response and recovery, the VBRC considered how the state would use land and fuel management to reduce the risk of very large fires.

A range of recommendations in the VBRC final report suggested the State Government:

- burn an average of 5% of public land annually to reduce fuel loads (Recommendation 56)
- report on the outcomes of that burning (Recommendation 57)
- upgrade current monitoring programs to assess the outcomes of planned burning on biodiversity (Recommendation 58)
- amend the Code of Practice to include a risk analysis model for planned burns with a clear set of risk-reduction objectives, expressed as measurable outcomes (Recommendation 59).

While the findings of the VBRC were welcomed and DEPI is making progress in the development of risk frameworks and reporting outcomes, criticism of Recommendation 56 has continued.

A 5% target is an unfortunate compromise that may not provide a significant increase in asset protection. At the same time it will result in a high rate of burning that will be detrimental to many Victorian ecosystems.

This problem is compounded by the revised management zones in the Code of Practice. Previously, the Code of Practice differentiated between zones where burning was carried out for asset protection and where it was justified primarily on ecological grounds, The management outcomes for these zones have now been reclassified to effectively give primacy to asset protection in order to meet the 5% target.

The target of yearly burning on 5% of all public land statewide is too blunt an instrument. A preferable option, echoed by the VBRC implementation monitor, is that government develops clearly articulated planned burning objectives for asset protection and ecological management. Furthermore, annual targets for these need to be based on sound evidence and clearly separated at the local scale. Any statewide target would be the sum of these regional targets and not vice-versa.

1.4.1.1 Impacts and losses from severe bushfires

Bushfires are a fact of life in Victoria and have played a central role in the evolution of the landscape over millions of years. However, while fires are crucial for the functioning of indigenous ecosystems – such as dry eucalypt forest – severe fires can lead to very large losses. These are losses in terms of life and property – with all their attendant secondary impacts – and also to the ecosystem services on which our society depends.

Some of the major fires of the last 20 years have inflicted significant initial impact* on ecosystems. The largest of these have been defined by the Bushfire CRC as 'severe' due to the magnitude of their impacts.

The most severe fires experienced in Victoria in recent years were the Black Saturday fires of 2009. These fires caused some of the most considerable loss of life and property in recent history. Other fires, including the Ash Wednesday fires of 1983, also caused major losses.

Victoria has also experienced severe fires that, while not causing major damage to life or property, have severely impacted on ecosystem services.

The Great Dividing Range fires (1996–97) and alpine fires (2003) each caused losses valued in excess of $2 billion.[120] The large majority of these losses were from primary production in the form of forestry losses but other ecosystem services were affected, such as the availability and quality of water in catchments.

* It is important to distinguish between the considerable initial impact of a major fire, and the well-documented capacity for long-term recovery if there is no subsequent fire. Generally the natural environment has been able to accommodate occasional 'catastrophic' fire (though that capacity may diminish considerably in isolated, fragmented or already degraded ecosystems). On the other hand, while a single low-severity burn may have little initial impact, high frequency low-severity fire has the potential to radically alter many EVCs. In this respect, note the FFG Threatening Process listing of 'High frequency fire resulting in disruption of life cycle processes in plants and animals and loss of vegetation structure and composition'.

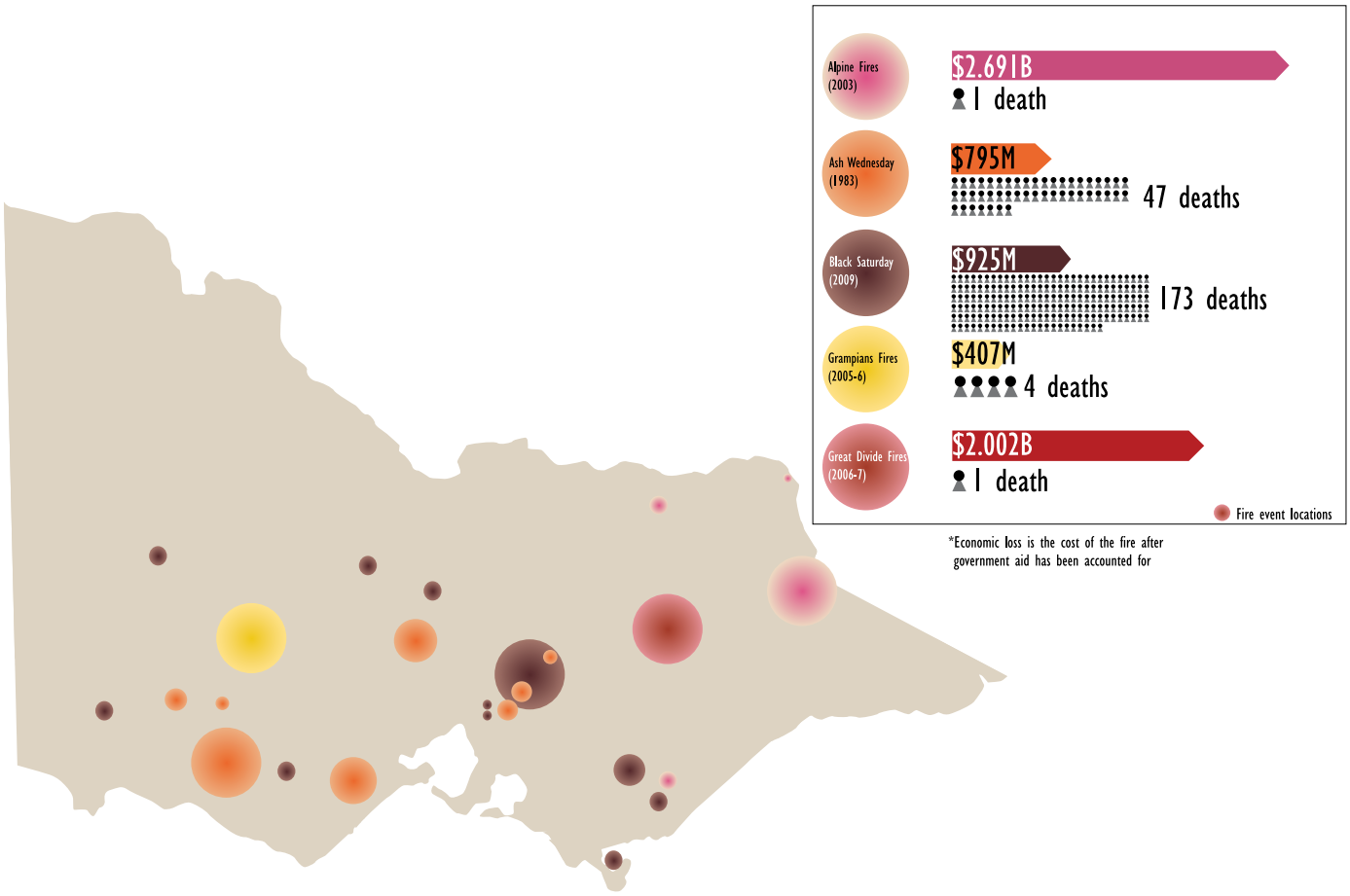

Figure B.1.6: Bushfire-related deaths and economic losses

Source Bushfires CRC.

The effect of the 2003 alpine fires on hydrology was observed in subsequent years. There has been an initial increase in streamflow in burnt areas but it is expected that there will be a subsequent reduction as the forest re-establishes – leading to long-term reduction in water available for consumptive use.[121] EPA monitoring also noted that water quality was negatively affected in burnt areas over the same period.[122]

As the Australian climate changes, fires are expected to become more frequent and, if there is no intervention, increase in severity.[123] Since populations in fire-prone areas are growing, managing the impacts of fires has never been more important.

1.4.1.2 Risk-based fire planning

Fire cannot be eradicated from the landscape, and it serves as an ecological process, so it is essential to develop effective management strategies that allow fire to carry out its ecological function while reducing the impacts of severe fires.

This can be best achieved through risk-based planning. This approach identifies assets in need of protection. This could include:

- property
- agricultural land
- ecosystems that provide services such as clean water
- fire-vulnerable areas of high conservation value (such as rainforest)
- areas of high tourism value.

Risk-based planning assesses the likely risks to these assets from uncontrolled bushfires, often using sophisticated modelling that incorporates landscape elements and fire behaviour. Management treatments, including planned burning for fuel reduction, are then deployed to reduce risks to acceptable levels.

This approach promotes a desired outcome. Complexity arises when outcomes require conflicting treatments. Often ecosystem assets can be under-represented in risk frameworks due to a lack of high-quality information on risks from fire.

DEPI's Future Fire Project[124] is working to provide recommendations on a methodology for defining and evaluating theoretical landscape-scale fire management options that deliver desirable outcomes for sustaining biodiversity and ecosystem services, as well as meeting community needs for protecting human life and property.

1.4.1.3 VBRC and the 5% burning target

The state has always taken measures to reduce bushfire risks through a range of strategies, including planned burning to reduce flammable material (and thus the likelihood of a severe fire).

This management technique received significant attention in the aftermath of the Black Saturday fires.

In the 20 years before 2009, the area of planned burning on public land was between 50,000 and 150,000 ha annually (between 0.6 and 2% of all public land).[125]

After consultation with an expert panel and representatives of the forestry industry, the Victorian Bushfires Royal Commission (VBRC) concluded that this burning level was insufficient to significantly reduce risk to life and property from major fires.

Ultimately the VBRC recommended an annual rolling target of burning of 5% (390,000 ha) of public land (Recommendation 56).* The aim of this recommendation was to reduce fuel loads across the entire state and so decrease the incidence and intensity of bushfires.

This recommendation was accepted in principle by the then Labor Government and it continues to be adhered to under the Coalition Government. Both governments have increased resource allocation annually to increase planned burning activities towards the long-term goal of 5% public land.

To this end, in 2011–12 DEPI completed planned burning of over 197,149 ha, representing the most extensive burning on public land since 1991[127] despite the unusually wet weather.

1.4.1.4 Impacts of planned burning

Meeting a rolling annual target of burning on public land will expose some areas of the state to a higher frequency of fires than have historically been achieved through planned burning.

This may be suitable for some open forest and shrubland systems that have relatively high frequencies of recurring fires (e.g. 10–30 years)[128] – indeed the VBRC expert panel recommended 5% annual burning of stringybark foothill forests.[129]

However, this target cannot be extended to other natural ecosystems in the state, which are less well understood and have different fire dynamics. For example, the average fire interval for mountain ash forests is 35–75 years.[130]

* VBRC Recommendation 56 is 'The State fund and commit to implementing a long-term program of prescribed burning based on an annual rolling target of 5 per cent of public land.'

Land managers use the tolerable fire interval (TFI) to assess suitable burning frequencies for natural systems. This is based on the assumption that the ideal interval between fires for any given vegetation community is in the range between the maximum interval – a frequency that allows constituent species to reach maturity and set seed – and maximum interval – the longest time possible before there are species extinctions in the absence of fire.

There are a range of habitat types in Victoria that have minimum TFI for low-intensity fires of less than 20 years (e.g. foothills forest, grassy forest, box/ironbark, grasslands). Conversely there are also several habitats with minimum TFIs of 30–80 years (Mallee Saltbush, closed forest, mist forest, high-altitude shrubland and woodland).

Planned burning of 5% of public land would likely be achieved with varying fire regimes across the state, meaning that some ecosystems would be exposed to a longer interval between fires.

However, if large areas of public land are burnt at a rate that far exceeds natural regimes, there are likely to be numerous impacts on biodiversity and ecosystem function (see Case Study: Fire Regimes and the Birds of the Mallee).

Research conducted in the Mallee has examined the outcomes from hypothetically achieving the 5% target in that region. This work found that, if implemented, burning would be nearly treble the historic rate of burning from bushfires and planned burning combined (Figure B.1.7).[131]

Furthermore, attainment of the target excludes anticipation or incorporation of burning from unplanned bushfires. This means that to experience any natural fires would result in a total burnt area that is potentially even greater than projected figures.

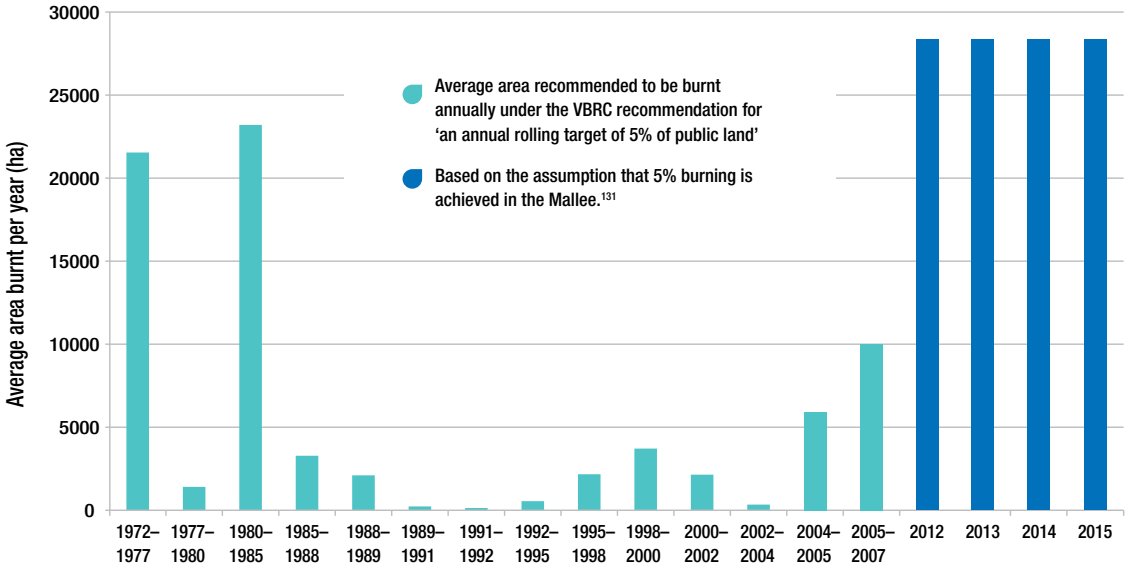

Figure B.1.7: Average area burnt per year by bushfires and planned burning in the Mallee region between 1972 and 2007 (lighter bars) shown with the average area recommended to be burnt annually under the VBRC recommendation for "an annual rolling target of 5% of public land" (darker bars)

Ultimately, adopting the recommended burning regime may lead to the burning of habitat that is predominantly in the early stages of generation (less than 20 years) since the last fire. This will disadvantage some species such as the Mallee fowl, which requires habitat that has remained unburnt for periods of greater than 60 years.[132]

It is also important to recognise that inappropriate fire regimes are a listed threatening process under the Victorian *Flora and Fauna Guarantee Act 1988*, potentially placing government burning programs at odds with conservation objectives.

Case Study: Fire Regimes and the Birds of the Mallee[133]

In semi-arid Mallee ecosystems, management that results in large proportions of recently burnt vegetation (e.g. by burning 5% of the landscape annually or permitting reserve-scale bushfires), or a high local diversity of age classes, will negatively affect more bird species than they would aid.

Management strategies that promote particular age classes (i.e. mid-age and older vegetation) are likely to benefit bird species.

Incorporation of species-specific knowledge from a landscape perspective can refine management strategies and assist in defining the characteristics of 'desirable' fire mosaics for maintaining biodiversity.

An inflexible burning target fails to recognise the importance of this sort of information.

Birds at Nhill Mallee

1.4.1.5 Changing the nature of fire management

The state Bushfire Plan includes the DEPI Fire Protection Plan, which covers fire prevention by DEPI. DEPI's primary objectives for bushfire management are outlined in the Code of Practice for Bushfire Management on Public Land.[134]

Objectives of the code are:

- To minimise the impact of major bushfires on human life, communities, essential and community infrastructure, industries, the economy and the environment. Human life will be afforded priority over all other considerations.
- To maintain or improve the resilience of natural ecosystems and their ability to deliver services such as biodiversity, water, carbon storage and forest products.

Under the Code of Practice used between 2006 and 2012, planned burning on public land was managed according to the designations:

1. Asset Protection Zone
2. Strategic Fire Management Zone
3. Ecological Management Zone
4. Burning Exclusion Zone.

Zones 1 and 2 were managed primarily for fire protection outcomes. The justification for burning was based on reducing fire risks to life and property.

Zones 3 and 4 were managed for ecological outcomes. While management was expected to contribute to regional risk reduction, burning had to be justified as meeting the requirements for ecosystems within the zone.[135]

Zones were intended to be managed in such a way that multiple objectives for asset protection and ecological management could be achieved in areas with an appropriate weighting according to the type of zone.

In 2012, the Code of Practice was revised and the Ecological Management Zone designation became the Landscape Management Zone. This expanded the purpose of planned burning in the Ecological Management Zone to give bushfire protection outcomes equal weight with ecological requirements.[136]

While the 2012 code still advocates multiple outcomes, the dominant need for public safety after the 2009 fires has allowed for biodiversity outcomes to be downplayed.

As a result of these changes, planned burning that is potentially ecologically inappropriate could be carried out if it contributes to overall targets for asset protection.

1.4.1.6 An alternative risk-based fire management strategy for Victoria

Specific criteria for assessing risk have not been specified by the VBRC, but DEPI has made significant steps in establishing risk management processes – recognised in the 2013 annual report from the VBRC implementation monitor[137] – and, at present, risks to life and property are well quantified.

In contrast, risks from large, uncontrolled bushfires to biodiversity and ecosystem function are relatively undefined and there needs to be extensive further work on incorporating this into fire management regimes.

Victoria requires a clear distinction between reasons for establishing burning regimes in asset protection zones (reduction of risk to life and property) and ecological management zones (what ecological asset or process will be put at risk if burns are not carried out; and how the regime is ecologically appropriate).

The Victorian Government needs to set targets for planned burning using clear distinctions between burning intended to protect asset values and that intended for ecological purposes. Appropriate zones for these outcomes would be set and risks assessed using relevant criteria and metrics, and based on appropriate criteria and zoning (striving, wherever possible, to achieve both objectives),

When assessing risk, there is an acceptance that some areas will always have a relatively high incidence of fire and, as such, be high-risk areas for habitation. When members of the public choose to live in these areas there needs to be clear communication of the attendant risks and tools available for assisting residents to understand and accept personal responsibility for fire preparedness.

A fully realised risk-based fire management strategy may require planned burning for fuel reduction near settlements, including risk reduction on farmland. This is often unpopular and expensive. Fire suppression strategies, including burning, are considerably more expensive when carried out in populated areas and it is important that appropriate resourcing is addressed.

Overcoming resistance to this will require a substantial public information campaign illustrating the damaging effects of some burning programs and realistic assessments of risk reduction under the current system.

Fighting fire

RECOMMENDATION 7

It is recommended that the Victorian Government implement a risk-based fire management strategy defining planned burning targets on public and private land, incorporating protection of financial, environmental and cultural assets.

ATTRIBUTES

This strategy would include:

- **a withdrawal of support for planned burning on an annual average of 5% of public land**
- **targets for planned burning that:**
  have clear distinctions between burning intended to protect asset values and ecological burning, supported by an amendment to the Code of Practice, and;
  include areas burnt by bushfires
- **implementation on both public and private land**
- **a range of fire risk-reduction methods including, but not limited to, planned burning, land management, fire preparedness, strategic town planning and zoning decisions.**

1.4.2 Identifying risks from fire

The final report of the Bushfires Royal Commission Implementation Monitor (BRCIM) noted the criticisms of Recommendation 56 and the logistical problems with such a substantial increase in planned burning, and concluded that the intention of the VBRC was to effectively reduce public risk from bushfires.

The BRCIM recommended that government 'reconsider the planned burning rolling target of 5% as the primary outcome and considers that the most important objective of the planned burning program must be to address public safety risks'.[138]

This considered view reinforces expert opinion that statewide targets are most effective when they are the sum of evidence-based regional targets, aligned with local objectives of risk reduction that are clearly defined in terms of asset protection or ecological function.[139]

There are potential tensions between managing fire risks and other land management objectives – such as improving native vegetation (which may be fire-prone) or establishing biolinks (which may act to spread fire). These questions will require rigorous scientific research to identify the issues with clarity and to assist policy makers to find the best resolution.

Fire in Victorian landscape

The challenge therefore lies in fully identifying assets of value (life, property, primary production, water, ecosystem health) and incorporating these into an appropriate risk framework for guiding management.

DEPI has begun this crucial work with HawkEye,[140] a targeted monitoring program that aims to assess the biodiversity effects of planned burning. The data produced could act as the basis for including ecological and biodiversity values in future statewide risk assessments.

A risk-based, rather than hectare-based, target for planned burning would align with the remainder of VBRC recommendations on land and fuel management.

1.4.2.1 Reporting the outcomes and impacts of planned burning

The VBRC recognised the importance of fire management to ecosystem functioning and proposed several recommendations to encourage the definition and reporting of outcomes.

- Recommendation 57 required annual reporting of planned burning outcomes – including reporting on risk reduction and biodiversity impacts.
- Recommendation 58 required DEPI upgrade its long-term data monitoring of the effects of planned burning and bushfires on biodiversity.
- Recommendation 59 required clarity in the Code of Practice, defining objectives as measureable outcomes and including an explicit risk analysis model.

Progress in implementing these recommendations has satisfied the BRCIM. However, many of the quantitative elements – such as measurable targets – are still being developed by DEPI.

At the time of publication of this report, there has been no annual reporting of the biodiversity impacts of the burning program. Improving monitoring regimes to comply with Recommendation 57 and inform decision making is a critical gap. A new fire management system that allows managers to map planned burns against biodiversity and heritage information[141] will allow DEPI to start addressing this issue.

RECOMMENDATION 8

It is recommended that the Victorian Government undertake statewide accounting and reporting of the outcomes of planned burning to demonstrate risk reduction to human and ecological communities.

ATTRIBUTES

Accounting and reporting would include:

- **the effects on ecological assets and services from planned burning and bushfires**
- **the risk reduction to life, property, biodiversity and ecosystem function attained by planned burning**
- **reporting in the context of projected losses from actual severe fires (the changes in risk contingent on planned burning or any other intervention needs to be clearly stated)**
- **a regular review of impacts on biodiversity need to be reviewed by an independent body, such as the VBRCIM, to establish appropriate targets for burning in landscape management zones.**

1.4.3 Fire preparedness and management in an appropriate planned burning regime

Information from reviewing and monitoring could be used to create a robust evidence base for a risk-focused fire management scheme that assumes that protection of life and property take primacy.

The Bushfire CRC is an alliance of all the fire and land management agencies in Australia and New Zealand, CSIRO, the Bureau of Meteorology, the federal Attorney-General's Department and several other fire-related organisations.[142] The CRC has produced work that describes how an integrated model for year-to-year fire management – sensitive to local variations in landscape – could include cost-benefit decisions for a range of fuel reduction strategies.

Management that integrates fuel treatment tools and landscape types will:

- include both fuel treatment and suppression deployment decision variables
- incorporate inputs from geospatial databases and fire-behaviour models
- view the landscape based on realistic fuel treatment units.[143]

Planned burning, when guided by appropriate risk management, is an important tool to reduce fuel loads and the intensity of naturally occurring bushfires but it is not be used in isolation.[144, 145, 146]

A risk-based approach to fire management needs to be fully integrated with all existing government interventions intended to reduce exposure in the highest risk areas, for example:

- overlays to restrict building in fire-prone areas,
- the current government buy-back of land where property was burnt in 2009
- public education for preparedness.

Improving and aligning a whole-of-government response to fire management that links fuel reduction and ecological needs will limit the likelihood of inappropriate burning regimes.

RECOMMENDATION 9

It is recommended that the Victorian Government assess options for private land managers for appropriate fire suppression in high-risk areas based on information generated by the CFA Vegetation Management Program.

ATTRIBUTES

This can be achieved as part of the review of CFA operations and processes.[147]

GOAL **TWO** SUSTAINABLE NATURAL RESOURCES

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GOAL **TWO** SUSTAINABLE NATURAL RESOURCES

2.1 Sustainable Food Systems

Proposition

The UN Environment Programme tells us that:

'... [in relation to food security] the current agricultural knowledge, science and technology model requires revision. Business-as-usual is no longer an option.'[1]

Interdisciplinary approaches, including the application of social sciences is necessary.

> **[Such inclusion] recognises the need for systems thinking at multiple levels and over multiple decades. It requires a shift from a narrow focus on production systems to an examination of complete food and fibre systems. It calls for the inclusion of issues of justice, intergenerational equity and inter-species balance.**[2]

Agriculture and food security are critical issues in discussions about environmental sustainability. Natural resources are not unlimited, and in conceiving of food as a whole-system issue we need to understand agriculture as multifunctional.[3] Statistics only tell part of the story.[4]

Context

An inflexible agri-industrial model lacks resilience in the face of climate change (to which Australia will be particularly vulnerable)[5] and projected population increases. We will need to adjust by planning adaptation, become more deliberate in our design of solutions, build on synergies, remain focused on equity and find new ways of ensuring environmental sustainability.[6]

No till farming stubble

2.1.1 Agricultural economy

Food and its production is a touchstone of the Australian economy.

Food and clothing are fundamental requirements of life and our farmers produce most of the food that Australians put on their tables as well as wool and cotton – raw materials for the clothes we wear.[7]

The gross value of agricultural production in 2009–2012 was just under $40 billion.[7] Australia remains a net exporter of food, including wheat, sugar and barley,[8] even as imports of other food stuffs, including fruit and vegetables continue to rise.[9]

Food retailing industries employed 434,000 people and food manufacturing employed 210,000 people across Australia in 2009–2010.[7] In Victoria, over 50% of land (and the vast majority of all private land) is farmed for food or fibre.[7]

The ABS documents the following Victorian agricultural economies (2011–2012):

- agriculture – $11.3 billion
- wheat – $867 million
- canola – $335 million
- grapes – $343 million
- apples – $257 million
- vegetables – $840 million
- milk – $2.5 billion
- wool – $671 million
- cattle and calves – $1.3 billion
- sheep and lambs – $1.1 billion.[10]

2.1.2 Environment and ecosystem services

The use of land for both environmental and agricultural outcomes is complex – requiring trade-offs and creating tensions, while simultaneously food policy and food security is dependent on the ecosystem services that our natural capital and ecological processes provide.[11, 12]

Many different modes of production interest a multitude of diverse consumers across regions and sectors, and we do know that the methods we adopt to grow the food we eat has a massive impact on the environment.[13]

As discussed in Foundation Paper Two, *Land and Biodiversity Victoria: The Science, Our Private Land Holders, Incentives and Connectivity*, ecosystem services are fundamental to sustaining human wellbeing. The environmental impact of farming on ecosystem services in Australia has included:

- the clearing of land for grazing or cropping resulting in the loss of native habitat
- soils eroded and degraded by extensive ploughing and grazing
- water exported from rivers for irrigation
- waterways polluted by agricultural chemical run-off
- an increased nitrogen soil budget[14]
- greenhouse gas emissions attending almost every step of the food production process, including the value-adding processes involved in manufacturing.

Innovative farmers, committed to sustainable outcomes, are working on these issues, facing an array of challenges – from the creep of urban development across arable land to climate change.[15] The community, local government and organised, innovative, food producers and retailers are also contributors to changing the ways we do things. Communities are driving these changes, not just waiting for others to do so.[16] At the extremes, responses to new conditions will include adaptation – which requires intelligent adjustments – or retreat.

Nhill community gardeners

Newstead College vegetable garden

PepperGreen farm, Bendigo

Newstead community garden

Horsham House kitchen garden

2.1.3 The response of the farming community

Broadly, farmers have been concerning themselves with the environmental bottom line, and this interest is illustrated in a number of places, and in the work being done between farming communities and government agencies.

The Environmental Farmers Network, Birchip Cropping Group and Australian Master Tree Growers are prime examples of the sort of research and networking addressing these issues.[17–19]

Examples exist across the agricultural landscape of farmers engaging in 'regenerative agriculture'[20, 21] and seeking to address the legacy of our environmentally unsustainable farming practices. This was outlined in the PMSEIC 2010 report,[9] where the national land and water resources audit tells us that 5.7 million hectares are affected by (or at risk of) salinity, soil acidification impacts 50 million hectares (surface soil) and 23 million hectares (subsurface soil), and erosion continues to be a major issue.[22, 23] Efforts to address these issues include:

- the non-government program Soils for Life,[24] which has received support from Caring for our Country and promoted holistic management
- time-controlled planned grazing (Dukes Plain)
- weed control without herbicide (Shannon Vale)
- strategic earth works to slow water run-off (Three Rivers Station)
- the strategic use of foliar fertilisers (Clover Estate).

The 2013 Winter Edition of *Victorian Landcare and Catchment Management* describes a number of examples of the adoption of more sustainable farming practices.[25]

Project Platypus Landcare near Stawell most southerly stand of buloke and farmers' replanting

Efforts that are not strictly speaking examples of 'regenerative agriculture' are also increasing as farmers make efforts to develop better practices while working within their economic and other constraints. Instances of energy-use reduction strategies appear to be proliferating. Solar panels are appearing on milking and shearing sheds.

One example offers an illustration. Our visit to Boort in 2011 included a visit to Simply Tomatoes, where pesticides and herbicides are no longer used. Drip irrigation has replaced more wasteful use of water. Refrigeration costs are reduced by embedding old shipping containers in the earth to gain a cooling advantage.[26]

Simply Tomatoes container refrigeration, Boort

Other examples are found in a range of settings. For example, the Jigsaw Farms and Dust Busting Croppers are explored in Foundation Paper Two, *Land and Biodiversity Victoria: The Science, Our Private Landholders, Incentives and Connectivity*.

Case Study: Jigsaw Farms helps answer the future farming puzzle

Which is more important for the future – meeting growing global food demands, or improving our performance on managing biodiversity, greenhouse emissions and water quality? Some innovative farmers in Victoria's south-west, adopting a more 'systems' thinking approach, have discovered a pathway that shows us how positive environmental outcomes do not have to be at the expense of increasing on-farm productivity and food production.

It has been suggested that, with some deviations, mixed cropping and grazing farming techniques:

- improve nutrient cycling
- increase spatial biodiversity, resulting in improved outcomes for ecosystem services.[27]

Jigsaw Farms is a 4,900 hectare farming enterprise owned and managed by Mark Wootton and Eve Kantor. Over the past 13 years, Mark and Eve have been striving to build a farming system that brings all the pieces of the sustainable agriculture puzzle together – hence the name Jigsaw Farms.[25]

Mark said, 'We run the farm as a company, but with a family farming model. There are six staff with their young families all involved in Jigsaw Farms. By consolidating farming into a system there is a greater access to capital and agribusiness knowledge and innovation while the social and landscape values of farming are also maintained.'

As owner-managers, Mark and Eve planned to combine a high-productivity sheep and cattle operation, while protecting remnant vegetation and revegetating Jigsaw waterways on a landscape scale. They are aiming for 25% of land being revegetated. They are well on the way, having planted their millionth tree.

Their plantings are a mix of permanent indigenous revegetation, riparian protection (along creeks), wetland protection and farm forestry plantings in corridor belts – managed on a cycle of harvest and replant. Using farm planning principles, the Jigsaw revegetation program has been focused on the 25% of the farm's less productive and degraded soils, which includes areas of salinity and shallow soils.

At the same time, the agricultural production from the remaining 75% of the farm land has increased from 30,000 DSE (dry sheep equivalents) to 70,000 DSE over the past 13 years.

According to Mark Wootton, 'The increase has largely come about as a result of management and structural changes such as improving fertiliser rates, modern perennial pastures, fencing to land type, developing an extensive laneway system, expansion of a deep water storage and reticulation system and continual development of staff to understand the key profit drivers of professional grass growing.'

All of the developments on Jigsaw Farms are done with concern for future sustainability, with Mark and Eve being passionate about tackling climate change. Mark can now claim, 'I've estimated that the emission reductions (carbon absorbed) by our new forests while they are actively growing will outweigh all of the on-farm agricultural emissions, which is about 15,000 tonnes per year of CO_2 equivalents.'

As for local birdlife, local ornithologist Murray Gunn has conducted seasonal bird surveys at Jigsaw Farms since 1998 and has recorded an increase from 49 species to 155, with total number of birds across these species quadrupling. These figures are seen by Mark and Eve as an indicator of improved biodiversity and a vindication of Jigsaw's connected wetlands and revegetation corridors.

Mark observes that, 'The farmers I speak to are keen to explore practical and market driven solutions to climate change and not to focus on the negative. They realise that the world has an increasing demand for food and fibre. They also realise that we are moving at great speed in an increasingly carbon-constrained world. The challenge is to meet this challenge now and to stop just talking about it.'

Mark and Eve are also confident that the carbon footprint of farming can be significantly reduced in the future, while still maintaining high levels of fibre and meat production. While many people ask if it's possible to meet the future challenge of growing more food, reducing emissions and developing sustainable and profitable farms, Jigsaw Farms offers a key piece in solving that puzzle.

Commissioner for Environmental Sustainability visits Jigsaw Farms

Case Study: Dust Busting Croppers – We Can Innovate and Change

Victorian grain growers have demonstrated how far farming systems have come in 30 years. Images of wind-blown Wimmera and Mallee soils darkening the sky above Melbourne in 1983 are a far cry from the current situation. Despite low rainfall during the 2012 cropping season – equal to the rainfall in 1983 – crops generally produced fair to average yields (1.5–2.5 tonnes per hectare in the Wimmera–Mallee) with minimal erosion.

What has changed to make crop production systems better and more resilient? Many things – starting with conservation farming practices. Use of conservation farming practices has been increasing ever since the devastating combination of drought and soil loss of 1983. Farmer groups, in conjunction with Victorian government agronomists, introduced conservation farming practices. Conservation farming practices enable retention of crop residues to protect the soil from erosion, and retention of water and nutrients while managing issues such as weeds and equipment capabilities. The result is that where wind erosion is seen today it is generally in isolated paddocks without crop cover.

Retaining crop residues improves soil function by increasing its ability to store water and retain nutrients, enabling the next crops to use them. Information disseminated about trials undertaken with new crop varieties gives farmers confidence that these will grow using conservation farming methods and encourages them to sow many of their crops under lower risk conditions. Timely control of summer weeds preserves summer rainfall for the following crop, and prevents nutrients being used by weeds. Integrated management of weeds and pests prevents the need for frequent removal of crop residue, protecting the soil from erosion risk and the crop from damage and competition for resources.

Synergy between conservation tillage practices and the more careful use of modern herbicides has allowed cropping farmers to sow a larger proportion of their crops either early or on time.

This has great productivity and environmental benefits, particularly in years with low spring rainfall. This system also allows farmers to gain greater efficiencies of scale to offset against declining terms of trade.

Work by Department of Environment and Primary Industries (DEPI) in measuring and promoting conservation farming practices in northwest Victoria reveals that the proportion of paddocks under conservation management nearly doubled from around 44% in 1996 to over 82% in 2009.

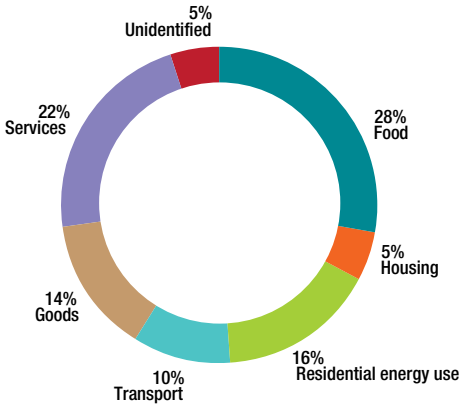
The monitoring of soil management practices promotes more targeted efforts to work with farming groups to protect soil. Areas of bare and high-risk soil in the north-western Wimmera are of higher priority than are those in the south-west, which are of moderate to low soil erosion risk. Communicating activities focusing on the benefits of crop residue retention has involved some novel approaches.

New tools developed by DEPI for working with farmers to protect and maintain soil health demonstrate that retained crop residues reduce erosion and also trap airborne soils and nutrients from distant sources. The erosion fan rig, for example, enables farmers and agronomists to measure and understand the greater protection that retained crop residues provides to productive soils.

2.1.4 The response of consumers – a public opportunity and a community responsibility

Food production is not undertaken in isolation from food choices and food consumption. The food we consume is produced by farming. In 2008, food made up 28%[28] of the average Victorian's ecological footprint – more than any other item of our consumption.[29]

Figure B.2.1.1: Average Victorian's ecological footprint



Making our food ecological footprint sustainable involves us all – not just producers. What follows from this is that the impacts of food production are driven by the demands and needs of consumers.

For our agricultural practices to have a lighter environmental footprint, the public needs to be prepared to adjust patterns of consumption to effect change.

Creation of a sustainable food system relies on addressing every food production-to-consumption step from farm to fork. While we are correct to focus on 'food security' as a 'master frame' for food regimes and systems discussions,[30] this is not simply about producing more food; it is also about environmentally sustainable production methods, equitable outcomes and fulfilling needs.[31]

An effective sustainable food policy would consider a wide range of issues in local – rural and urban[32] – regional and national settings, including:

- what we produce
- where and how we produce it
- how farming communities, farming cooperatives, food companies and retailers influence the system.

The research community is increasingly calling for the study of sustainable food policy, as distinct from embracing 'food security' as a social and economic issue divorced from environmental outcomes.

Interdisciplinary, community-focused, systems approaches which move away from a tight 'productivist' agenda are seen as promoting environmentally sustainable outcomes. This shift is being driven at the national level, and locally it is being forged by the public and agricultural communities. Short-term project funding arrangements with a vertical and agricultural commodity focus and a lack of policy options will not meet the needs of the 21st century.[33]

RECOMMENDATION 10

It is recommended that the Victorian Government develop a comprehensive sustainable food strategy.

ATTRIBUTES

The strategy will promote and plan for the triple-bottom-line outcomes of:

- **what we produce,**
- **where and how we produce it, and**
- **how farming communities, farming co-operatives and food companies, and retailers influence the system.**

Although food 'security' would be considered in the strategy, it would be addressed in terms of environmental sustainability rather than 'productive' landscapes.

2.1.5 Food production opportunities for environmental improvements

Below we explore in summary the possibilities of improving soils, water efficiencies and the reduction of greenhouse gas (GHG) emissions for better outcomes for agriculturalists and the environment.

2.1.5.1 Soil health improvement

The Victorian Government has recently released a Soil Health Strategy to generate knowledge of the environmental impacts of our agricultural practices on soils and improve practice about soil maintenance. Good, healthy soils produce the food we eat. Soils provide ecosystem services that cannot be replicated artificially.[34–37] The strategy promotes an ecosystem services approach to soil management.

It is well recognised that some farming practices contribute to increasing soil salinity and acidification, as well as to erosion and soil structure decline.[34] Combined, these effects have been estimated to cost Victoria over $500 million per year in lost agricultural output.[38] The Soil Health Strategy notes the role of soil in supporting $9 billion worth of agricultural production each year.

Internationally, Cornell University's College of Agriculture and Life Sciences reflects the importance of this sort of work,[39] and nationally the University of New England and others run soil health research programs. Published research tells us that there are both impediments to change and a role for incentives in attaining better outcomes. A well-resourced, scientifically supported Soil Health Strategy is an essential ingredient for improved and more sustainable agricultural practices.[40] The operationalisation of the Soil Health Strategy is a fundamentally important step in promoting sustainable food production practices.

The Victorian Soil Health Strategy arises out of long-term research concerns and in response to a recent report from the Victorian Auditor-General's Office (VAGO) in which a more integrated Soil Health Strategy was recommended.[41]

The Commissioner for Environmental Sustainability endorses the recommendations of the VAGO contained in the report Soil Health Management 2010.

Landslip, west Gippsland

2.1.5.2 Water health – water footprinting

What we do on the land affects the health of our waterways. The interface and impacts are multiple and complex.

For instance, changing irrigation techniques – to centre pivot applications – threaten old-growth singular paddock trees. The removal of these trees impacts bee and bat populations. University of Melbourne researcher Dr Pia Lentini reported to the University of Ballarat Biodiversity Conference (2013) that one single old-growth paddock tree had been the roosting place for 19 different species of bat, all of which had ecosystem services to perform.[42]

More recently, it has been reported that some pesticides are having a major impact on bee populations.[43–46] This deleteriously affects the fundamental ecosystem service of crop pollination, which forms the basis of rural cropping economies.[47] Concerns about pollination are increasingly reported in research.[48]

The 'Apiculture on Public Land Policy' was recently released by DEPI. This policy represents years of research by beekeepers, DEPI and Parks Victoria to improve apiculture management on public land. The policy aims to assist industry expansion, cut red tape and provide beekeepers with greater access to public land.[49]

Excess fertiliser – applied in an effort to address declining phosphorous and nitrogen levels – not only causes soil acidification but also leaches into waterways. Pesticides also run off into and pollute creeks and rivers.[50–53] These chemical applications can have disastrous consequences for aquatic ecosystems, even as they make a valuable contribution to food production.[54–58]

Broadly, agriculture uses 52% of total state water consumption[59] and, as reported in Part A of this report, 75% of the surface water harvested in Victoria is typically used for agriculture.

As the impacts of food production are not just the responsibility of the agricultural community, it is increasingly important for consumers to be aware of the water footprint of food. 'Virtual water' is an estimation of the amount of water required to produce an amount of food. The work of Hoekstra and others has been providing us with water footprinting for the last decade.[60, 61]

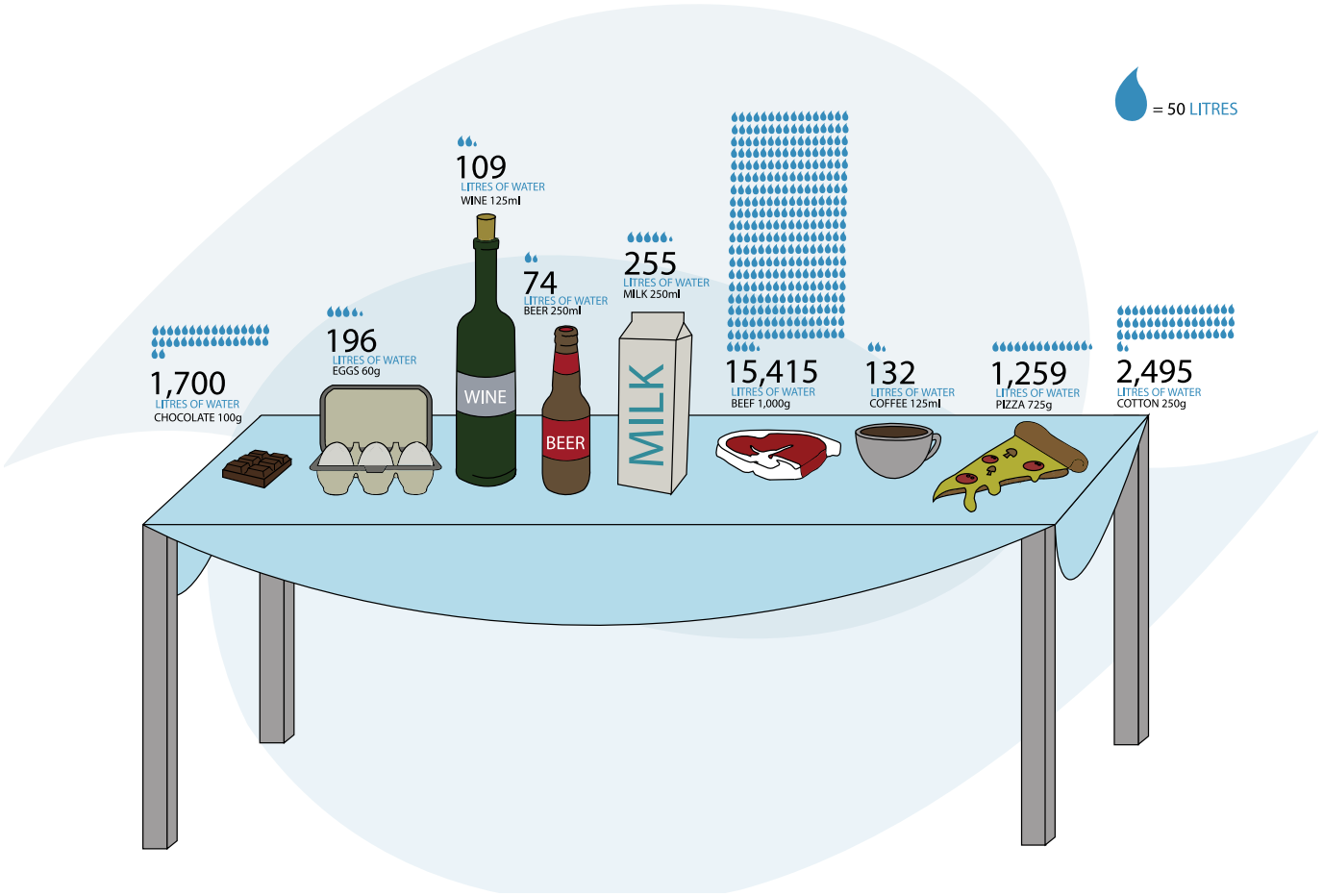


Figure B.2.1.2: Water footprinting

Water footprinting has been cited as a poor basis for policy given the variety of conditions in which products are produced.[62] This is a fair criticism in relation to water availability – as arid areas will have different policy criteria than humid ones. However, as an accurate assessment of the water associated with the consumption of food, water footprinting provides an indication of the environmental impact of our consumption choices. UNESCO has recently reported on the methodologies that underpin both water and carbon footprinting illustrating the importance of understanding underlying issues.[63] City West Water, Yarra Valley Water and Melbourne Water are all showing their customers and the broader public, water efficiency improvements and environmental and economic co-benefits.

It is important that consideration be given to a water footprinting public information campaign to better inform people of this issue particularly as our climate changes. The modelling presented in Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play* illustrates the potential for changes to drier and hotter climates here in Victoria, and the consequent importance of water footprinting in understanding the breadth of our environmental impacts.

2.1.5.3 Greenhouse gas emissions

Methane emissions

Cattle and sheep make a substantial contribution to our overall greenhouse gas emissions, chiefly through methane produced by enteric fermentation[64] (bacteria found in the stomachs of ruminants). Approximately 11% of national GHG emissions are produced in this way.[65, 66]

Methane (CH_4) as a greenhouse gas

Methane has the second-greatest warming effect of human-emitted greenhouse gases, after CO_2,[67] contributing approximately 20% of global radiative forcing.

Atmospheric residence time[67]

Greenhouse gas	Lifetime in atmosphere years
CO_2	30–95[68]
Methane	12
Nitrous oxide	114

Global warming potential is a relative measure of how much heat a greenhouse gas traps in the atmosphere, compared to CO_2. Over 100 years, 1 tonne of methane will trap 25 times as much heat as 1 tonne of CO_2.

Greenhouse gas	Global warming potential over 100 years[67]
CO_2	1
Methane	25
Nitrous oxide	298

Atmospheric concentrations of methane have risen from 715 ppb (parts per billion) pre-1750 to 1700–1800 ppb in 2010.[69]

The IPCC considers it very likely that the observed increase in methane concentration is due to anthropogenic activities, predominantly agriculture and fossil fuel use, but relative contributions are not well determined.

The main global sources of methane are:[70]

- fossil fuel production and use
- livestock
- landfills.

In Australia, the agriculture sector is the dominant source for methane emissions (58%).[71]

Methane accounts for approximately 20% of Australian greenhouse gas emissions, and emissions have fallen by 3.1% between 1990 and 2011.

Secondary impacts of methane

Ozone is an important greenhouse gas and air pollutant.

Methane is a precursor to background tropospheric ozone, and its growth since pre-industrial times has contributed to an increase in ozone globally. Future changes in methane emissions are expected to affect ground-level ozone concentrations, including in polluted regions.[72]

Farmers are now engaging in practices that seek to capture methane as a resource, and various schemes provide incentives. An abattoir in Inverell in northern NSW is in the process of installing a biogas energy system to reduce its reliance on coal.[73] Organic waste from the cows passes through a digester, creating methane that can be burned to power equipment. This will reduce the emissions of the Bindaree Beef processing facility by 95%. The innovation is partly funded by a $23 million grant from the Clean Energy Fund.[74, 75]

Piggery methane capture methods are expected to increase to 30% of the herd by 2019–2020. As at 2013 ClimateWorks reports that 7% of piggeries are already undertaking this abatement of GHG emissions.[76] At the Blantyre Farms near Young in NSW, methane capture methods earn the farm $5,000 per month in sales of electricity to the grid. The sale of carbon credits will also earn the farmer $175,000 per year.

Kaniva College pig – not all pigs enjoy free range conditions

Pig Farmers Anaerobic Digestion (AD) efficiencies and environmental and economic co-benefits

Internationally, the *UK Green Investment Bank First Report on Anaerobic Digestion 2013* records the environmental and economic co-benefits of finding new ways to use 'waste products'.[77]

The key findings of the report are:

- **AD is a growing opportunity: There was 106MWe of capacity installed or in construction by FY [financial year] 2012, more than double that of FY 2010. An additional 148MWe of specific capacity has been identified as potentially available to be developed.**
- **Fragmented and young market: The top five operators account for less than 28% of the market, which compares to 71% in the offshore wind sector. The majority of AD facilities in the UK have been in operation for less than three years. This presents a funding challenge for the sector, as it lacks an established and informed investor community.**
- **Wide ranging performance factors: There is a marked divergence in operational performance between different facilities.**
- **Critical factors to project success: The main barriers to growth in the sector are feedstock selectivity; deep understanding of, and access to local markets for digestate; dedicated operating personnel; active process management.**
- **Finance: The identified development pipeline requires capital investment of approximately £650 million. Although the AD market has indicated that it is in need of debt funding, equity may be more appropriate in many cases due to the youth of the market.**

Pay-for-performance methane abatement is of increasing interest internationally, as it is capable of being effected relatively easily and it can have quick and significant implications. The World Bank and the G8 have recognised the potential.[78] These farming process opportunities will impact methane in important ways and they should be actively encouraged (see Incentives for better practice and conflicted possibilities below).

Food transportation – carbon food miles

Of the embodied emissions associated with food, it is clear that 'food miles'– the distance food has travelled to arrive at the retailer – produce emissions. However, research informs us that the carbon food miles equation is complicated. Food miles as a tool for assessing the environmental impact of production and consumption are 'one part of a larger complex life-cycle assessment'.[79, 80]

While transport emissions can be reduced, it is now apparent that they do not actually represent a major proportion of the overall emissions associated with the production stage of food.[80, 81] Many more emissions can be involved in the growing and processing of food than in the transportation of food to consumers,[80] with the consequence that dietary changes can be more effective at reducing GHG emissions than simply 'buying local'.[82] This is not to say that buying local does not have multiple other benefits – it clearly does.

2.1.6 Cyclical Implications of climate change – produced and exposed

'The battle on the 2 degree warming limit is lost – we must come to terms with a 4 degree warmer atmosphere and urgently focus on adaptation, on flexibility and resilience to cope with the daunting challenges. Agriculture will become the key battlefield of the 21st century because there will be an unprecedented rush for water and arable land and huge migratory movements thus triggered. That's the language of facts and figures.'[83]

Ulrich Hoffmann, senior trade policy adviser UNCTAD Secretariat – 2013 (OECD)

Climate change will increasingly affect agricultural processes across the world. As it does, it will aggravate impacts on already stressed environmental systems, adversely affecting ecosystem services and all the diversity upon which we rely. Food production will be impacted.

We discussed these impacts in Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play*.[84] Impacts will include:

- reduced rainfall at key times of year affecting cropping capacity and economic returns
- heat stress on livestock
- more arid conditions reducing pasture growth
- elevated issues with pests and disease
- reduced yields and poorer quality produce as a result of sharper frosts (even though there will be fewer frosts).[85]

We depict impacts in the following info graphic (see Figure 2.1.3).

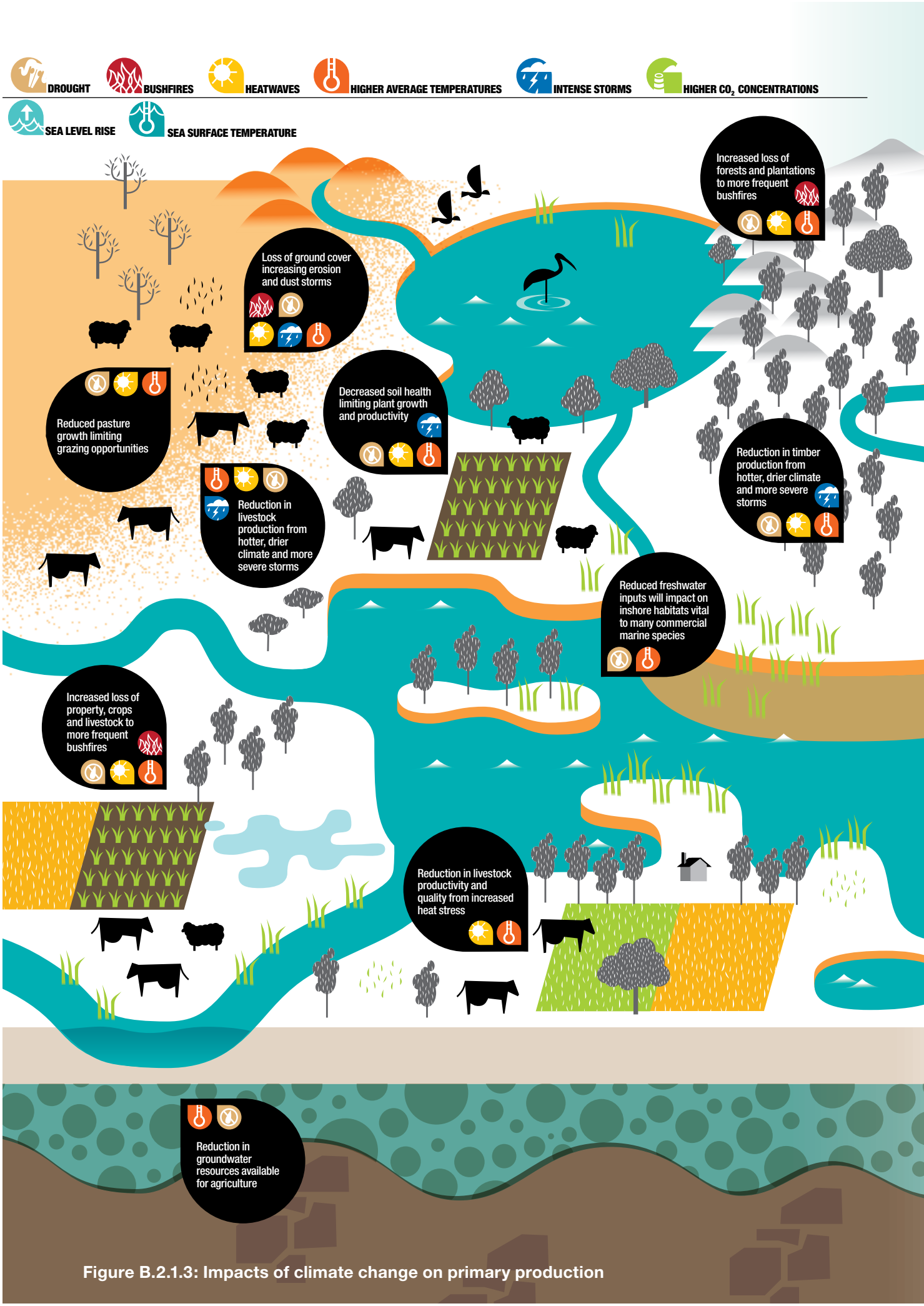


Figure B.2.1.3: Impacts of climate change on primary production

Reduction in water resources available for agriculture
Possible increase in crop and forestry yields when not limited by other climate change impacts
Relocation of agricultural industries to more suitable areas
Increases in pests and disease reducing yields and raising management costs
Reduction in crop yields from hotter, drier climate and more severe storms
Less frequent frosts reducing the yield and quality of crops that require chilling for production
Rising ocean acidification will impact on many commercial species
Migration or loss of marine species will affect the viability of current fisheries
Impacts on seagrass beds and coastal habitats important recruitment sites for many commercial species
Range extensions of marine pests threatens fisheries such as Rock Lobster and Abalone

As average temperatures rise over time, reflecting the trends we have already witnessed and the scientific projections, it is possible that some current agricultural industries will need to move out of Victoria.

The wine industry has already started to move its operations from northern Victoria into cooler climates. Brown Brothers, an iconic Victorian producer over generations, has purchased large tracts of land in Tasmania – with mixed results.[86]

While climate change may impact our own food production, it will also affect food production globally. Climate change and associated drought conditions may produce stronger demand for Victorian produce if crops fail or are destroyed internationally. Conversely we can also expect to suffer when others compete for markets and our own agricultural production is reduced due to the predicted increase and frequency of droughts.

Significant socioeconomic change, including job losses and regional town retail closures, is expected to eventuate.[87] Just as we stand to benefit economically from the misfortune of others, we are also exposed. To improve environmental, social and economic outcomes we need to grasp the possibilities of developing sustainable food production methods and mechanisms.

2.1.7 Government programs, incentives, research and environmental outcomes

The Millennium Ecosystem Assessment[58] and a report to the UNEP, *Report of the Working Group on the Environmental Impacts of Product and Materials to the International Panel for Sustainable Resource Management*[88] – have stressed the need to reduce the impact of agricultural production methods on ecosystems. This research tells us that these impacts are a threat to ecosystems and also to food production.

Research is being conducted in many jurisdictions to reduce the impact of food production on the environment.[54] This work often aligns with a shift to farming techniques likely to prove valuable as climate change impacts become more severe. For example, water resources are vulnerable under climate change scenarios, and improved outcomes will follow for farming ventures if water resource use is reduced with the adoption of no-till farming methods.[89]

2.1.7.1 Incentives for better practice and conflicted possibilities

Governments can assist in driving conservation tillage changes with the introduction of incentives, as has been occurring in no-till farming where tax offsets are provided for the purchase of the farming equipment necessary to change practices.[90]

Also genetic modification,[91, 92] noting all the associated controversies,[93] is promoted as having the potential to assist in the adaptation of agriculture to climate change.[94–97] Our regulatory environment may not be positioning Australia to take advantage of these possibilities.

The Federal Caring for our Country program aimed to increase the uptake of sustainable farm and land management practices among 30% of farmers by 2013, with the goal of delivering improved ecosystem services.[98] By 2012 this program had already reached approximately 33% of farmers with a range of projects, including information campaigns and the provision of assistance in the preparation of property management plans.[99]

In Victoria, the Department of Environment and Primary Industries runs the FarmPlan21 program, designed to assist farmers to develop a whole farm plan, incorporating training and practical work addressing productivity, biodiversity and adaptation to climate change. Program outcomes and co-benefits include the encouragement of innovative programs and the promotion of:

- crop rotation to limit weeds and diseases, which has the beneficial environmental impact of reducing the need for external inputs such as pesticides
- controlled traffic, keeping farm machinery on the same tracks through paddocks, which improves soil quality by reducing overall soil compaction
- reduced tillage of fields and modern technology, which aids the sowing of seed through residual crop stubble and promotes the retention of soil moisture
- the take-up of GPS and optical sensing, which promotes precision farming and enables the more targeted use of chemical additives, which is also better for the environment.

RECOMMENDATION 11

It is recommended that the Victorian Government extend the use of incentives to agriculturalists to adopt environmentally sustainable farming practices and deliver improved ecosystem services.

ATTRIBUTES

These activities would include, but are not limited to:

- **crop rotation**
- **on-farm traffic control**
- **reduced tillage**
- **reduced and targeted use of chemicals, and**
- **increasing biodiversity.**

Case Study: Innovation Promoting Productivity and Environmental Outcomes

Our visit to the Hamilton DEPI research farm introduced us to the work that agricultural scientists have been undertaking to improve productivity – more lambs per ewe, better weights as a function of understorey and grass shelter belts, and scrutiny of the potential for some grasses to do better under increased CO_2 conditions. While this research is being driven by a desire to gain increasing productivity, it also illustrates the sort of environmental co-benefits that can eventuate. For example, shelter belts for biodiversity outcomes.[47]

Commissioner with DEPI researchers

Outside Horsham, DEPI is conducting experiments on free air carbon dioxide enrichment, for which crop scientist Garry O'Leary has won a Victoria Wheat Research Award (2013).

These experiments are designed to understand how higher atmospheric levels of CO_2 might affect crop growth and production. As such they are instructive, provide guidance and promote best practice.

Adopting different varieties of crops may provide environmental advantages. It is reported that dryland salinity affects more than 2 million hectares of southern Australia. Some cropping innovations may help to settle associated environmental issues. For example, the CSIRO has researched a variety of durum wheat that can be grown on salt-affected soils, with up to 25% improvements in yield.[100] Not only are yields expected to improve but environmental outcomes, including avoidance or reduction of wind and soil erosion, are anticipated as a function of the stabilisation of saline soils.[101]

2.1.7.2 Industry innovations with environmental benefits

Our regional tours took us to the no-till farming work being undertaken east of Horsham where farmers, with limited or no government assistance, have established their own farm planning enterprise. The no-till farmers hold their own conferences, share insights at field days, have reduced their water use, improved their soils, recorded better productivity in dry years and better soil health as a direct function of their efforts.[102–105]

Industry-led Target 100 seeks to deal with livestock environmental impacts and involves research, development and extension projects. In its first 12 months, it has received awards from the Banksia Foundation and held events and programs that have reached over 200,000 people.[106] In 2013, Target 100 won the UNAA World Environment Day Award for Sustainability Education across the agricultural sector, forming networks and informing the community about agricultural opportunities in sustainable production.[107] These initiatives will all have education functions. The benefits of informality are clear but it is also timely to consider and actively promote environmental education in agriculture at the post-secondary level.

Across all of these areas we need to be actively cultivating a skills base for the 21st century challenges we will be facing as our population grows, climate change impacts and agriculture and food security is affected. The loss of skills in the agricultural sector in organised broad-scale farming, is an issue that needs to be addressed.[108, 109]

2.1.7.3 Regeneration and organic farming

A wide range of emergent and already embedded opportunities for better practice in food production have started to take root in Victoria. Some of them are explored above. Research supported by the Food and Agriculture Organization[110] suggests that:

> **Mixed farming is probably the most benign agricultural production system from an environmental perspective because it is, at least partially, a closed system. The waste products of one enterprise (crop residues), which would otherwise be loaded on to the natural resource base, are used by the other enterprise, which returns its own waste products (manure) back to the first enterprise.**

Because it provides many opportunities for recycling and organic farming and for a varied, more attractive landscape, mixed farming is the favourite system of many agriculturalists and environmentalists.

Victoria Market

Organic farming, often conducted at a smaller scale than mainstream farming methods, is one of a number of a growing list of regenerative and mixed farming techniques[111] building on systems thinking and responding to concerns about the need to improve farming methods and protect the environment.

Regenerative agriculture builds an understanding of farming as a system working with natural processes and focusing on storing carbon, supporting biodiversity and watercourses, and improving soils.

In Australian contexts regenerative agriculture is promoted as holistic management, no kill cropping, pasture cropping, natural sequence farming and biological farming of which biodynamic and organics farming are subsets.[112] It should be noted that the regenerative farming movement is a broad church.

If we explore organic farming as an alternative to farming techniques which are criticised for their deleterious impact on the environment, organic farming techniques have been shown to:

- reduce soil loss
- increase soil organic matter – storing carbon and improving water holding capacity
- typically, provide improved biodiversity outcomes when compared to many conventional farming techniques
- avoid the use of harmful chemicals
- improve energy efficiency when contrasting inputs and outputs.[113–117]

Organic farming is not focused on higher productivity and reportedly engenders lower productivity.[118] Longitudinal studies from the Rodale Institute in Pennsylvania, USA, suggest, however, that yields from organic farms are equivalent to conventional farms.[119] The Leopold Centre for Sustainable Agriculture at the Iowa State University provided the research environment for a long-term organic farming research project – 1998 to the present – and results indicate that there are discernible soil health benefits from organic farming methods.[120] In drought years, organic farming has been shown to deliver higher productivity.[113, 121]

Having regard to these observations it is clear that organic food production is one part of the puzzle to produce our food supplies more sustainably.

Katie Finlay, Mount Alexander Fruit Farm

2.1.8 Urban agriculture

As agricultural land is affected by continuing urban expansion, people embrace the slow food movement, and the farmer's market movement moves into cities, suburbs and regional towns – urban agriculture may begin to make a greater contribution to our food production systems.[122, 123]

Potential exists for urban food production to provide a much greater share of our unprocessed food. International examples are proliferating. Local opportunities are being explored. This potential could be achieved through the active promotion of a combination of:

- community gardens on public land (such as the PepperGreen Farm in Bendigo)[26]
- more widespread use of backyard vegetable gardens
- locally operated food-preserving efforts (such as in Castlemaine)[26]
- the development of innovative and highly productive commercial urban greenhouses (such as polydomes).[124]

Again the picture is complex. While there are many diverse examples of community gardens, it is simplistic to assume that these are necessarily 'sustainable' although they can engender an interest in sustainable living and sustainable food production in particular.[125] The role of these gardens is as much social as environmental.[126]

2.1.8.1 Food-sensitive planning and urban design, a Victorian proposal

Addressing these developments and understanding the need for a framework to drive organised or systemic change, the Heart Foundation commissioned a report on urban food production systems from the Victorian Eco-Innovation Lab (University of Melbourne) in 2011. A *Conceptual Framework for Food Sensitive Planning and Urban Design* was developed. A number of case studies – state and international – were considered and compared.[127]

Examples of the growth of sustainable food production efforts in Victoria included:

- Yarra Valley Gateway Estate – a producer, and value-adding vending enterprise providing an outlet for others as a function of its diverse business model.
- Vic Urban Meridian Public Orchards – where development uses water-sensitive urban design, stormwater harvesting and involves the Homeowners Association through a $50 quarterly levy in the upkeep of public orchards.
- VicHealth Food for all projects – a five-year program involving Victorian local governments, all of which were evaluated. Micro movies were produced at the time to publicise the work being done. Of these projects, Wodonga adopted land-use planning outcomes, including a Municipal Strategic Statement which was 'food security sympathetic', and provided for walkability in catchments and higher residential densities. Baw Baw Shire established 'Active by design' to enable subdivisions to promote active transport and local quality of life.
- Melbourne Municipal Markets (including Queen Victoria, South Melbourne, Prahran, Preston and Dandenong Markets) promoted more sustainable food choices.

Victoria Market vegetable stalls

Demonstrating the elevation of interest in this issue the Victorian Eco-Innovation Laboratory (University of Melbourne) with partners including DPI South Australia, VicHealth and the Department of Health South Australia and Horticulture Australia, is embarking on a project 'Modelling Policy Intervention to protect Australia's Food Security in the Face of our Sustainability Challenges'.

The earlier study, framework and the planned research provide the beginnings of an interesting road map for change. Our current planning reform agenda in Victoria offers a unique opportunity to marry this research to organisational and institutional structures to promote changes in the way we understand and produce food.

The environmental benefits of urban food production may not be so clear on a simple comparison of inputs and outputs with rural agriculture, but there a number of additional benefits.[128] Locally produced food can build community resilience and provide food security.[129] Local production can help promote healthier diets producing fresh fruit and vegetables.[130]

As food waste in Australia is estimated at AUD $5.2 billion annually[131] – with vegetables and fruit comprising $1 billion[132] – the short supply chain associated with urban production can reduce food waste. It has been estimated that 30–50% of all food that is produced globally is wasted.[133] The UNEP has just released its alarming report on the implications of food waste on natural resources – *Food Wastage Footprint: Impacts on natural resources*.[134]

There is potential in Victoria's urban areas to investigate more intensive urban food production options to maximise the benefits outlined above and, potentially, reducing the strain on marginal land in rural areas.

RECOMMENDATION 12

It is recommended that the Victorian Government develop a strategy to support and promote food production in urban contexts.

ATTRIBUTES

This review will complement a sustainable food strategy by:

- **improving sustainable food outcomes**
- **embedding spatial planning for food-sensitive urban design**
- **increasing biodiversity.**

2.1.9 Sustainable local food manufacturing – community self-help in Victoria

Sustainable food production is not just about growing the product and getting it to the table in its unprocessed state. There are also real possibilities in community management of food systems and the manufacturing which can be undertaken beyond the operations of the big food processing factories.

Goulburn Valley Food Co-operative

Recently, a north-east Victorian food processing community demonstrated its ability to think laterally in working to save jobs in tomato processing, establishing a food processing co-operative and using a 'virtual factory' to generate employment and local food production outcomes.

The Goulburn Valley Food Co-operatives launched its first tomato and pasta product manufactured from local produce in mid-2013.

A food processing factory closed in the Goulburn Valley, jobs were lost, and no factory premises could be found for this enterprising co-operative group to purchase. The co-operative decided to produce a healthy $10 meal by combining local interests in pasta making, tomato growing, jobs creation, sustainability interests and sourcing a manufacturing plant which was not operating to full capacity.

The co-operative has also created a network with ten local schools which operate sustainability programs and awarded grants of $1,500 for ongoing environmental projects.

A discussion panel was convened which included the local federal parliamentarian, a senator from Tasmania, a representative from Oxfam, the marketer and manager from the local pasta manufacturing business, and the Victorian Commissioner for Environmental Sustainability. It was here that the community got involved in the big issues of tariffs, distribution, productivity and competition, safety and sustainability.

The GV Food Co-operative does not just provide an example of good local community practice but also invites consideration of sustainable food issues: production – by whom and for whom; security across and within borders; transportation and associated issues of greenhouse gas and spoilage; processing and the use of preservatives and other additives; marketing in the electronic age; access and equity; regulation; who consumes the produce – where and in what quantities; and waste, over-consumption and their impact on the market.

As the GV Food Co-operative was launching, local orchardists were pulling out trees or, where this was too costly, leaving them in the ground exposing the properties to the threat of pests.

The picture is complex and a national approach supported by sub-national and local interventions is necessary.

2.1.10 Promoting sustainable food consumption in a healthy diet – the role of agencies and government

In seeking sustainable outcomes there is value in addressing the underlying issue – the choices we make about the food we eat and what informs those choices.

In its latest statement of strategic direction, VicHealth has included the promotion of a healthier diet as one of its five ten-year goals.[135] Healthier diets are also sustainable diets, involving in-season fruit and vegetables, less processed foods, reductions in red meat and dairy consumption[82, 88, 136–141] and consideration of the source of fish products.

There is the potential for change. The Buying Better project, run by NSW-based group Green Capital and affiliated with the Total Environment Centre, is currently developing guidelines to assist consumers to make better environmental choices at their supermarkets, including guidelines for meat and dairy.[142]

2.1.10.1 Food planning

A five-point approach to tackling the sustainability of our diets has been presented to the United Nations Food and Agriculture Organization (FAO).[143] Beyond consideration of the consumables themselves – the definition of a sustainable diet, clarity about environmental impacts and the need for research – the FAO sees a benefit in understanding the institutional structures necessary for reform. The Danish Government provides an illustration of the role and extent of potential government intervention in the development of their Nordic Diet.[137, 144, 77]

National and sub-national food plans are being developed in a number of jurisdictions, and they go well beyond the issue of food security which deals with only some of the issues and which can promote 'food productivism' to the exclusion of sustainable food outcomes.[145]

Vancouver's Food Policy Council is a collaborative effort between the community and government and it has delivered:

- changes to local government by-laws
- changes to the *City of Vancouver's Urban Agriculture Design Guidelines for the Private Realm*
- the publication of a *Food Assessment Report*
- the *Vancouver Food Charter 2007*, which provides for street vending, beekeeping and backyard chickens.

The *Scottish Food Manifesto*,[146] which builds on four themes – low carbon communities, culture and education, health and wellbeing and innovation and enterprise – and the *Canadian People's Food Policy*,[147] promoting education, ecological production and localisation are both advanced at the community level as much better models than the Australian *National Food Plan*.

The Australian *National Food Plan*[148] references food in the curriculum, moving food, community food grants, and becoming a food production power house in our region. The issues paper that produced the plan, however, had only one question on environmental sustainability, and much of the plan is built on the assumption that the future will look like the past. Given our exposure to climate change and the current population projections, the future is considerably more uncertain.

Reporting and evaluation may assist in this regard, and it will be interesting to see what the *State of the Food System* report (every five years, first due in 2018) and the ongoing effort in *Foodmap* deliver.[149]

2.1.10.2 Reducing our food waste

There is clearly a role for governments in food policy and planning. Leadership and community consultation is necessary to promote sustainable production and limit waste.

The potential for innovation is enormous. For instance, the European Landfill Directive requires European Union member states to 'reduce "biodegradable municipal waste" sent to landfills to 35% of 1995 amounts by 2016'.[150] In 1990, Copenhagen ceased accepting food waste as landfill.

Household food wastage has been attributed to:

- a combination of relatively low food prices
- consumers having high expectations of how food looks
- a growing disconnection between consumers and where and how their food is produced.[151–153]

Reduction of food waste is important. Studies from the UK have found that the majority of this waste occurs at the household stage, and that 25% of food wasted was edible.[154] In Victoria, food waste represents about 40% of total household waste to landfill.[155] Food waste is not only financially inefficient, but it also involves wasted energy, soil nutrients and, significantly, given the water footprint of food, water.

New initiatives outlined in the Victorian Government's waste policy include an awareness campaign to help reduce waste from households, and to have better monitoring of and data collection from waste streams to improve our understanding as to where program intervention would be of greatest value.[155]

There is a broader discussion of these issues in the text which follows.

The announcement of the Melbourne Metropolitan Organics Plan, designed to take food and garden waste from across the metropolitan area and convert it into compost and fertilisers, may address some of these issues, identifying markets for end products.[156]

Closed Loop Cafe, Castlemaine

2.1.10.3 Labelling schemes

As we develop methods of working on these issues, there are some seemingly smaller but equally ambitious and perplexing problems to deal with, including the question of labelling food to better inform an interested community, reflect better environmental practices and ensure standards are being met and improved.

The labelling discussion – questions of benefits, difficulties and limitations – is ongoing, and it crosses sectors and interest groups, with environmental sustainability being only one of a number of considerations.[157–159] The Fair Trade movement illustrates the potential for change, using every possible marketing tool to improve outcomes, most recently ascribing to a Better Cotton Fast Track Fund and continuously seeking to improve and report on outcomes.[160]

The complexity of the choices for consumers can be difficult and overwhelming.[161] Consistent with international studies,[162] surveys of Australian consumers of organic products suggest that their choices are driven more by health than environmental concerns.[163]

There is typically an information gap or misunderstanding between consumer and producer.[162] Consumers either cannot know as much about a food product as the producer or misinterpret words or phrases on packaging (such as ‘all natural’).

Labelling schemes can help address these issues and there is a significant role for government in working through the jurisdictional and other complexities. Research has shown that certification-based labelling schemes are more effective when regulated by government.[162]

The Legislative and Governance Forum on Food Regulation is currently oversighting a national labelling agenda with varying degrees of anticipated success.[164]

An alternative approach is for supermarkets and other large retailers to take a lead role in making these decisions for consumers, i.e. by minimising the availability of products that have sub-standard environmental performance.[81] We have not seen much evidence of the potential for success of such a proposal in Australia, although some better examples exist in other jurisdictions.[165]

2.2 Sustainable Use of Urban Water

Proposition

Uncertainties in future water supply and the increasing need to provide adequate water to aquatic ecosystems mean that wise water use is essential in the 21st century.

Integrated water cycle management (IWCM) and good urban design and planning can help deliver this but these need to be supported by public and political will. This work has been begun by the Office of Living Victoria, and will need to be continued over the long term by changing our overall approach to water management in urban areas. The water-sensitive cities of the future need to use good design and integrated water cycle management to use the city itself as a catchment, providing fit-for-purpose water for a broad range of uses.

Context

City water services – the provision of potable water (drinking water) and 'sanitation' services – are ecosystem services for which we need to share responsibility.

'Town water' is energy-driven into our homes from distant storages – through pipes, out of taps. It is delivered on demand – sanitised and safe – as a commodity. It is no longer a 'commons'.[166] In this driest of continents, potable water has often been treated as if it is plentiful.

Drinking water should not be used to flush toilets, wash clothes, water trees, wash down driveways and cars or water lawns when other water would serve just as well. The International Water Association's draft *Montreal Declaration on the Cities of the Future* program Principle 7 reminds us that 'sustainable cities will recognise that all water is good water – based on the concept of "fit-for-purpose" use'.[167]

2.2.1 Fit-for-purpose water

Associated with our historical lack of interest in the sourcing and management of the water we use, we have not readily questioned the hundreds of thousands of litres of water which we waste. When we actually know how much water we lose, centralised and non-integrated water resource supply methodologies seem odd, if not cavalier.

For example, we know that approximately 650 GL (gigalitres) of rainwater, nearly double Melbourne's annual consumption, falls in urban Melbourne,[168] and less than 2% of this water is used.[169]

Figure B.2.2.1: Rainfall and water use in Melbourne

In Melbourne we generate upwards of 540 GL per year of excess water through stormwater run-off. Add to this the fact that only 30% of the water demand in Melbourne is for quality drinking water,[170] and it is clear that – in terms of fit-for-purpose resource use – we have, as a community, vast potential for reforming our water-use habits and our infrastructure.[171]

2.2.2 Water in the future: availability and demand

As the global climate changes, Victoria will become warmer and rainfall patterns will change (see Part A and Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play*). While there is uncertainty in exactly how rainfall will change, it is reasonable to expect that historical decisions, made on the assumption of stationarity (rainfall that fluctuates within set boundaries but is essentially predictable over long time scales), will not necessarily meet future needs – particularly in the light of anticipated population growth. Additionally it is probable that future water will need to have a larger proportion committed to maintaining vital ecosystem services and less for consumptive use than has traditionally been available.

On the demand side, Melbourne's population is expected to grow by over 2.3 million in the next 40 years.[172] The infrastructure we put in place today will have to provide adequate water to future Victorians. In regional areas, total water demand is expected to grow by 6.5–9 billion gigalitres by 2021.[173]

A potentially growing demand and an uncertain water supply require robust and sustainable planning.

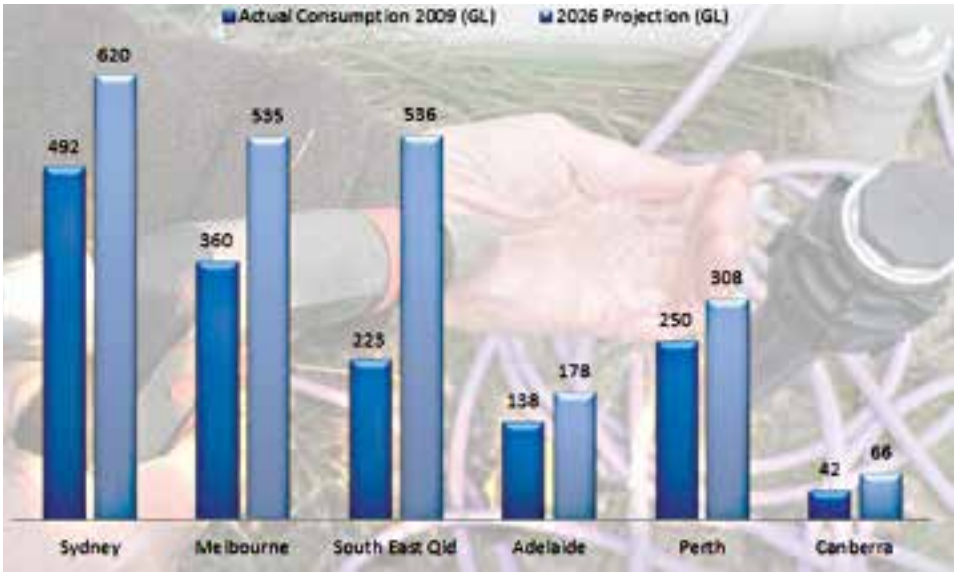


Figure B.2.2.2: Projected total urban water consumption, 2026

Source: Water Services Association Australia Report Card 2009–2010.

2.2.3 Living Melbourne, Living Victoria and the Ministerial Advisory Council

The Living Melbourne Ministerial Advisory Council (MAC) was appointed In recognition of the need to properly integrate sustainable water use with urban development. The MAC was formed to provide independent advice to government and this was delivered in the form of the *Living Melbourne, Living Victoria Implementation Plan*. The plan contained a suite of recommendations to government that fell into three broad themes:

- Transform the way we manage water resources and the water system.
- Establish the Office of Living Victoria (OLV) to drive reforms by coordinating urban and water planning.
- Overhaul the water planning framework to respond better to broader community needs and more effectively integrate with urban planning.[174]

In response, the government adopted many, but not all, actions from the MAC. The immediate actions that the government has committed to are:

- a review of the current Water Supply and Demand Strategy
- changes to the tariff arrangements, providing greater choice, pursuant to the water industry regulatory order
- developing investment guidelines that reflected the true values of amenity and environment
- partnering local government and water authorities to extend Melbourne Water's stormwater licensing arrangements for government infrastructure
- aiding investment in wastewater reuse, impacting sewer mining guidelines
- improving regulatory arrangements
- working with the Smart Water Fund and the CRC for Water Sensitive Cities.[175]

The government response was also broadly supportive of the remaining actions from the implementation plan and has implemented a broad range of actions to achieve them (details are given in *Melbourne's Water Future*, including 19 case studies of current initiatives ranging from stormwater action through to intelligent networks). However, in the case of longer-term recommendations that are concerned with transforming the broader water management landscape, the government has stated that implementation of the recommendations will depend on cost to and regulatory impacts on the water industry.

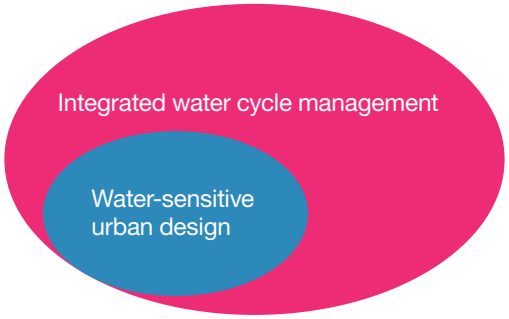


Figure B.2.2.3: Relationship of IWCM and WSUD

2.2.3.1 The Office of Living Victoria (OLV)

Also key to the government's response to the implementation plan was the formation of the OLV, which seeks to develop strategies for integrated water cycle management (IWCM) that are suitable for Melbourne, and to embed these in planning processes and design standards.

In July 2013 the OLV released *Melbourne's Water Future*, the draft plan for water management in Melbourne for the next 40 years.[176] This has been endorsed by the State Government and identifies priority areas for action:

- Engage the community in whole-of-water-cycle management.
- Design our old and new suburbs with water in mind.
- Encourage sensible use of water in our homes and businesses.
- Build resilient water systems that work well during flood and drought.
- Improve the health of natural waterways.
- Reduce inefficiency and waste.
- Accelerate water innovation and world recognition of expertise.

The plan adopts a 40-year outlook for water planning in Melbourne and lays out initiatives for achieving each long-term goal, advising that water management plans be reviewed and updated every three years.

2.2.4 Integrated water cycle management (IWCM)

The practice of IWCM (also called whole-of-water-cycle management by the OLV[177] – there are other definitions of IWCM which are narrower and less ambitious)[178] – involves coordinating water and land-use planning and development. IWCM is a multidisciplinary and multi-objective approach, used to promote the sustainable use of all available water resources in ways that best deliver multiple community objectives.

In practical terms, IWCM may fulfil multiple purposes and operate over longer time frames than traditional planning. It has the potential to harness and promote many of the intangible yet vital attributes of urban liveability, across landscapes and the built environment.

When applied ambitiously, integration may address traditional and new-generation climate change and water cycle concerns, and promote the following:

- meaningful, long-term water supply security
- greenhouse neutrality
- public health protection
- economic vitality and robustness
- flood and flash-flood protection
- intra and intergenerational, cross-cultural, socioeconomic equity
- waterway health and ecosystem services protection
- amenity, recreation, mental health and other co-benefits of demonstrable long-term environmental sustainability
- reputational benefits.

Figure B.2.2.4: Stormwater harvesting

Moonee Ponds Creek

Royal Park Wetlands
Courtesy of City of Melbourne.

2.2.3.2 Stormwater

Planning for the use of fit-for-purpose water and the clever and sustainable retention and use of stormwater will help to address Melbourne's future water needs.

The most obvious effect of urbanisation on catchment hydrology is the increase in the magnitude of stormwater flow events in urban streams. As climate change drives an increase in rainfall extremes we will need to deal much more effectively with impacts of flooding, stream erosion and loss of aquatic habitats, and threats to public safety.

Stormwater management has traditionally focused on drainage. The principal technical challenge – and often the primary objective – has been to convey this run-off away quickly and safely to 'receiving' waters. Traditional approaches in 'efficiently' conveying stormwater and its pollutants as they are flushed from urban areas into receiving waterways have a double negative impact. The potential for reusing the stormwater is wasted, but this sort of management also produces a waste product – as the outflow causes the deterioration of the water quality in the receiving water environment.

Fifty years ago, the water quality of Moonee Ponds Creek was very poor due to these conventional management methods.

More recent waterway treatments understand waterways as ecosystems with ponds, wetlands, currents, rockfalls and riparian zones, need to be nurtured as habitat zones, and as having social and cultural meaning. These wetland ecosystems help derive benefits from stormwater in creeks because they slow down the flow of water and help reduce the amount of sediment in stormwater run-off. They also allow natural processes, the sunlight and time to help clean the water.[179]

The Merri Creek – once neglected but never a concreted drain – is now a community project and meeting place. It provides valuable social and recreational ecosystem services across cultures and generations.

Its management enables the development of wetlands. New infrastructure investments in greenfield developments, which draw the pollutants out of stormwater and which also reduce run-off, allow us to redefine stormwater management services, reflecting the many attributes associated with water-sensitive urban design.

Engineering solutions and analysis of the benefits of sensitive water design have a significant place in addressing future water supply and demand, but this project also illustrates the outcomes that can be achieved by integrated planning and multidisciplinary collaborations.

A network of 'green and blue corridors' of open spaces – places for walkability and of amenity – is a longer-term possibility for installations that process stormwater. Corridors will filter urban stormwater through vegetated treatment systems, detain and convey flood waters, and provide potentially productive landscapes intrinsically linked to soft and hard infrastructure.

This will contribute to human thermal comfort in areas immediately adjacent to corridors – within 100–300 metres.[180, 181] Water spaces, canopy, and grassed areas will also promote biodiversity in the urban environment.

Merri Creek, Northcote

2.2.3.3 Water-sensitive urban design – an international context

Water-sensitive urban design is the practical application of water conservation efforts, and is an essential component of integrated water cycle management. This sort of design has delivered rain gardens, roof gardens, rainwater tanks, bio-retention swales (areas of land designed to retain rainwater), mini wetlands, and stormwater collection and use.

Adoption of this design strategy gathered pace as we felt our way through the big dry – crisis drove change.[182] Reactive action is what we now want to avoid. Design of this type needs to become the new normal and it needs to expand its reach and influence moving from a design feature to an operational water cycle integration ethic.

The practice of water-sensitive urban design (WSUD) will almost invariably encapsulate the principles of integrated water cycle management, so our baseline is good. Water-sensitive urban design represents the integration of urban planning with the management of urban hydrology and the water cycle, and is the design component of integrated water cycle management.

Taking a holistic view, and including the public in the conversation, it is the incorporation of water-sensitive urban design within integrated water cycle management that will give us water-sensitive cities. These are the sort of cities we will need to adapt to climate change and help insulate us from drought.[183]

WSUD reinforces the view that is possible to develop cities as sustainable ecosystems,[184] or biophilic cities[185] and build green infrastructure.[186] By choosing inventive and responsive urban design strategies it is possible to reconsider the way we use water, our demand for it, and also our responsibility for (re)producing it.[187]

Water-sensitive cities, in which urban water cycles are designed and managed as integrated systems enmeshed with urban design and communities will be the 'cities of the future'.

To deliver WSUD – with all its multiple attendant benefits – the following social, economic and environmental ethos will be necessary in these cities of the future:

- a community with a heightened receptivity to innovative practices for sustainability, which is also striving to live an ecologically sustainable lifestyle, aware of the balance and tension between consumption and conservation of the city's natural capital
- reflective practitioners threaded through the water industry demonstrating inventive capacity and showing an active interest in innovation and adaptation
- enabling regulatory regimes and policies, formulated by proactive governments which will be used to facilitate an ongoing adaptive evolution into the water-sensitive city.

2.2.3.4 Water-sensitive urban design in Victoria

Great progress in implementing water-sensitive urban design projects has been made in many municipal areas. Numerous towns and cities across Victoria have offered stories of success, inventiveness and willingness to adopt new and sustainable water conservation development practices.

Melbourne has developed several major stormwater harvesting projects because it currently generates large amounts of unused stormwater. In the Fitzroy Gardens, a new garden area will include a biofiltration area to clean stormwater that can be used to irrigate nearby street trees.

At the Alexandra Gardens and Queen Victoria Market, existing ponds and underground tanks are used to produce fit-for-purpose recycled water to replace 119 ML/yr of potable water historically used for irrigation in Melbourne.[188]

In Swan Hill, the development of the Tower Hill subdivision is an example of achievable water technologies. VicUrban drove the initiative in tandem with the local council. The site was a greenfield and leant itself to innovative design. Growing housing demand promoted the proposal. Sited to the east of the development is a wetland, providing thermal comfort but also a habitat for native bird life. Water used on playing fields is 'recycled', roadscapes are used to catch and retard stormwater, and drought tolerant plants have been installed. Pocket parks dot the development.

Developments across Shepparton have become demonstration sites for changing ways of thinking about and valuing water. At Kialla Lakes a wetland, roadside drains, drought tolerant plantings have turned a dry and hot plain into a cool and comfortable residential development. Elsewhere in the city, the Boulevard development has pocket parks, a wetland and dry creek water retention area has produced a sandy environment which has water-sensitive features across its whole expanse.

The City of Greater Geelong and Barwon Water have worked closely together over years to address the issues of population growth and climate change adaptation (e.g. the Eastern Park Stormwater Harvesting Project).

Wodonga City Council expresses its commitment in its planning instrument, which states that:

- the position of Wodonga in the upper catchment of the Murray River will be respected at a local level through the implementation of *Urban Stormwater – Best Practice Environmental Management Guidelines*[189] and *Water Sensitive Urban Design Engineering Procedures Stormwater Technical Manual*
- the encroachment of urban areas onto the floodplains of the Murray and Kiewa Rivers will be restricted
- the retention of existing wetland systems will be encouraged through the implementation of the principles defined in the *Urban Stormwater – Best Practice Environmental Management Guidelines*[190]
- a water capture and storage system is being installed with tanks, pumps and integrated pipe systems for the Bonegilla Migrant Experience.[191]

Furthermore, Yarriambiak Shire Council is working on the installation of rainwater tanks.

These regional centres are framing the discussion in terms of a wider ecological understanding of the role and management of water. They are reflecting the culture of change which is found in IWCM across the state. The challenge is to craft this as the new normal, to embed it in every practical effort and to import this sort of change into the difficult and resistant places, not just overlay them on the greenfield sites.

RECOMMENDATION 13

It is recommended that the Victorian Government adopt a strategy that delivers water-sensitive urban design (WSUD) and integrated water cycle management (IWCM) as standard practice.

ATTRIBUTES

The prerequisites of this framework are:

- **establishing an economic valuation for urban water projects based on WSUD and IWCM principles**
- **establishing clarity in governance structures**
- **strengthening science-policy partnerships**
- **fostering evidence-based policy development**
- **active community engagement.**

Public policy developed and implemented to meet these priorities will have to explicitly attend to:

- **determining the economic value of urban water infrastructure and water reuse benefits**
- **identifying decision-support frameworks for policy makers.**

2.2.5 A vision for Victorian cities

It is critical that urban water management change from water provision and processing waste water (taps and toilets) to treating the urban space as its own catchment. This transition needs to be led by good urban design.

Three fundamental principles of practice have been developed by the CRC for Water Sensitive Cities for the attainment of a water sensitive city:

- Cities will see themselves as water supply catchments, promoting the access of a portfolio of alternative water sources through a diversity of supply scales – in a catchment.
- Cities will align themselves with the provision of ecosystem services: allowing us to understand the city as a built environment which actually functions to supplement and support the natural environment.
- Cities will be comprised of water-sensitive communities: asserting the existence of socio-political capital for sustainability and enabling citizens' decision making and behaviour to encourage urban water sensitivity.[192]

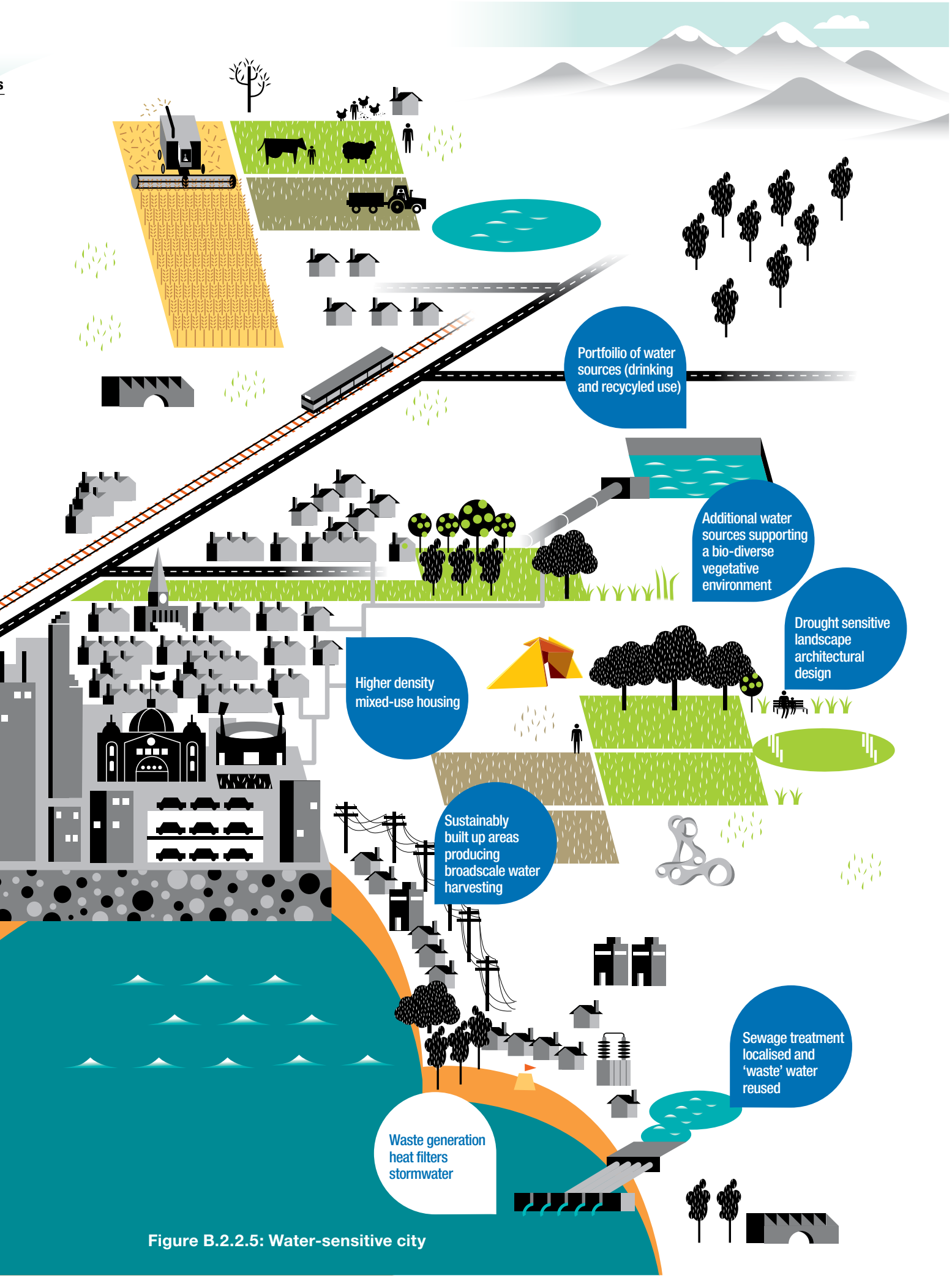


Figure B.2.2.5: Water-sensitive city

In the water-sensitive Victorian cities of the future, these principles will need to be supported by community norms actively encouraged and maintained by government:

- active engagement and strong community adoption of best practice
- community participation
- the public will be better informed about the role of Victorian ecosystems in providing water as a resource from which we derive numerous services
- the community will be interested in water conservation, water's ecological and other attributes
- the community will be more resilient in the face of climate change.

Ultimately, we need cities that are optimised for sustainable water use and use higher-density mixed-used housing types to provide a basis for innovation in:

- localised sewage treatment and recycling
- stormwater treatment
- optimal harvesting of rainfall from roofs, streets and urban drains.

Collectively, these additional water sources will work to support a bio-diverse vegetative environment that does not depend on conditions in the city's water catchment. Urban vegetation can then be incorporated into precinct design. Green corridors and pocket parks will serve as flood detention and conveyance systems during extreme storms.

Public participation in this vision is key. When a city is truly water sensitive, people are better informed about water and the broad range of services it provides. They are also more able to deal with its conservation and management in climate-constrained times.

Active engagement and strong community links are critical to realising this vision for the future.

Scientists and engineers will play a role in designing the new systems and structures, but will integrate their knowledge with a broad range of other disciplines. This 'new normal' interdisciplinary research agenda will need to cross domains as diverse as landscape architecture, social and development aid discourses, sociology, anthropology (all about public participation, evaluation and, more obscure, the cultures which attach to our understandings of water) and the design professions.

The range will extend to those concerned about water conservation and efficiency, including those already working in water organisations. The disciplines which need to be included to address supply security will extend beyond engineering and even environmental engineering. The role of engineers in understanding the cultural meaning of water should not be underestimated.

To attain the outcomes we desire we will need to include the insights of public health professionals, geo-morphologists, water body health scientists and the public; biodiversity scholars, wetland ecologists, design scholars and social scientists with an interest in amenity and recreation and environmental interpretation.

The new planning paradigm will need research to go beyond the existing knowledge bank, and include both thematic aspects such as water production, harvesting, anticipating extreme events and spatial scales that transport us from households to landscapes.

2.2.6 Community participation

At a national level, WSUD is being explained and promoted, but we should consider whether there is adequate administrative, legislative and institutional support for the step change we require. To effect change we will require enabling policies and water pricing measures that are conducive to change and that provide policy stability. For the creation of the new 'normalised' water-sensitive city we will also need to actively cultivate the public.

The rate of adoption of water saving efforts by the community, such as installation of rainwater tanks, suggests enthusiasm for the practical work being done.

While this work builds critical mass, the overarching question continues to be whether a plethora of individual, somewhat circumscribed WSUD projects is actually delivering integrated and systemic change.

> Plainly, reforms to the whole water cycle will not be driven by local government and community efforts alone. Local government does not have the water and sewerage management capacity or responsibility to progress WSUD to the same level as do water corporations or higher tiers of government.[193]

For this reason, State Government intervention – through the Office of Living Victoria's intention to actively engage communities[176] – is welcome. All of these efforts can be seen as prongs of systemic and necessary erosion of the old centralisation paradigm. They should not be seen as ancillary to, and paradoxically supportive of, its continuation.

2.3 Reducing Resource Use

Proposition

It is critical that we support transition to an economy with an emphasis on the environmental provision of services and goods, and where consumer choices are informed by assessments of the environmental impacts of consumption.

Ultimately, we need a movement from 'ownership' of products (e.g. cars) to 'access' to desired services (e.g. transport). Waste will be avoided through improved design and product stewardship and resources maximised by treating waste products as a resource stream. Life-cycle assessment (LCA) of consumer products is a valuable tool that can encourage manufacturing companies to make their supply chains more efficient.

Context

There has never been a greater recognition of the need to properly assess and protect the financial and non-financial values of natural capital and ecosystem services.

New international initiatives are providing frameworks to carry out this valuation (see Part B: 5.1 Monitoring and Data Collection). For example, after Rio+20, the financial services sector published a high-level commitment to incorporating long-term sustainability into its operations.[194] However, there is still a disconnect between these high-level frameworks and pledges, and the consumption of goods and resources in the developed world.

2.3.1 A contemporary approach to consumers and consuming

When the costs of resource use and ecosystem degradation are fully quantified and included in company accounts (and not simply cited as 'externalities'), we will know the true costs of consumption. This will enable us to evaluate the real costs and benefits of our actions. Clearly demonstrating the economic benefits of, for example, improving essential ecosystem services could form the basis of an incentive structure in the market that would cause rational, self-interested decision makers to maximise environmental benefits.

Minimising waste is an essential step in improving production efficiency. This extends to recognising the resource value of materials that would historically have been treated as waste. State and federal governments are enacting polices to prevent high-value materials from entering landfill and promoting product stewardship initiatives.

Product stewardship requires manufacturer responsibility for products over the entire lifetime of the product, including its final disposal. This challenges designers to create goods that can be cheaply deconstructed with components recycled. Some companies (see below for specific examples) have embraced this ethos and are using it to introduce efficiencies to their processes.

A necessary condition of product stewardship is the notion that products will be returned to the resource reclamation facilities at the end of their life with the immediate cost of this borne by the manufacturer passed on to consumers according to individual markets.

For example, you might buy a laptop, use it for five years and then return it for the components to be reclaimed. While the costs of this process will be covered, at least in part, by the value of the reclaimed elements, there will be some additional cost borne by the owner. The consumer is, in essence, paying to access the services of a laptop, rather than owning it forever.

This concept of access-not-ownership – which may also be considered as a 'subscription model' – is at the core for 'collaborative consumption', encapsulated in the idea that, as a society, we can obtain maximum value from consumer goods by spreading costs across multiple users. We are witnessing an uptake of collaborative consumption in Victoria in the creation of schemes that facilitate product sharing (see below for specific examples).

These innovations are part of a range of actions being used in Victoria to reduce the environmental impacts of production and consumption.

Life-cycle assessment (LCA) provides a range of techniques for assessing the environmental impacts of products over their whole life, from manufacture to disposal. LCA techniques are increasingly being used by manufacturers of all sizes to identify and reduce risks and inefficiencies in their processes and supply chains. Ultimately the use of life-cycle assessments is influenced by initial assumptions and limited by the availability of high-quality data. However, as LCA becomes more common and the public becomes familiar with the concept, simplified assessments could form the basis of life-cycle thinking. The information generated – when used in conjunction with other measures to change consumer choices – has the potential to reduce demand for products that create a relatively high environmental impact. This would see increased awareness of the implications of consumption choices particularly if supported by initiatives focused on certain impacts, for example: greenhouse gas emissions, water use, or biodiversity losses.

It is important to note that any strategy to influence consumption behaviour may well be employed against a background of a global trend towards the use of other economic tools – primarily carbon pricing – intended to reduce the environmental impact of climate change. Therefore, any programs that use life-cycle thinking to improve resource-use efficiency need to be designed to act in conjunction with carbon pricing mechanisms.

It is important that research conducted in collaboration with best-practice business and government efforts is undertaken to compare the efficacy of strategies and tools and identify how these can be deployed.

2.3.2 Moving from ownership to access

As manufacturers use resources with greater efficiency and begin to incorporate the costs of recycling, consumers are seeking new ways to reduce individual costs and maximise the utility of products.

If, as a society, we focus solely on product greening through marginal improvements in manufacturing efficiency, then we will miss the chance to effect large changes by rethinking and redesigning how we access services and products.

Collaborative consumption represents a new model for gaining access to high-value resources in which communities can use new networking technologies to swap, barter and share products. Several successful businesses such as AirBnB[195] (recently declared illegal in New York City)[196] or car sharing services, where subscribers pay a fee-for-access to personal transport, are starting to emerge and gain traction.

Consumers, designers and service providers have the opportunity to begin to move away from the expectation that people will buy, own, and eventually dispose of products.

Two examples of this collaborative consumption are Mud Jeans and Flexicar.

In the Netherlands, the company Mud Jeans leases jeans for €5 per month.[197] After a year, the leaser can replace the jeans for a new pair. This allows the company to retain control of the material (an expensive resource) and increase the recycled content of their product to as much as 50%.[198]

Flexicar is a membership-based carshare company that aims 'for carsharing to become a mainstream public transport option for urban Australians; providing a cheap, green and easy alternative to car ownership'.

2.3.3 Reclaiming resources from the waste stream

Victorian waste policy has addressed the need to increase reclamation of high-value material that would typically end up in landfill. When the value of high commodity materials (materials that that can be profitably diverted from landfill) was assessed, an estimated $172 million was determined as 'lost to the Victorian economy' annually.[199]

In Victoria, the landfill levy – a charge for disposal of waste in landfills – exists to promote the development of resource recovery industries and the levy funds improvements in recycling programs.

The Victorian Waste and Resource Recovery Policy[155] seeks consistency with the National Waste Policy and proposes actions to ensure Victoria fully participates in national product stewardship schemes and develops trial schemes.

The State Government has promoted high recycling rates in government departments. On average, 85% of office waste has been diverted from landfill over the last four years.[200]

Although it has been cited as a best-practice organisation, Zero Waste South Australia[201] – the agency responsible for promoting waste avoidance and recycling – was closed in 2013 to reduce government expenditure[202] despite protests from some waste industry representatives.[203]

2.3.3.1 Market development

Efficiency of material reclamation needs to be complemented by creating a stable market for recycled products. There is a great deal of 'push' for creating products from recycled material but only a small 'pull' of demand from the market. There is, therefore, a role for government in accelerating the development of markets.

This could take the form of creating certainty for consumers that recycled products are fit for purpose through the enforcement of ISO standards or, where these do not exist, creating standards for sale of products in Victoria.

For example, compost is required to meet certain quality standards irrespective of whether it is derived from recycled green waste. Consumers can therefore be confident that products they are buying are functionally identical to the non-recycled equivalents and are fit for purpose. This information could be conveyed as part of education campaigns to increase public understanding of currently undesirable recycled materials (e.g. plastic, glass).

The government can also act to establish markets for waste stream products through procurement strategies that guide state purchase contracts. This process has begun with the requirement for recycled content in office products (such as paper) and could be extended to other state purchase contracts.

Similar processes can also be introduced by local governments. For example, the City of Whitehorse has made the use of recycled asphalt standard practice in contracts for road resurfacing. The council has included sustainable conditions in its tendering conditions, including a price incentive of 10% for recycled content. By adopting green purchasing strategies in line with federal guidelines for sustainable procurement[204] and reporting use of recycled products, government bodies can ensure revenue streams for manufacturers and demonstrate the effectiveness of products.

There are a number of initiatives that are leading this process. Within government, Health Purchasing Victoria – which guides procurement for the health services sector – has appointed a sustainability officer to ensure that the environmental impact of purchased goods is minimised.[200]

This example could be followed by the other key authorising agencies – the Victorian Government Purchasing Board and the Building Commission. Outside government, the EcoBuy program is working primarily with local governments, but also state agencies, to establish such polices and provide tools that facilitate the purchase of lower impact products.[205] EcoBuy is already working with a number of State Government departments and agencies.

RECOMMENDATION 14

It is recommended that the Victorian Government strengthen incentives and assume a leadership role to improve the efficiency of material reclamation from the waste stream.

ATTRIBUTES

Initiatives to assist Victoria in becoming a leading jurisdiction could include:

- **establish and develop markets, and remove barriers, for trade of resources from the waste stream**
- **facilitate information for transfer of waste stream between sectors**
- **promote design standards to ensure efficient reclamation of reusable materials**
- **government and industry coordinating the monitoring of material flows by sector.**

2.3.4 Encouraging the adoption of product stewardship

Encouraging efficient manufacturing and informed consumer choices is crucial to reducing consumption impacts.

There are numerous complementary approaches to current LCA techniques, and to further reduce impacts we need to assess how we can use and reuse the resources already in circulation that are often lost as 'waste'.

We must learn to view the waste stream as a valuable resource. In fact, we should think in terms of 'resource recovery' rather than waste.

Product stewardship is exemplified in Australia in container deposit legislation (South Australia), which has, for decades, provided for a refundable deposit on reusable food containers such as bottles.

Minimising the impacts of product disposal is central to the National Waste Policy. To this end, the *Product Stewardship Act* was introduced in 2011. This provides the regulatory framework to effectively manage the environmental, health and safety impacts of products, and in particular those impacts associated with the disposal of products. The Act includes voluntary, co-regulatory and mandatory product stewardship.[206] It includes regulations that enable:

- a National Television and Computer Recycling Scheme
- a National Packaging Covenant
- recycling of tyres
- recycling of mercury-containing lamps
- recycling of some plastics (e.g. degradable plastics, plastic bags, PVC).

The National Television and Computer Recycling Scheme provides households and small business with access to free recycling services for televisions, printers, computers and computer products (such as keyboards, mice and hard drives).

The scheme is intended to increase the recycling rate for television and computer products in Australia from an estimated 17% in 2010 to 30% in 2012–13 and to 80% by 2022.

Porland Sustainability Group TV recycling effort – 26 tonnes
Courtesy of Portland Sustainability Group

The scheme is funded by mandated contributions from large manufacturers and importers of televisions, computers and computer products.

Product packaging is now covered by the Packaging Covenant, and there are stewardship schemes in place for tyres and lamps (that contain mercury). Schemes like these could be used as the basis for devising product stewardship initiatives for other consumer products.

A proposed framework for product stewardship in Australia has identified factors that will increase the likelihood of success.[207] For example, products that contain hazardous or valuable materials may lend themselves to this approach.

Other factors that may be conducive to change include:

- concentration in supply side of market
- significant local production relative to imports
- strong industry cohesion
- a mature market
- an industry characterised by repeat business.

RECOMMENDATION 15

It is recommended that the Victorian Government develop a Product Stewardship Strategy.

ATTRIBUTES

The product stewardship strategy would:

- **act to identify mature and stable sectors for new schemes**
- **develop inclusive schemes in consultation with industry and stakeholders**
- **amend regulation (if required) to integrate with new schemes.**

AroundAgain Mildura Waste Facility

2.3.5 The importance of good design

The philosophy of product stewardship intersects with the principles of good design.

If a company expects to reuse products (either whole or as components) across iterations of production, those products should be designed to fulfil this purpose as efficiently as possible.

This means products need to be designed for longevity or recycling.

Figure B.2.3.1: 'Four design models for circularity'

Source Great Recovery UK

These principles can be seen in action at global companies like Interface Carpets[208] (who produce carpet tiles that can be easily recycled) or BMW[209] (with its Design for Recycling program).

2.3.6 Life-cycle assessment

Life-cycle assessment provides a tool whereby the environmental impacts of production can be assessed and potential 'hot spots' identified that can be used to focus efforts to improve production efficiency. The key elements of LCA are:

- compiling an inventory of relevant energy and material inputs and environmental releases
- evaluating the potential environmental impacts of those inputs and releases
- interpreting the results to better inform decision makers.[211]

Case Study: Desso Carpets

Stef Kranendijk was CEO of Desso between April 2007 and October 2012, and a key driving force in rethinking the business model of the company. He explains, 'The idea is to become a service industry, relying on a leasing system: then you don't buy the product, you only pay for its use, which means materials remain our responsibility and of course it's not our interest to see them wasted, at the end everybody wins.'

This ongoing transition to a circular business model has demanded an ambitious strategy with challenging milestones. Desso identified that the business-to-business (B2B) market was more readily open to the performance model: 'We started with the carpet tiles for offices and industry, then we will make our sports systems Cradle to Cradle, move to our woollen carpets – in that field, we're working on a biodegradable base made out of corn by-product – then we'll tackle the consumer market.'

Designers and materials experts have also experimented in the biosphere, notably taking yarn from bamboo, which has the benefit that once the carpet is worn, it can be safely returned to the food-farming system. However, Kranendijk notes, 'We still have to improve the product though, notably to enhance its durability.'[210]

Case Study: Antarctic life-cycle assessment benchmarks

Recent environmental impact assessment in the Antarctic could provide innovative sustainability benchmarks for life-cycle assessment measures, which could be replicated in similar self-contained areas such as mining and outback communities.

Simon Lockrey, Research Fellow at RMIT's Centre for Design and a member of the Victorian Chapter of the Australian Life Cycle Assessment Society, recently travelled to Scott Base with Associate Professor Mick Abbott of Lincoln University to conduct on-site auditing and analysis.

Lockrey said, 'Each of the things they do will interact with the environment in some way. Solar panels might reduce fuel use, but at the same time increase physical footprint or diminish aesthetic values.

'A triple membrane filtration waste water system would protect the oceans, but would there be greater net environmental benefit from installing new highly efficient incinerators?

Scott Base Antarctica
Courtesy of Simon Lockrey

'For years, Scott Base has been pursuing different, excellent ideas to manage the environmental aspects of its activities.

'But there's currently no straightforward or objective way to compare apples and oranges – to figure out which ideas will actually have the most impact – or to determine what mix of options would give the best overall result.

'LCA brings it all together – you can talk a common language.'

The researchers also assessed personnel behaviour to determine where process and work-flow improvements could be made. During this process, they found storage systems forced the cook to travel daily from one end of the station to the other in order to restock food. This complexity made menu planning arduous resulting in substantial food wastage.

Abbott said, 'That's a result of how the base was originally designed, and then extended over time, but identifying these kinds of problems faced by the people on base is also part of our approach.'

The study found design improvements in the station's storage systems could greatly contribute to making the station operate more efficiently. Changes in logistics and supply systems would also greatly reduce food waste. Abbott said, 'The constraints of operating in remote environments challenge conventional approaches to logistics. It's these constraints that force us to develop innovative systems and services, that once resolved can be more widely applied in similar contexts.'

The LCA process, as defined by the Australian Life Cycle Assessment Society has four components:

Goal definition and scoping This involves defining and describing the product, process or activity, establishing the context in which the assessment is to be made and identifying the boundaries and environmental effects to be reviewed.

Inventory analysis Identifying and quantifying energy, water and materials usage and environmental releases (e.g. air emissions, solid waste disposal, waste water discharges).

Impact assessment Assessing the potential human and ecological effects of energy, water and material usage, and the environmental releases identified in the inventory analysis.

Interpretation Evaluating the results of the inventory analysis and impact assessment to prompt the selection of the preferred product, process or service with a clear understanding of the uncertainty and the assumptions used to generate the results.

When applied, LCA can supply information on the relative comparative impact of two products and help to tease out how and where impacts occur.

As an illustrative example, LCA can be used to estimate the relative impact of using polystyrene as packing material against a potentially 'greener' alternative – in this case, popcorn. In this analysis, although polystyrene is a non-biodegradable material, it has a lower overall environmental impact than popcorn due to the energy and water requirements of growing plants to use as packaging material.[212]

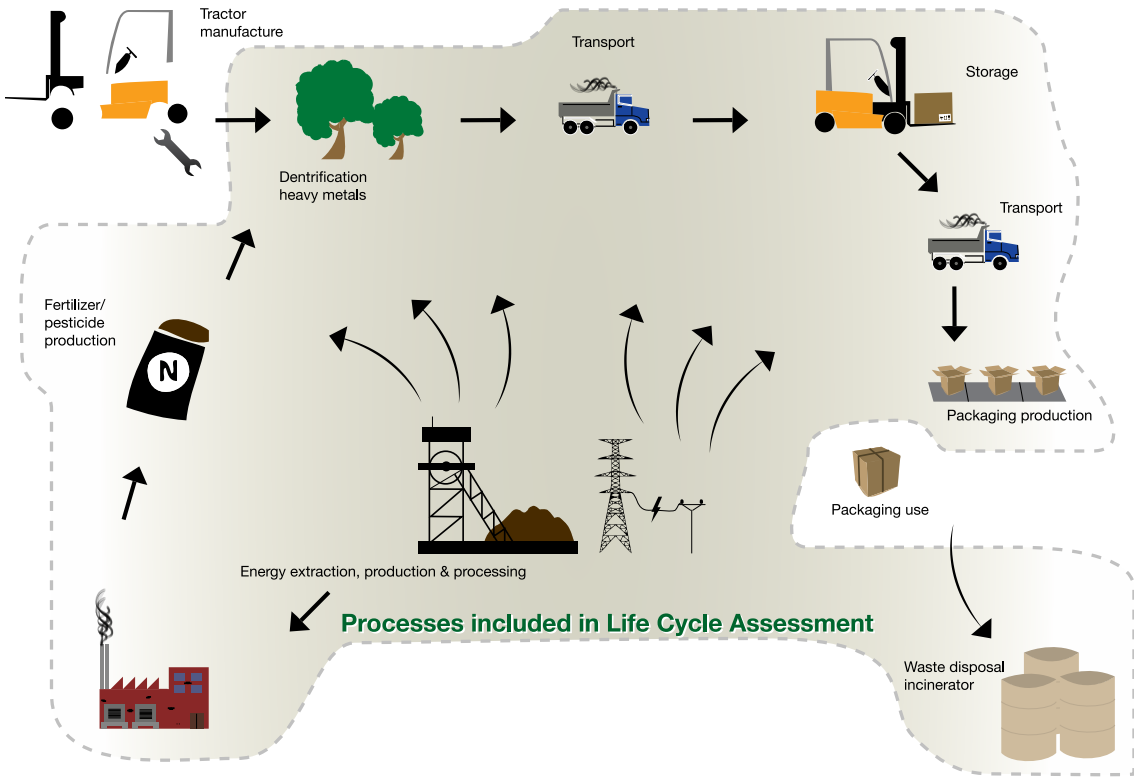


Figure B.2.3.2: Infographic demonstrating boundaries and assumptions of packing material LCA study

Two key messages emerge from this example. First, it is critical that policy decisions are based, as far as is practical, on rigorous analyses as this can yield outcomes that contradict expectations. Second, outcomes depend on initial parameters and assumptions and are subject to value judgements made in the process of setting those parameters.

Crucially, the example assumes that agricultural activity required to produce popcorn is based on fossil fuels. A change in energy sources and farming practices may shift the balance in favour of popcorn over polystyrene.

Initial parameters need to also address issues of temporal scale: how can we weigh a shorter term environmental gain (e.g. fewer natural resources expended now) against a longer-term environmental cost (e.g. low-degradable or low-recyclable materials that will create cost for future generations)?

Such issues would be highly relevant to using LCA to examine contentious policy issues in Victoria. One such issue is the adoption of a container deposit. Broadly, NGOs (e.g. Environment Victoria, Friends of the Earth) are in favour of using deposits to improve recycling rates. Financial modelling suggests that container deposits will benefit local councils.[213] However, some industry bodies oppose suggestions for change, arguing that such schemes will increase rates and undermine the current roadside recycling programs, which are well implemented.

An independent and well-defined LCA could be used to assess the costs and benefits of material and energy flows associate with container deposit schemes in Victoria.

2.3.6.1 Where LCA can be useful

It is important to take into account both the outcomes of applying LCA reporting and the methods and data it is based on. Reporting of resource use and environmental impacts can have two principal outcomes:

- encouraging manufacturers to identify and correct inefficiencies in their supply chain
- public education of the true impacts of production.

A good starting point for the application of LCA assessment would be the use by large-scale manufacturers, who coordinate large amounts of primary goods into their supply chains. Several large companies have recognised the market benefits of increased sustainability and have publically stated long-term goals to reduce environmental impacts. In an assessment by Deloitte, a small number (Puma, Nike, Nestlé, Natura, Unilever and Ricoh) have been praised for acting to embed policies into a long-term strategic vision designed to make the organisation sustainable in the long term.[214]

The race to harness the growing market for sustainable products is highly competitive, and there is still scope for improvement. Of the companies studied, none have yet reached the highest standard of delivering zero impact growth in a working product-development strategy. There is still a need to develop measurable short and long-term targets with clearly defined benchmarks.

Case Study: Puma Environmental Profit and Loss (EP&L)[215]

Working with PricewaterhouseCoopers and Trucost, Puma developed the EP&L and associated methodology using recognised ecological and economic measuring techniques.

Puma started with greenhouse gas emissions and water usage – which were reported earlier in 2011. Later Puma added land use, air pollution and packaging throughout its operations and supply chain. It then costed these as services that must be paid for – in this case, with the planet as a service provider.

The total value of these services was estimated at €133 million, with most costs incurred several steps removed from manufacture.

Analysis of where these costs were being incurred showed that €8m (£6.4m) or 6% of the costs lay with company's own direct operations, such as offices, warehouses and stores. A further 9% (€13m) lay with its Tier 1 suppliers – the companies responsible for manufacturing Puma shoes and clothing.

The remaining €124m – or 85% of the impacts – were distributed through its Tier 2, 3 and 4 suppliers going right back to the actual sourcing of raw materials – such as leather, cotton and rubber.

Puma is also launching biodegradable products.[216]

The methodologies and outcomes of Puma's reporting have been assessed by a panel of experts convened by the company.

While this approach was deemed to be a good tool for identifying business risks linked to the use of natural assets, the assessment acknowledged that there was room for improvement in the accuracy of reporting. At present the method relies heavily on estimation techniques. Reporting would be improved by gathering more data direct from suppliers or from LCA databases.

Puma's initiative gives a useful illustration of how product impacts could be communicated to consumers. The success of such an approach depends on wide-scale adoption by other manufacturers. This will be helped by further developing – with government support – simpler, easily applicable methodologies that use existing, recognised international standards.[217]

Aligning the project with related initiatives, such as The Economics of Ecosystems and Biodiversity (TEEB) for Business Coalition framework[218] may help this process.

Case Study: Food Miles – Comparative Life-Cycle Assessment of Food Commodities[219]

A life-cycle inventory (LCI) was first produced for each commodity and then a life-cycle assessment (LCA) associating inventory data with specific environmental impacts.

Each included established LCA criteria, including: primary energy use (PEU); global warming potential (GWP); acidification; eutrophication; abiotic resource use; pesticide use; and land requirement.

The study concluded that unless the UK embarks on a radical change of lifestyle, including drastically reducing the consumption of livestock products, opting for more seasonal consumption, or adopting very different food choices, including veganism, food for the UK may need to be imported from overseas to meet the demand.

2.3.6.2 Limitations of LCA

LCA is not a magic bullet for solving the problems of inefficient over-consumption.

The principles of LCA are well-established and the LCA research community is developing rapidly in terms of both methodologies and data. There are now standardised international methodologies (the ISO 14040 series),[220] as well as guides for their application,[221] which could form the basis of any new initiatives. Reliable datasets, however, remain problematic.

Manufacturing is a dynamic process, and sourcing decisions can change rapidly, meaning data is difficult to collect. These issues will need to be addressed to inform more accurate and comparable assessments of the impacts of consumption.

A further complication when using LCA is that, traditionally, it does not account for the rebound effect (described in SP-1.1). This phenomenon describes how, when production efficiency is improved, only 20–60%[222] – on average – of the anticipated benefits may be achieved. This occurs either directly (where efficiency savings drive increased demand for the same goods), or indirectly (where efficiency savings allow spending on other forms of consumption).

For example, an LCA of a product assesses the environmental impact while assuming that demand for that product remains constant (known as attributional LCA). Changing to LCA methods that represent the rebound effect through shifts in demand (consequential LCA) can better simulate the overall impacts of 'consumption as usual'.[223]

Even if these problems were to be solved tomorrow, undertaking comprehensive LCA on products is often time-consuming and costly.

It is not realistic to expect that we can one day have information on the full impacts of any given product. Instead, we could use simple assessments to guide 'life-cycle thinking' – where we use the best information available to consider the impacts of our consumption choices.

2.3.6.3 LCA reporting as the basis for life-cycle thinking

Examples like those above demonstrate the total impacts of product choices by framing them as a handful of easily comparable metrics.

However, just making this information freely available will not necessarily change production methods or consumer choices. Ultimately, long-term change to more sustainable consumer choices will require a suite of complementary initiatives. In particular, sustainable consumption policies need to find ways to tackle the question of social practices, and embed individual behaviours. Strategies will include:

- product standards, ethical standards, technical standards
- positive, well-publicised and communicated examples from role models (e.g. employers and opinion leaders)
- initiatives – complementary to simple information provision – designed to influence consumption practices by improving choice architecture (known as 'nudging').[224]

2.3.6.4 Standardised methods for LCA reporting

The precise requirements for LCA will vary between industries, and some methods for LCA are better established than others. The food packaging industry has established LCA practices in Australia, and this could be used as a model. A review of LCA reporting in this industry could identify lessons that can be transferred to other manufacturers. This will establish both best practice and a framework for transition to more transparent reporting.

Standardised methods will also require robust datasets to estimate impacts. There will, therefore, also need to be increased government investment in research that can reduce uncertainty in quantification of impacts.

Case Study: Co-Benefits – Making Better Procurement Decisions

In 2009 the Department of Health commissioned a mass balance and eco-footprint summary of the Victorian health service. These figures served as a baseline for estimating the environmental impact of the Victorian public health system as a whole.[225]

The findings of the study allowed for a rational choice of products based on environmental and financial data.

At Western Health, with this evidence, six operating rooms made the change from single-use trays with cotton gauze to reusable trays, with cotton used as required.[226] This change is expected to generate savings of US$6,500, 600 kg CO_2 emissions and 170,000 litres of water each year.

RECOMMENDATION 16

It is recommended that the Victorian Government assume a leadership role and develop expertise in LCA tools in a Victorian context to reduce carbon and environmental footprints.

ATTRIBUTES

This work commences with the development and maintenance of a public database (potentially based on the Life Cycle Database (ELCD)[229] maintained by the EU).

Future development would include:

- **establishing inventories (e.g. Australian Life Cycle Assessment Society life cycle inventory (AusLCI)[227] project) and tools (e.g. Packaging Impact Quick Evaluation Tool)[228] specific to Victorian context**
- **assisting manufacturers use LCA reporting to identify areas for resource-use efficiency along the supply chain.**

GOAL **THREE** SUSTAINABLE ENERGY

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GOAL THREE SUSTAINABLE ENERGY

3 A Modern Energy System for Victoria

Proposition

International and national responses to increases in energy costs and climate change are creating compelling pressures for the traditional energy sector to adjust its business model. Future energy supply will need to have lower greenhouse gas emissions in order to meet the challenges posed by climate change. The falling cost of renewables and the move to decentralised power generation add to the complexity of sustaining traditional energy business models. An opportunity exists for a system-wide reconsideration of how energy, in particular electricity, is supplied and used in Victoria.

Context

The reconsideration needs to be integrated process, led by government, involving the business and community sectors, resulting in a Modern Energy System (MES) for Victoria. The transition to an MES needs to be characterised by regulatory certainty and policy alignment.

Public funds are needed to support this transition, and they should be allocated and managed as investments in the future prosperity of Victoria, ultimately adding to gross state product. The efforts of government need to be supported by, and leveraged against, the efforts of the community and business sectors.

Solar Trailer Sunraysia TAFE Mildura

3.1 A Change is Needed

In the briefing 'Distributed energy: Disrupting the Utility Business Model' the following observation is made:

> **'Utility executives around the world are watching the rise of distributed energy systems and trying to determine the best ways to react to this challenge to their traditional businesses. The rise of distributed energy (DE) – smaller power-generation systems for homes, businesses and communities – is a response to environmental concerns, rising power prices and regulatory pressures and incentives.'**
>
> B. Hannes and M. Abbott M, Bain & Company*

This analysis concludes that the growth of distributed energy will force change on utilities' business models, noting that some of their most profitable customers will reduce their regular power consumption from the central grid in favour of locally produced power. Interestingly, the brief observes that the most profitable customers may still depend on the central grid for their emergency or peak use and as a consequence of this the energy utilities will have to maintain their costly infrastructure and power-generating capabilities even as revenues from consumption decline. In many markets, energy utilities are working with regulators to adapt to this structural change by promoting a pricing model based more on connectivity and capacity, and less on usage.

Alongside this change in the traditional energy utility model, investment in renewable energy is growing. Since 2004, globally, it has increased six-fold. Annual growth in investment (6%) is outstripping the growth rate of the global economy (3.5–4%).[2] Our major trading partners and competitors are engaged.

We will need a developed workforce capacity along the right policy settings. Australia is ranked only 17th among the G20 countries for preparedness to compete in a low-carbon economy.[13]

* Source: bain.com/Images/BAIN_BRIEF_Distributed_energy_Disrupting_the_utility_business_model.pdf.

As the global energy revolution unfolds, Victoria needs to ensure it is well-placed to transition to renewable energy sources and take advantage of the opportunities such a change provides. Failure to do so could leave Victorian business and industry exposed to rising costs as the world increasingly becomes committed to containing global emissions. A Modern Energy System will assist Victoria to meet 21st century energy objectives.

RECOMMENDATION 17

It is recommended that the Victorian Government plan an integrated Modern Energy System for Victoria.

ATTRIBUTES

The MES would aim to:

- **be economically constructive – transition our economy**
- **reduce emissions – increase renewable capacity**
- **promote energy efficiencies – smarter use of electricity**
- **empower consumers – provide consumers with choice**
- **ensure equity – increase accessibility and affordability.**

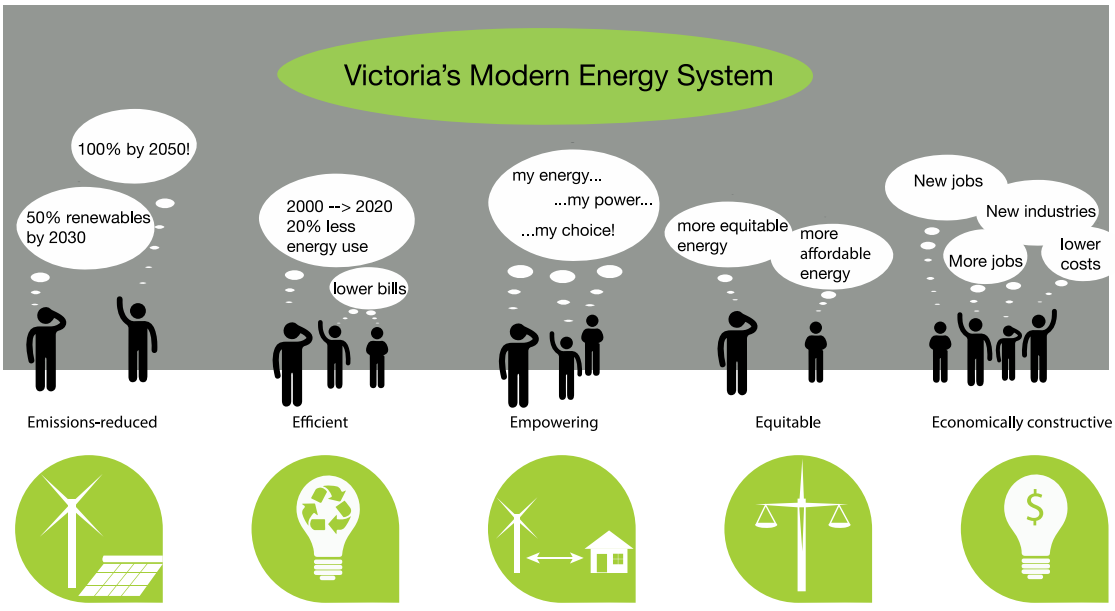


Figure B.3.1: Victoria's Modern Energy System

3.2 Attributes of a Modern Energy System

3.2.1 Economically constructive

The Modern Energy System (MES) described here represents a major component of a transition in the economy towards a better Victoria. For this to happen, the MES must be economically constructive. Federal government emissions policies will be important, providing market signals for investment.

The International Energy Agency (IEA) has identified four policies that could combine to achieve 80% of the emissions reductions required globally to keep us on track to stay below 2°C of warming.[14] These can be implemented at no net economic cost by:

- introducing energy efficiency measures, particularly in relation to the operation of buildings
- limiting use of the least efficient coal-fired power stations
- reducing methane emissions from upstream oil and gas production
- phasing out fossil fuel subsidies.

In 2012, the Australian Bureau of Resource and Energy Economics (BREE) projected that, by 2030, renewable energy sources such as wind and solar photovoltaics will be cheaper to build than coal or gas-fired power stations.[15]

Since then, analysis by Bloomberg New Energy Finance found that this price point had already been reached.[16] This means that any increases in energy demand could be met most economically through renewable energy. Even without carbon pricing, new wind energy capacity can be built 14% cheaper than coal.

What is renewable energy?[3]

Renewable energy is energy that can be obtained from natural resources that can be constantly replenished. Renewable energy technologies include technologies that use – or enable the use of – one or more renewable energy sources. Types of renewable energy technologies include:

- bioenergy
- geothermal energy
- hydropower
- hybrid
- ocean energy
- solar energy
- wind energy.

Renewable energy technologies also include those that:

- store energy generated using renewable energy
- predict renewable energy supply
- assist in the delivery of energy generated using renewable energy technologies to energy consumers.

Transition to a MES should lead to positive economic outcomes for Victoria. New manufacturing capacity can be created and regional centres can expect to be stimulated with additional jobs through more geographically diverse sources of energy. Higher-value manufacturing capacity and opportunities in research and development can be established.

As global efforts towards clean energy advance, our coal-dependent energy sector risks becoming an economic liability.[13] Large structural changes might be necessary, but these can be harnessed to support economic development.

Proactive steps to reduce the 'carbon exposure' of local industries will arguably provide a competitive advantage.[17] A rising demand for carbon-efficient products is expected, associated with the rising costs of using carbon-intensive energy and it is clear that businesses that use more renewable energy will have opportunities to reduce costs, improve geographic efficiencies and boost sales.

Transition to a MES is an opportunity for cost savings for business as well as significant employment opportunities, especially throughout regional Victoria. As is the case for all triple-bottom-line outcomes, the economic constructiveness of the transition to a MES should be determined over the long term – not within one or two electoral cycles.

Boosting jobs and stimulating the economy

During the 2012 calendar year the contribution of renewable energy to Australia's electricity supply broke 10% for the first time this century, producing more than 13% of the total – powering the equivalent of almost 4.2 million homes.[12]

There are extensive wind and solar resources across the state, and these resources ought to be exploited to maximise future state prosperity.

Opportunity

The construction and maintenance of renewable energy facilities can be expected to create many jobs and stimulate the economy. This is especially in rural Victoria where the better opportunities for using wind and solar energy are found.

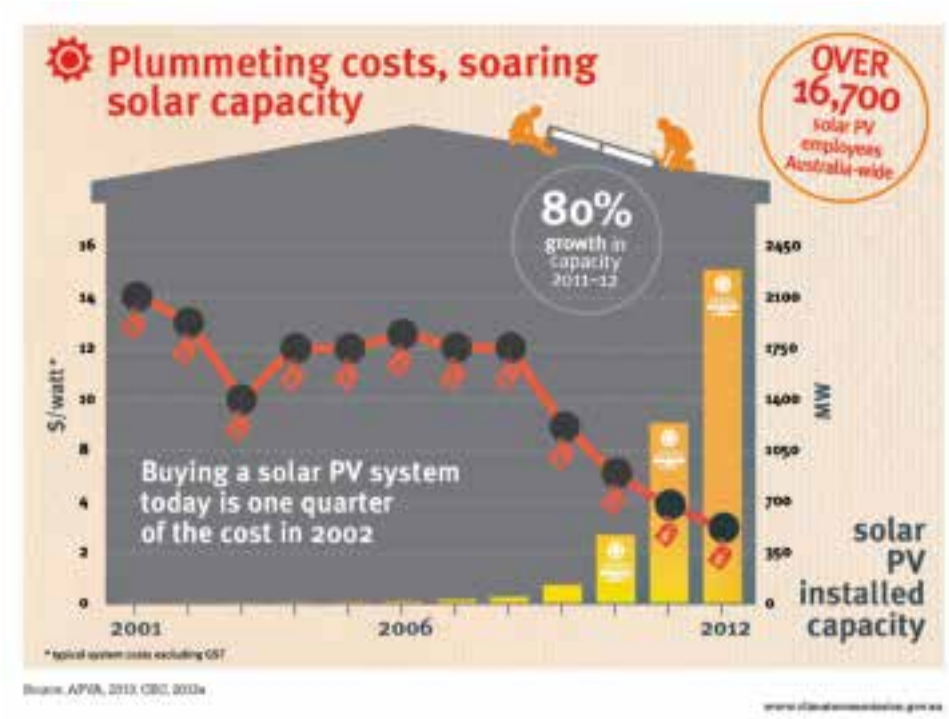


Figure B.3.2: Solar costs and capacity

Improvements in local skills are also expected. A recent senate inquiry into the social and economic impacts of rural wind farms was told that wind farm developers can source around 80% of employees from local communities.[19]

For example, a 50 MW wind farm can be expected to create around 160 local jobs, with flow-on effects to the economy supporting a total of over 500 jobs within the state.[18]

A recent joint report from the Australian Council of Trade Unions and the Australian Conservation Foundation reported that, across Australia, a concerted push towards the deployment of renewable energy would result in the creation of more than twice as many new jobs, compared to the business-as-usual growth scenario.[20]

Case Study: Economic Benefits of a Wind Farm to the Local Economy[18]

- Construction of a 50 MW wind farm provides a gross value added of some $50 million to a state and contributes up to 0.21 per cent to gross state product depending on the size of the state economy.
- Construction of a 50 MW wind farm is estimated to contribute up to 2.6 per cent to gross regional product depending on the size of the regional economy.
- Construction could lead to potential local personal expenditure of $25,000 per person per annum. If, for example, a wind farm had an average construction workforce of some 35 over a two-year construction period then the expenditure in the region would be some $875,000 in total per annum on accommodation, food and other services.
- The same wind farm could employ between five and six full-time-equivalent staff for operations and maintenance with a potential ongoing expenditure of $125,000–150,000 per annum.
- In addition, a 50 MW wind farm project is likely to provide up to $250,000 in payments to farmers and an ongoing community contribution that could be some $80,000 per annum for the life of the project.
- This expenditure is likely to be a minimum as wind farm developers' policies of sourcing suppliers and services locally as far as possible also mean that transport, plant hire and materials such as crushed rock, cement, sand and gravel are likely to be provided from local sources.

Wind turbine installation

In August 2011, the Victorian Government passed Amendment VC82 to the Victorian Planning Provisions.

This amendment prohibited the construction of wind turbines in a range of areas, including tourist areas such as the Great Ocean Road and 'locations that feature a high degree of amenity'. Turbines cannot be erected within 2 km of a house without the written consent of the home owner (clause 52.32-3 State Planning Policy Framework; see also departmental policy and planning guidelines).[21]

The Explanatory Memorandum states that the amendment promotes 'positive environmental, social and economic effects by facilitating a more balanced assessment of the impacts of a wind energy facility against these factors'.[22]

This change of policy and the new regulatory regime are critiqued as having the following impacts:

- Discouraging the shift to a low-carbon economy by entrenching existing forms of power generation.[23]
- Making it more difficult and more expensive to reduce our greenhouse gas emissions.[24]
- Arguably it will drive up the cost of electricity, because wind projects required for the RET will be built in areas with poorer wind resources, resulting in less return and higher cost.
- Damaging investment in Victoria, as energy companies are unwilling to take chances with such restrictive regulations.[25, 26]
- Many proposals for new wind farms in Victoria have been withdrawn.[27]
- Lost investment has been estimated at $4 billion and 3,000 jobs (figures calculated by Clean Energy Council).
- Turbine component manufacturers now going out of business or relocating interstate, depleting the skill base.[28]

The development of a Modern Energy System would provide the opportunity to reconsider the continued longer-term utility of such provisions.

Wonthaggi turbine

Case Study: Macarthur Wind Farm*

The 420 MW Macarthur Wind Farm is currently the largest of its kind in the southern hemisphere and is jointly owned by AGL Energy Limited (AGL) and Malakoff Corporation Berhad. It represents an investment of approximately $1 billion. It is located approximately 16 km east of the township of Macarthur in Western Victoria.

Construction of the Macarthur Wind Farm took approximately 2.5 years and it has been fully operational since late January 2013. It has the capacity to generate enough clean, green energy to power the equivalent of approximately 220,000 average Victorian households per year and also save approximately 1.5 million tonnes of greenhouse gases per year.

During the development and construction of the wind farm, the total number of jobs (including flow-on employment) was estimated at 875 from the region, 2,490 from Victoria and 2,782 from Australia. Eighteen local residents from south-west Victoria also make up the majority of the permanent site team responsible for the ongoing maintenance and operations of the Macarthur Wind Farm.

Macarthur Wind Farm
Source Google Images

Cost savings for businesses

Industry is a major contributor to Victoria's GHG emissions.[29] Analysis by ClimateWorks Australia has found that, nationally, practical energy efficiency measures in industry could reduce energy consumption by 11%, at a financial saving of over $3 billion.[30]

Most of these savings relate to the use of natural gas. Barriers to the uptake of these energy efficiency measures include:

- lack of access to finance
- insufficient awareness of skills
- operational risks
- regulatory barriers
- supply chain barriers.

* www.agl.com.au/about-agl/how-we-source-energy/renewable-energy/macarthur-wind-farm.

Environment and resource efficiency plans

The Victorian EPA has managed a program designed to help overcome some of these barriers. Large energy users were assisted to create Environment and Resource Efficiency Plans addressing water, waste and energy. The EREPs program has been terminated ahead of schedule due to overlap with federal reporting requirements, even though the state scheme contains some additional advantages.

Under the program, changes to processes that had payback times under three years were required to be carried out.

Across the 254 participating commercial and industrial sites, the program identified cost savings of $90 million and emissions reductions of just under 1% of the state's total, the equivalent to taking 180,000 cars off the road each year.[32]

Energy efficiency of buildings

Retro-fitting existing buildings to become more energy-efficient is a straightforward way to reduce costs to business. (Approximately a quarter of Australia's emissions come from use of buildings.[46] This includes heating and cooling of our houses and use of electrical appliances.)

Buildings greater than 2,000 square metres (i.e. commercial office buildings), are governed by the new national Commercial Building Disclosure program. Designed to require disclosure of information about the energy efficiency of office space to potential occupants of that space, the program relies on measurements of efficiency provided under the National Australian Built Environment Rating System (NABERS). At the state level, Sustainability Victoria manages the ResourceSmart Commercial Buildings program.

In Victoria, government buildings (including school and tertiary education facilities, prisons, hospitals, sporting facilities, etc.) are eligible for the Greener Government Buildings program.[33] This program is designed to help achieve both resource and cost savings. The program is projected to reduce the GHG emissions of government operations by 20% by 2020 while simultaneously saving $1 billion.[34]

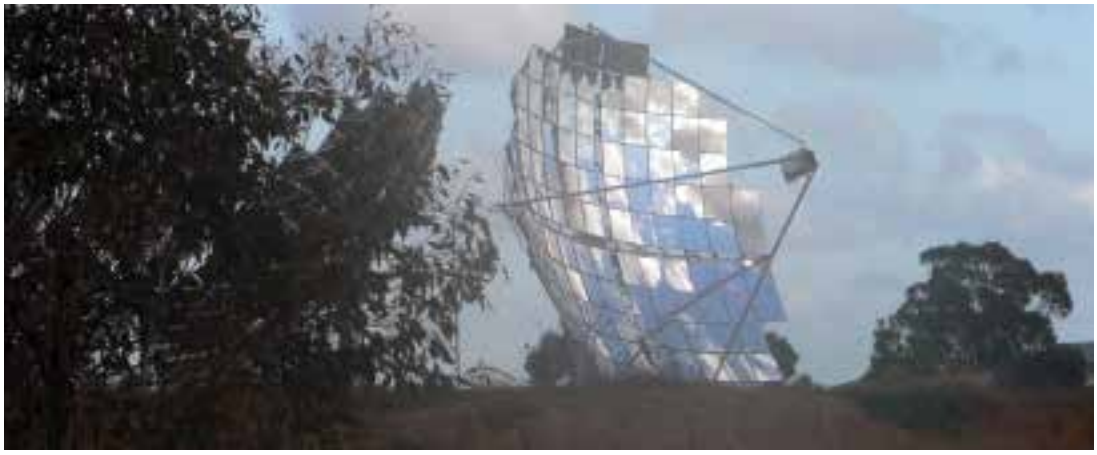
Buildings in the City of Melbourne alone, dominated by commercial office space, account for almost 50% of the state's total office buildings emissions. Much of this building stock is smaller than the 2,000 square metre threshold for the Commercial Buildings Disclosure program and the federal Green Building Fund.

Australian Catholic University windpower, Victoria Parade

3.2.2 Emissions reduced

By capitalising the state's plentiful renewable resources we increase renewable capacity in Victoria and the renewable energy sector becomes the state's major energy source.

Victoria's high-quality renewable resources make a statewide shift to an energy system with dramatically lower emissions achievable. Emissions reductions in Victoria alone will not solve climate change, but we can limit our contribution to the problem while simultaneously creating an equitable, empowered, efficient and economically constructive energy market. Many jurisdictions across the world are exhibiting foresight, innovation and leadership with regard to renewable energy supply, and Victoria should aim to join this 'leadership group'.



Solar panels Bridgewater

Availability of the resource

Wind, solar, gas – Victoria is well-placed to take advantage of the economics of renewable energy.

Maps of Victoria's wind resource show wide areas with average wind speeds above 6 metres per second at 65 metres above ground (considered to be a 'good' wind resource). These are mainly in western and coastal Victoria, with several hotspots through alpine areas. A study for the Department of Environment and Primary Industries concluded that our solar resources are suitable for all commercially available technologies.[35] Good resources also exist for other forms of renewable energy.

Multiple studies,[36, 37] including a recent draft report by the Australian Energy Market Operator (AEMO),[38] have now shown that powering Australia, or at least the National Energy Market states, with 100% renewable energy is technically feasible. The reports agree that this requires a combination of diverse geographic locations (i.e. the wind must be blowing somewhere), sufficient peak generators and storage capacity.

The AEMO's assessment estimates that the transition to 100% renewables by either 2030 or 2050 will cost between $220 and $338 billion. Estimates for 80% or 90% renewables scenarios might be significantly cheaper, as displacing the final fossil fuel generation might be disproportionately expensive.

Beyond the comparatively low cost of wind energy discussed earlier, the rapidly falling cost of solar photovoltaic (PV) systems is approaching a point of affecting the structure of the energy industry itself, as documented in reports by major investment banks such as UBS,[39] Citi[40] and Macquarie.[41] Unsubsidised solar PV has now reached 'socket parity' – that is, it is as cheap to put solar panels on a roof as it is to get electricity from the grid.

The Citi report also projects that solar PV will reach parity with baseload gas by 2017 – a significant development given AEMO projections that no additional generation capacity will be required to meet demand in Victoria until 2018–19.[27] The continued technical development of renewables and their market penetration may mean that in Victoria gas will be used to provide peak generation capacity rather than be relied upon as the only alternative for baseload capacity.[40]

Policy alignment and integration across sectors will be required to enable a smooth transition to this lower-emissions system of electricity supply.

Division of responsibilities

The Federal Government carries increasing responsibility for emissions reductions.

Despite this, there is still an important role for state governments. This includes:

- setting a strategic direction for energy policy
- providing information to facilitate the transition
- enacting planning regulations to boost the deployment of renewables
- creating incentives for deployment and uptake of renewables.

The Victorian Auditor-General has reported that the growth in Victoria's 'capacity to generate renewable energy is not on track to meet future targets'.[43] As noted, the development of a Modern Energy System should include considerations of policy alignment and regulatory certainty and in that way work to ameliorate concerns such as those expressed by the Victorian Auditor-General.

3.2.3 Energy-efficient

Energy efficiency is the smarter use of energy. Emissions are reduced, costs are reduced and capital expenditure is deferred. Wide ranging and cost-effective efficiency measures will lead to lower electricity bills for consumers. Through better system planning and load control, peak demand can be significantly reduced, resulting in further cost savings.

Electricity consumption per person in Victoria has increased almost five-fold since the 1960s.* Generation of electricity alone is responsible for 53% of all Victoria's greenhouse gas emissions.[29]

A Modern Energy System should make the most efficient use of the resources that are available, through changes to both the way we consume energy and the way we supply energy.

Efficiency helps address the affordability of energy by avoiding the need for investment in more energy supply infrastructure through reducing peak demand, and reducing the amount of electricity each efficient consumer needs to buy. This offsets electricity price increases, which are primarily a result of upgrading the capacity of the grid to meet electricity demand on a small number of hot days.[44, 45]

It should be noted, however, that reductions in electricity consumption need to be assessed cautiously. Reductions that are the result of efficiencies or avoidance of wasteful use are encouraged, however, reductions that come from decreased economic activity such as the closure of businesses or less consumer demand due to cost require attention.**

* Commissioner for Environmental Sustainability, Foundation Paper One Climate Change

** www.esaa.com.au/Library/PageContentFiles/2c52db90-6475-4a3a-9fbd-959753d57267/120629_Where_are_electricity_sector_emission_heading.pdf

Energy Saver Incentive

The primary State Government program to support improvements in energy efficiency at the residential and small business level is the Victorian Energy Efficiency Target, marketed as the Energy Saver Incentive (ESI).

The ESI aims to make energy efficiency measures more affordable for homes and businesses, by effectively subsidising for consumers a list of approved activities (such as buying energy-efficient appliances). The funds to support the program come from a levy on electricity consumers, proportionate with their use: the more electricity you use, the more you contribute to the program.

Data for the ESI projects it to achieve up to 7–8% reductions from business-as-usual by 2015 (approx. 3,400 GWh per year).[47]

A key improvement that could be made to the scheme is the reintroduction of the residential ceiling insulation. Insulation remains one of the most effective ways of reducing household energy consumption.

The ESI is complemented by a national framework on Greenhouse and Energy Minimum Standards (GEMS), which sets minimum energy efficiency and efficiency labelling standards for a wide range of appliances, including white goods, air-conditioners, televisions and light globes. Further, steps have been taken to create a national energy efficiency scheme comparable to the Victorian ESI.[48]

Existing homes

The Victorian Government has committed to raising all existing housing stock to a 5-star average energy efficiency.[49] It has been estimated that improving an average 2-star house to a 5-star standard would save 32% of the total household energy consumption.[50]

A report by the 'One Million Homes' coalition of organisations focused on raising the energy efficiency of the 700,000 homes in Victoria that are currently eligible to receive concessions. It found that spending approximately $3,000 per house to raise these homes from an average of two stars to five stars would *save* $600 million over 10 years through reduced need for financial support through the concessions budget.[50]

While much can be done to improve the physical efficiency of buildings, the way we use our buildings can play a major role in total energy consumption.[62]

New homes

Houses have been calculated to use approximately 60% of total household energy for heating and cooling.[50] Much of this demand could be more effectively addressed both through superior building design, including better materials and insulation, and through smarter planning procedures, such as site orientation and street layout. These are cheaper solutions than using more energy, but for take-up to be encouraged such options also need to be the easier solution.

Since 2004, all new homes in Victoria have been required to meet a 5-star energy efficiency rating. In 2011, this was upgraded to 6 stars. Data over that period shows that household daily energy consumption in two- or three-year-old houses is markedly lower than that for houses over 10 years old (i.e. before the introduction of the 5-star standards).[51]

Energy use by buildings is a function not only of their efficiency (measured by energy per square metre), but also their total size.[52] Gains from rising energy efficiency in/as a function of the shell of a house have been at least partly cancelled out by the rising size of the average new home, which in Australia is the largest in the world,[52] as well as by energy-inefficient appliances that are used in many homes.

Emissions associated with the actual construction phase and the manufacture of building materials can account for up to 45% of total emissions over 50 years of a house's operation.[53] Modelling has shown that if housing stock is to be consistent with the strong emissions reductions targets required to mitigate climate change, houses ought to be built to a 9-star standard – assuming no significant reduction in house size.[52]

It follows that policy on housing must address total energy consumption as well as efficiency per square metre. Post-occupancy energy performance assessments, as currently take place for commercial buildings, would help develop an understanding of exactly how much energy a house consumes. Disclosure of a house's performance as a whole, not per unit area, could help create a price signal for more energy-efficient houses.

Demand management – setting the regulatory framework

Peak demand – typically on hot summer afternoons – is an important issue to address because it is a major driver of investment in the electricity network. The regulatory framework is the jurisdiction of the Commonwealth.

A recent Senate committee heard that significant amounts of money, perhaps as much as $16 billion,[44] have been spent building the infrastructure needed to cope with peak demand that only occurs on a handful of days each year.[54, 55] There is a strong argument that this expenditure could have been largely avoided through greater regulatory emphasis on reducing demand.[44]

The Senate committee agreed that 'The current regulatory framework not only permits but incentivises inefficient over-investment in network infrastructure.'[44] This echoed an earlier report published by the Department of Climate Change and Energy Efficiency.[57] Regulations through the NEM that encourage reductions in demand ('demand management') have the potential to reduce emissions and provide cost savings.

Further developments to help reduce emissions would include rule changes that allow the Australian Energy Regulator to require distributors to make greater use of demand management. Only 5% of the Demand Management Incentive Allowance for 2011 was used by Victorian distributors,[58] which demonstrates that even within the allowed budget for demand management there is significant scope for more concerted efforts.

A key recommendation from the Australian Energy Market Commission's 'Power of Choice' report was to task AEMO with developing a rule change proposal that would allow for demand-side participation in the wholesale market – potentially creating a situation where third parties can be paid the wholesale spot price for reducing demand.[59] At times of peak demand, when spot prices can reach $12,000/MWh (compared to a more typical $50/MWh), this provides a strong financial incentive for reducing consumption.

3.2.4 Empowering consumers

The Modern Energy System should allow Victorians much more control over their energy use and provide consumers with choice. Through improved access to information and data, consumers are able to make better decisions about their energy use. Through reduced costs of domestic-scale renewables and battery storage, households are able to become more self-sufficient, and community groups are able to establish medium-scale generation capacity with local economic benefits.

As electricity networks developed through the 20th century, households mostly lost control of the energy they received. Distant, centralised, state-owned power stations became the dominant source of supply. Privatisation of the networks and retail competition in the late 20th century introduced some choice for consumers, but the real empowerment is just beginning.

Victoria's Modern Energy System will support individuals through better provision of information such as usage data and will support households by facilitating distributed generation and models of community ownership.

The report by the Climate Commission, *The Critical Decade: Australia's Future – Solar Energy*,[60] provides an overview of the rapidly changing solar industry, including international developments and opportunities for Australia to better utilise and benefit from solar resources in the future. Solar photovoltaic (PV) systems have become more and more affordable. As prices have fallen, ordinary Australians have been quietly driving a solar revolution. Some of the key findings include:

- For Australian households the price of an average solar PV system has fallen to the point where solar is now competitive in some areas with daytime electricity prices.
- The cost of buying a solar PV system today is less than a quarter of the price a decade ago.
- Over 1 million rooftop solar PV systems have been installed in Australia, up from over 8,000 in 2007. About 2.6 million people, 11% of our population, now use the sun for their electricity needs.
- Queensland had the largest number of solar PV installations of any state, followed by New South Wales and Victoria. Australian households in outer metropolitan suburbs with high concentrations of home mortgages have a higher proportion of rooftops with solar PV than other suburbs.

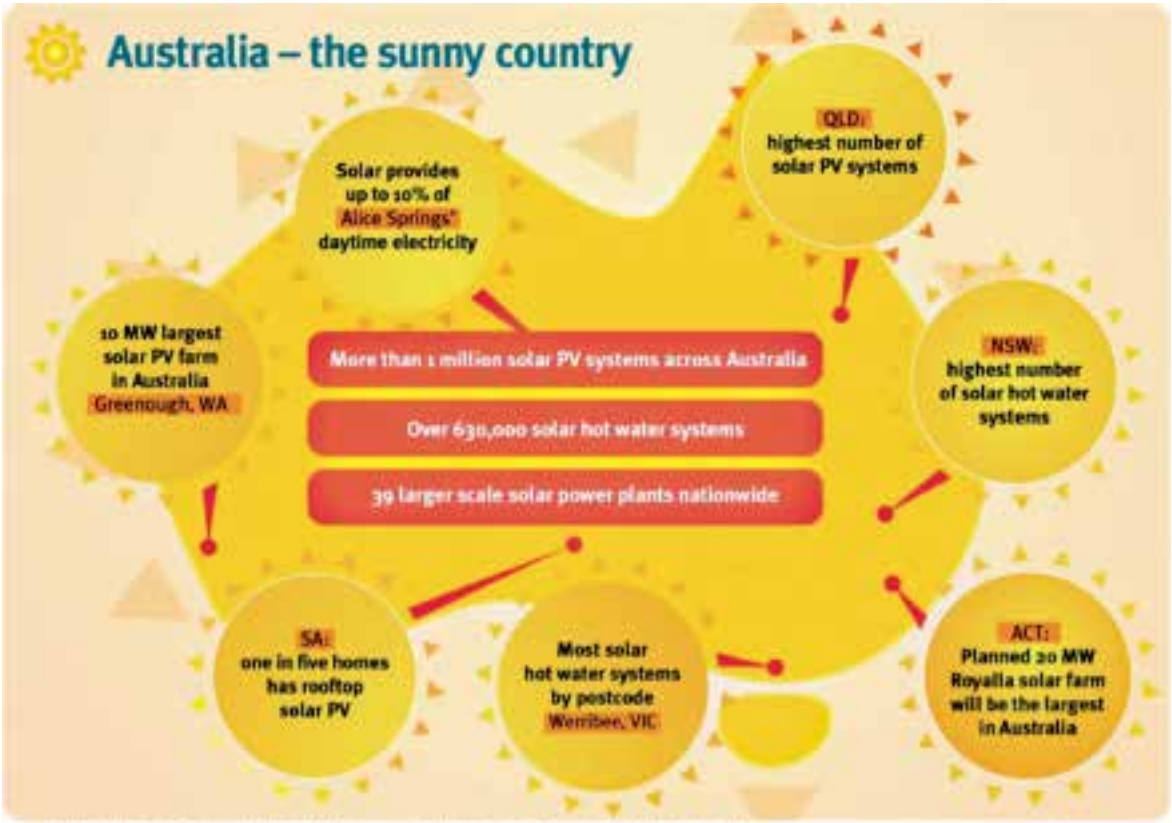


Figure B.3.3: PV insallations in Australia

Source AEMO 2012 Australian Government

Case Study: The suburb a power station of the future?

Suburbia energy

The suburban sprawl surrounding the world's cities could become the power provider for energy-hungry city centres, according to a university research report.

A team of researchers headed by Professor Hugh Byrd from the UK's University of Lincoln has revealed that far from suburban areas creating an energy drain, the increased adoption of rooftop solar photovoltaic (PV) panels on suburban roofs and an increase in use of electric vehicles (EVs), would give the outer suburbs the ability to harness excess energy for use in the city.

The 'Transforming Cities' research found that low-density suburban housing has the potential to capture up to 10 times more energy than city-based, energy-hungry commercial structures.

'This study challenges conventional thinking that suburbia is energy-inefficient, a belief that has become enshrined in architectural policy. In fact, our results reverse the argument for a compact city based on transport energy use, and completely change the current perception of urban sprawl,' said Professor Byrd.

'While a compact city may be more efficient for internal combustion engine vehicles, a dispersed city is more efficient when distributed generation of electricity by photovoltaic installations is the main energy source and electric vehicles are the principal mode of transport.'

'However, if this energy contribution is to be effective, controls of new suburban development may be needed that require the installation of photovoltaic roofing, along with smart meters and appropriate charging facilities for vehicles. City planners will need to make the changes necessary to control suburban development,' he said.

Professor Byrd said rather than rebuilding cities, an embrace of smart technologies combined with dispersed suburban areas allows us the opportunity to power cities in a cost-effective way as well as reducing our needs on fossil fuels.

'It is more a case of building for the future – when the climate will be warmer, harvesting solar energy will be cheaper than the grid and emerging technologies will replace the internal combustion engine. Particularly for city centre travel where longevity isn't an issue, electric vehicles will become increasingly more attractive as their price drops with mass production and the cost of fuel continues to rise,' said Professor Byrd.[61]

Regulation is needed to support such a transition as the Californian Case Study shows.

Case Study: Lancaster, California leading with solar regulation*

The Lancaster, California City Council unanimously approved changes to the city's zoning code that require housing developers to install solar with every new home they build.

This is the latest piece in what Republican Mayor R. Rex Parris described at the City Council meeting as a plan to make Lancaster 'the solar capital of the universe.'

Lancaster's now official Residential Zones Update specifies, along with a range of green building provisions, that new single family homes meet minimum solar system requirements in the same way that they must meet minimum parking space requirements.

'The purpose of the solar energy system standards,' it reads, 'is to encourage investment in solar energy on all parcels in the city, while providing guidelines for the installation of those systems that are consistent with the architectural and building standards of the City.' It is further intended 'to provide standards and procedures for builders of new homes to install solar energy systems in an effort to achieve greater usage of alternative energy.'

Residential homes on lots of 7,000 square feet or more must have a solar system of 1.0 Kw to 1.5 Kw. Rural residential homes of up to 100,000 square feet must have a system of at least 1.5 Kw. The standards spell out simple, commonsense rules for both roof-mounted and ground-mounted systems. They also deal with some interesting issues:

- A builder's model home must show the kind of solar system the builder will offer.
- Builders of subdivisions will be able to aggregate the houses' requirements. If 10 houses in a subdivision each have a one-Kw requirement, the builder can install a single ten-Kw system, two five-Kw systems or four 2.5-Kw systems.
- If a housing tract is built in phases, each phase must meet the requirement.
- Multi-family developments can meet the requirement with a rooftop system, or a system on a support or shade structure.
- Finally, and importantly, builders 'may choose to meet the solar energy generation requirement off-site by providing evidence of purchasing solar energy credits from another solar-generating development located within the City.'

Lancaster, with a population of 150,000, built approximately 200 new homes in 2012 and is on track to build at least as many – and therefore 200 more Kws of rooftop solar – this year, the mayor told GTM. But, at the height of the financial expansion in 2007, Lancaster added 2,800 new homes, which would be 2.8 megawatts of residential rooftop solar.

To turn his city into 'a place the solar industry comes to innovate,' Mayor Parris has led the City Council to:

- create the California Clean Energy Authority, which has brought in utility-scale solar developers like Silverado Power and a pipeline of 700 megawatts of large-scale solar within the city's boundaries

* www.greentechmedia.com/articles/read/Lancaster-CA-Becomes-First-US-City-to-Require-Solar

(Continued from previous page).

- create the High Desert Power Authority, which has proposed a new transmission project to the state's grid operator that would increase the delivery of renewables-generated electricity to other municipal utilities and relieve grid congestion between Northern and Southern California
- create Solar Lancaster in partnership with SolarCity (NASDAQ:SCTY), SunPower (NASDAQ:SPWR) and other installers, which identified Creative Renewable Energy Zones (CREZs) that have spawned over 27 megawatts of distributed solar across the city, including 7.5 megawatts of solar on Lancaster's schools at a profit to the city.

The next targets for Lancaster, Parris said, are:

- requiring all new homes to be meet LEED certification standards
- requiring grey water systems on all new homes
- requiring, when partner BYD's batteries are certified, battery systems for new homes' solar systems so they would be energy-independent for up to four days, and
- using LED bulbs and batteries so the city's street lights will be entirely off-grid.

'The salvation of this planet, if it is not already too late, will be from the bottom up,' Parris said, 'and there is no reason Lancaster can't be the example for the world.'

Giving people the information they need

There is a need to enable people make better choices related to their energy consumption. An important first step in this process is availability of information for households regarding their energy consumption.[63] Real-time electricity consumption information was a key justification for the roll-out of smart meters across the state. With this information people can make informed decisions about how to best reduce their electricity consumption.

Time-of-use pricing

Time-of-use pricing can provide added incentives to reduce consumption, especially at times of peak demand when electricity is more expensive to generate. Flexible pricing options can present financial risks to certain groups who may have fewer options to alter their energy use (e.g. lower-income groups and those who are home more during the day). It will be important to ensure a shift to flexible pricing structures does not place an unfair burden on those groups.[44, 64]

The introduction of time-of-use pricing, however, must go hand-in-hand with ensuring consumers have practical options for how to shift or reduce their electricity usage at peak times.

Community focus on climate change: supporting household renewables

There is a growing international trend among rural communities to take direct action in relation to tackling climate change. A recently example was reported in the *Guardian*. An Oxford community successfully implemented a hydroelectricity project with an end cost of £300,000 funded entirely from a pool of individuals which included 75% local beneficiaries.

Community-driven sustainability projects are becoming more common in the Northern Hemisphere in countries including Germany, Canada and the Netherlands, generating significant energy by and for the local stakeholders who fund them.

In fact, Germany had 670 energy cooperatives operating or in development in 2011, with a key feature of all being that over 90% of the project was funded by local, individual investors.[65]

While in Australia, it appears that solar is the people's choice, wind projects like Hepburn Wind show real leadership and community involvement. (see 3.5 for more information).

Case Study: A Victorian exemplar, Hepburn Wind

An example of local action on climate change is Australia's first community owned renewable energy project, Hepburn Wind, located at Leonards Hill, 100 km north-west of Melbourne. The following time line illustrates the community's commitment to long-term planning:

- 2004 – first meeting held at the town hall to discuss the proposal
- 2007 – planning permit for two wind turbines was secured
- 22 June 2011 – the turbines first generated electricity
- 5 November 2011 – Hepburn Wind had its official launch

The residents of Leonards Hill drew funding from grants and the contributions of individuals' own savings. The entire project was estimated to cost $13.5 million, and the breakdown was thus:

- Capital from members and applicants – $9,640,225
- Sustainability Victoria RESF grant – $975,000
- Regional Development Victoria RIDF grant – $750,000
- Bendigo and Adelaide Bank loan (10 years, not fully drawn) – $3,100,000
- A debt guarantee from Embark Australia – $1,000,000.[66]

Hepburn Wind has proved such a huge success that the money raising activity that provided the initial project is being regenerated by locals to support a diverse range of activities. This arm, called, SHARE (Sustainable Hepburn Association – Renewing the Earth), aims to develop collaborations to support youth and local issues and also make a difference to their local environment, which includes harvesting and purchasing locally grown produce.

Climate change researchers from Japan visited the rural Victorian town to study the work done in Leonards Hill with the hope that Hepburn Wind's success could be replicated within a Japanese cultural context.

The overseas scientists were particularly impressed with the careful and close communication maintained with local stakeholders, which helped to overcome an initial lack of understanding and support among the community. Hepburn Wind organisers also explained how they dealt with anti-wind protestors, emphasising professional, open communication with the wider public, all the while being supported by clear, scientific reasoning.

Ultimately, the trend towards community-led renewable energy projects demonstrates that action on climate change is not only possible, but successful at a local level. Furthermore, it demonstrates that individuals want to make real changes and understand the long-term cost benefits. SHARE is an example where community collaboration can start with green electricity and evolve into projects that can address wider environmental and social issues in the region.

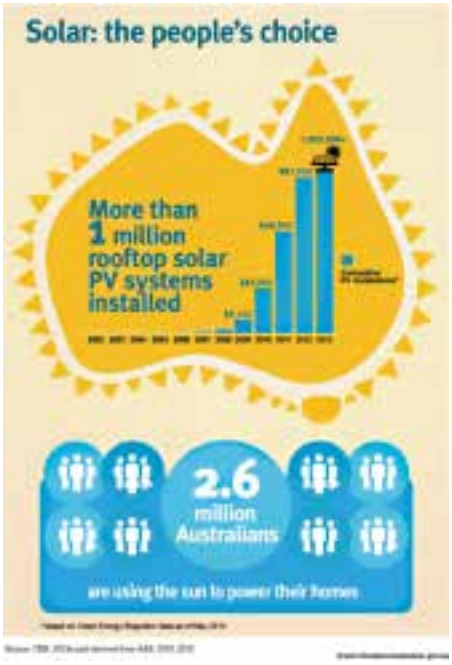


Figure B.3.5: The solar choice in Australia
Source CER 2013

3.2.5 Equitable access

With the significant changes to the electricity sector that will be driven by both global economic trends and government policy, it is crucial that the interests of all Victorians are considered in the transition to a Modern Energy System, it should increase accessibility and affordability. This includes ensuring that efficiency initiatives and household-scale renewables are available to low-income and other disadvantaged groups.

Solar panels WestWyck Brunswick

Access to grid

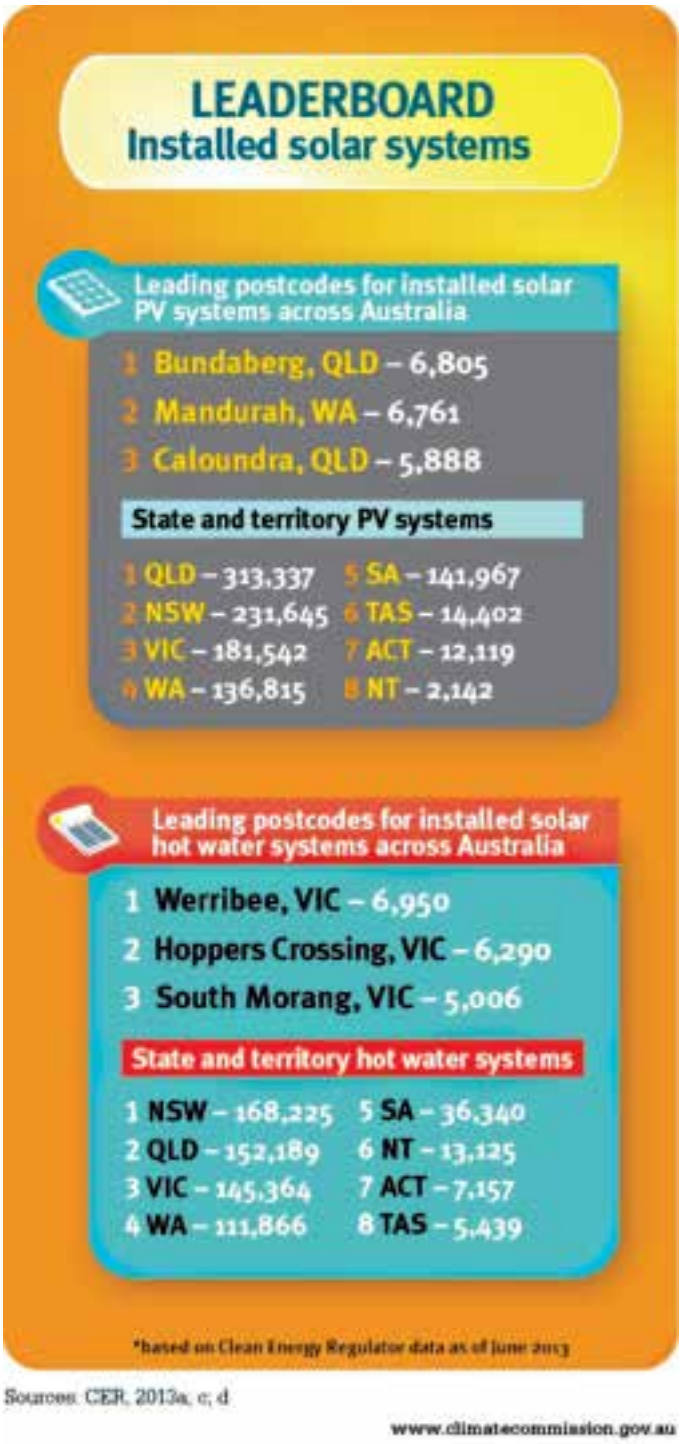
One of the primary barriers preventing the uptake of renewable energy in Victoria is a regulatory regime that remains tailored to traditional centralised generation processes. The current framework fails to recognise and accommodate the proliferation of distributed generation technology.[44] Contrasted with traditional centralised generation, distributed (or embedded) generation involves a higher number of smaller scale energy production units. It typically involves small- to medium-scale renewables such as solar PV and wind, but can also include co- and tri-generation and small gas turbines.

There is currently no automatic right for distributed generators to connect to the grid, and connecting to the grid remains at the discretion of the individual utility companies.

A recent review by the Department of Climate Change and Energy Efficiency found that several regulatory requirements currently inhibit connection to the grid, including obtaining approval from network service providers and distributors, compliance with technical standards and registration charges payable by larger embedded generators for connection.[57]

Nonetheless, Victorian households are leaders in the uptake of solar, and the breakdown of suburbs provided at Figure 3.14 indicates that our outer suburbs are installing solar PV at faster rates than inner-city dwellers.

Figure B.3.6: Leading postcodes for installed Solar PV



3.3 Transition is Complex but Necessary

3.3.1 What are others doing?

Countries that account for 90% of the global economy have emissions reductions commitments, including China and India, and they are implementing policies and funding programs to achieve these reductions. These countries are also positioning themselves as renewable technology leaders as they see the benefits to their economies.

Figure B.3.7: Large-scale economic decarbonisation strategies[4]

Overview of targets, costings and assumptions about social and political change

Transition strategy	Energy and emissions targets	Approximate cost of transition policies	Assumptions about social and political change
European Commission Low Carbon Roadmap eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF	Reduce EU GHG emissions by 20% by 2020 and 80–95% by 2050 (on 1990 levels).	Approx. €270 billion p.a. over 40 years (1.5% of EU GDP p.a. above 2009 investment levels). Savings between €175–320 billion p.a. (not incl. savings on social costs).	Political and social change drivers not covered in detail. Notes importance of policy innovation, public education and behaviour change.
Government of the United Kingdom Carbon Plan www.decc.gov.uk/en/content/cms/tackling/carbon_plan/carbon_plan.aspx	Reduce UK GHG emissions by 34% by 2020 and 80% by 2050 (on 1990 levels).	Total net present cost over lifetime of policies in past carbon budget periods approx £9 billion. Average cost 0.4% of UK GDP p.a. in period 2008–22 and 0.6% of UK GDP per year over 2023–27.	Importance of UK Government, industry and citizens 'pulling in the same direction' in order to achieve low carbon transition.
Government of South Korea Green Growth Strategy www.greengrowth.go.kr/english/en_main/index.do	Reduce Korean GHG emissions by 30% below projected 2020 levels (equivalent to 4% reduction on 2005 levels).	Total investment announced as part of Five-Year Plan (2009–13) US$83.6 billion.	Emphasis on education and raising public awareness about need for lifestyle change needed to support green growth.
Government of People's Republic of China 12th Five-Year Plan and Climate Change White Paper cbi.typepad.com/china_direct/2011/05/chinas-twelfth-fivenew-plan-the-fullenglish-version.html www.gov.cn/english/official/2011-11/22/content_2000272.htm	Reduce Chinese CO_2 emissions per unit of GDP by 40–45% by 2020 (on 2005 levels).	Total investment (public and private) in 'new energy' of approx RMB5 trillion (US$760 billion) over next 10 years.	Assumption of strong, ongoing role for coordinated government planning and intervention, consistent with overall Chinese economic and political governance arrangements.

Transition strategy	Energy and emissions targets	Approximate cost of transition policies	Assumptions about social and political change
Government of India National Action Plan and Low Carbon Growth Report pmindia.nic.in/Pg01-52.pdfhttp://planningcommission.nic.in/reports/genrep/Inter_Exp.pdf	Reduce India's emissions intensity of GDP by 20–25% by 2020 (on 2005 levels).	Does not include detailed costings.	Notes need for final report to include discussion of ways of overcoming barriers to policy implementation and adoption by communities, business and governments.
Government of Australia Clean Energy Future www.cleanenerg yfuture.gov.au/clean-energy-future/ourplan	Reduce Australian GHG emissions by 5% by 2020 and 80% by 2050 (on 2000 levels).	Carbon price and related measures to raise approx. A$25.5 billion in the period 2011–15. Further $3.9 billion public funds to augment.	Carbon price as central driver of change. Strong emphasis on limited impact of policy measures on Australian economy and lifestyles.
Government of Germany Energy Concept www.bmu.de/files/english/pdf/application/pdf/energiekonzept_bundesregierung_en.pDf	Reduce German GHG emissions by 40% by 2020 and at least 80% by 2050 (on 1990 levels).	Additional investment €20 billion p.a., offset by energy cost savings.	Importance of public understanding and support for transition. Emphasises importance of accessible information, transparent decision making and opportunities for public dialogue.
Government of Denmark Our Future Energy ens.netboghandel.dk/publikationer/publikationsdetaljer.aspx?Pld=5308989e-ea64-436b-8346-4e29c8a84d62	100% renewable energy in all Danish energy supply by 2050.	Cost to 2020 approx. DKK 5.6 billion (US$952 million). Immediate net costs of <.25% GDP in 2020. Average additional costs to Danish households approx. DKK 1,700 (US$ 289) in 2020.	Assumes strong ongoing role for government in encouraging innovation and community education.
Government of California Scoping Plan and Clean Energy Future Plan www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm www.cacleanenergyfuture.org	Reduce GHG emissions to 1990 levels by 2020 and 80% of 1990 levels by 2050; 33% of electricity from renewable energy by 2020.	Ongoing costs approx. US$36 million p.a. Benefits by 2020 (compared to BAU) include increases in economic production of US$33 billion and overall gross state product of US$7 billion.	Active public participation essential. Emphasis on role for market forces and growing environmental awareness to shift individual choices and attitudes. Targeted public outreach, marketing and education programs.

Case Study: The EU Covenant of Mayors: Sustainable Energy Action Plans*

In March 2007 the European Union's leaders endorsed an integrated approach to climate and energy policy that aims to combat climate change and increase the EU's energy security while strengthening its competitiveness. To start this process, the EU Heads of State and Government set a series of demanding climate and energy targets to be met by 2020, known as the '20–20–20' targets. These are:

- a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources
- 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

The Covenant of Mayors is the mainstream European movement involving local and regional authorities in the fight against climate change. It is based on a voluntary commitment by signatories to meet and exceed the EU 20% CO_2 reduction objective through increased energy efficiency and development of renewable energy sources.

Local governments are seen to play a crucial role in mitigating the effects of climate change, all the more so when considering that 80% of energy consumption and CO_2 emissions is associated with urban activity.

Actions speak for themselves

Covenant signatories represent cities, from small villages to major metropolitan areas such as London or Paris, which are committed to implement sustainable energy policies to meet and exceed the EU 20% CO_2 reduction objective.

Notably the signatories undertake to prepare a baseline emissions inventory, which is a quantification of the amount of CO_2 emitted due to energy consumption within a given period of time – the recommended base year being 1990. It allows the identification of the principal sources of CO_2 emissions and their respective reduction potentials and requires the submission, within the year following their signature, of a Sustainable Energy Action Plan (SEAP). This is the key document in which the covenant signatory outlines how it intends to reach its CO_2 reduction target by 2020. It defines the activities and measures set up to achieve the targets, together with time frames and assigned responsibilities. Covenant signatories are free to choose the format of their SEAP, as long as it is in line with the general principles set out in the covenant SEAP guidelines outlining the key actions they plan to undertake.

Beyond energy savings, the results of the actions of the signatories include:

- creation of skilled and stable jobs, not subject to delocalisation
- healthier environments and quality of life
- enhanced economic competitiveness
- greater energy independence.

These actions serve as examples for others to follow, through referring to the 'Benchmarks of Excellence', which are relevant examples of initiatives that covenant signatories, coordinators and supporters feel particularly proud of, and moreover endorse as useful actions for other local authorities, provinces, regions or networks to replicate.

* www.eumayors.eu/about/covenant-of-mayors_en.html

3.3.2 Carbon budgets: part of the change

'Carbon budgets' are playing a role in shifting the status quo. These budgets are based on the idea that if we understand how the planet will warm in response to certain concentrations of greenhouse gases in the atmosphere, then we can determine how much can be emitted to limit warming to a given level.

Current estimates are that, globally, approximately 1,000 billion tonnes of CO_2-e can be emitted between 2000 and 2050 to make it likely that warming will be limited to 2°C above pre-industrial levels[5] – thought to be the threshold between dangerous climate change and *very* dangerous climate change.[6] In the 13 years since 2000, we have already consumed 40% of this budget.[2]

To meet the 2°C target, the International Energy Agency has calculated that only one-third of proven fossil fuel reserves can be burnt before 2050.[7] Investment analysts are now looking at the effect this 'unburnable carbon' might have on the value of existing assets and on the ability to finance new fossil fuel operations.[8, 9, 10]

Wasted capital and stranded assets

> **'Smart investors can see that investing in companies that rely solely or heavily on constantly replenishing reserves of fossil fuels is becoming a very risky decision. The report raises serious questions as to the ability of the financial system to act on industry-wide long term risk, since currently the only measure of risk is performance against industry benchmarks.'**
>
> Professor Lord Stern[7]

Unburnable Carbon 2013: Wasted Capital and Stranded Asset[1] a research report from Carbon Tracker and the Grantham Institute calls for regulators, governments and investors to re-evaluate energy business models against carbon budgets to prevent a $6 trillion carbon bubble in the next decade.

The report revealed that fossil fuel reserves already far exceed the carbon budget to avoid global warming of 2°C, but in spite of this, $674 billion was spent in 2012 to find and develop new potentially stranded assets.

Between 60–80% of coal, oil and gas reserves of publicly listed companies are 'unburnable' if the world is to have a chance of not exceeding global warming of 2°C.

- The total coal, oil and gas reserves listed on the world's stock exchanges equals 762GtCO_2 – approximately a quarter of the world's total reserves.
- If the same proportion is applied to the global carbon budgets to have an 80% chance of limiting global warming to 2°C, their allocation of the carbon budget is between 125GtCO_2 and 225GtCO_2, illustrating the scale of 'unburnable carbon'. However companies in the coal, oil and gas sectors are seeking to develop further resources that could double the level of potential CO_2 on the world's stock exchanges to 1,541 billion tonnes.

Figure 3.2 shows that even a less ambitious target of 3°C would still apply significant constraints on our use of fossil fuel reserves.

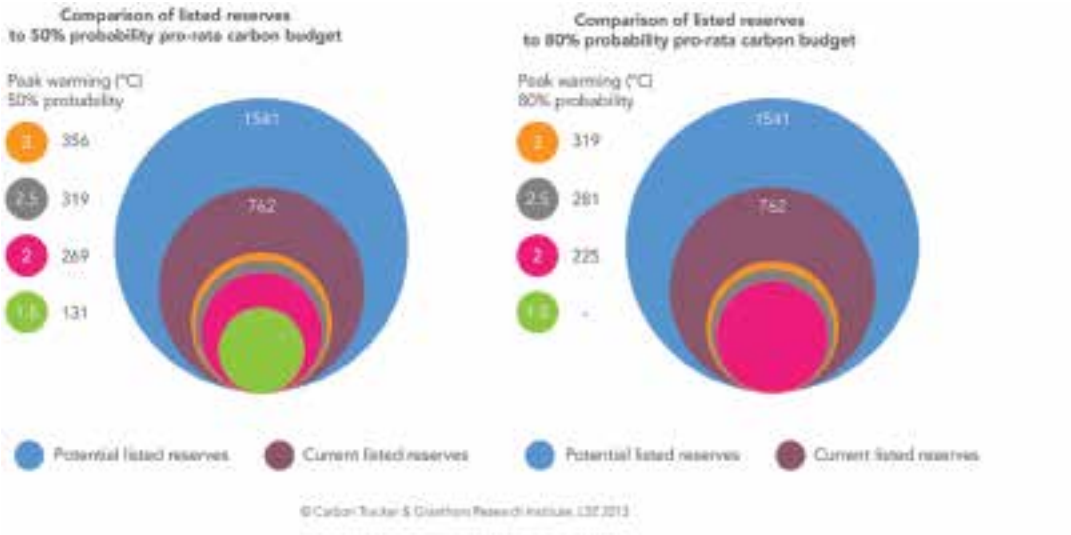


Figure B.3.8: Listed fossil fuel reserves

The research indicates that globally, coal reserves are centred in Pacific and Eastern regions, while oil is predominant in Northern and Western regions of the world.

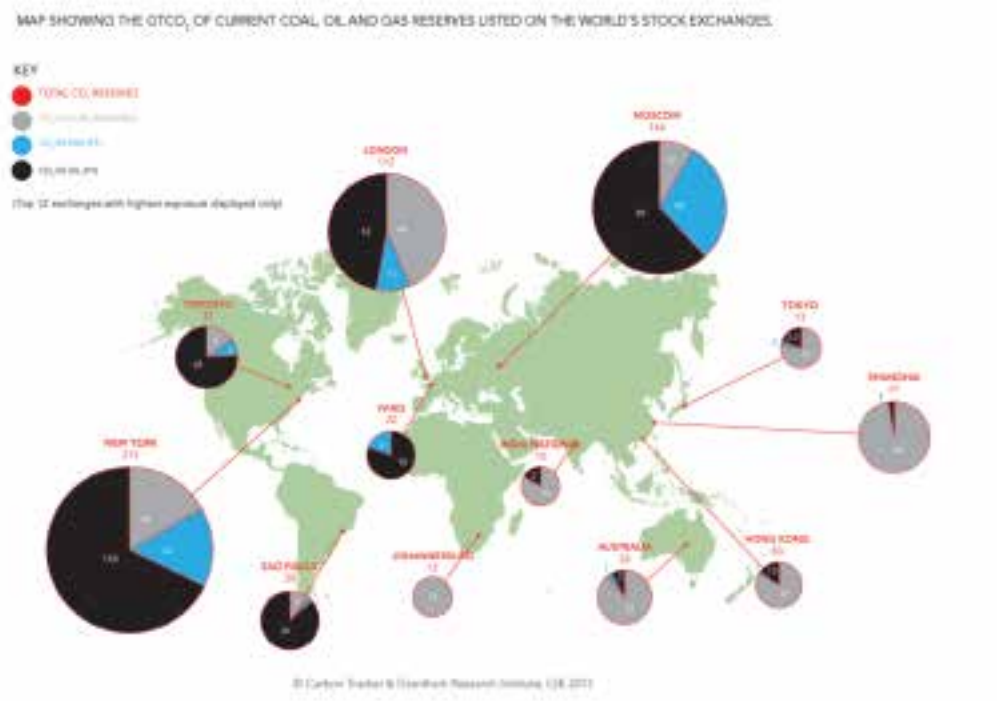


Figure B.3.9: Global coal reserves

The report notes that company valuation and credit ratings methodologies do not typically inform investors about their exposure to these stranded assets, despite these reserves supporting share value of $4 trillion in 2012 and servicing $1.27 trillion in outstanding corporate debt over the same period.

A challenge to these methodologies is recommended.

- To avoid systemic risks such as climate change, investors will have to demand to go beyond the traditional definition of risk as underperforming the benchmark.
- The rebalancing and redistribution of funds if required to protect shareholders' interest and prevent wasted capital, the scale of which can be seen in Figure 3.4. Greater understanding of the uncertainty and risk around fossil fuels can help the redistribution of these funds towards alternatives more attractive.

The report makes a number of recommendations for action by governments, financial intermediaries, institutional investors and citizens to manage this risk.

Figure B.3.10: Recommendations for governments

Unburnable Carbon: Australia's Carbon Bubble

Following the Carbon Tracker's Unburnable Carbon 2013 global analysis, the Climate Institute assessed the risks facing the Australian coal, oil and gas sectors.[11]

Its report, *Unburnable Carbon: Australia's Carbon Bubble* report reveals that Australia's coal reserves are already more than double their market share of the precautionary global carbon budget for coal. Nevertheless, Australian listed companies spent an estimated A$6 billion on finding and developing more coal reserves.

Australia's coal budget

The Climate Institute's report finds that Australia contributes approximately 56GtCO$_2$ of fossil fuel reserves. Australian fossil fuel production has a particularly high exposure to coal reserves, which make up 51GtCO$_2$ of this total.

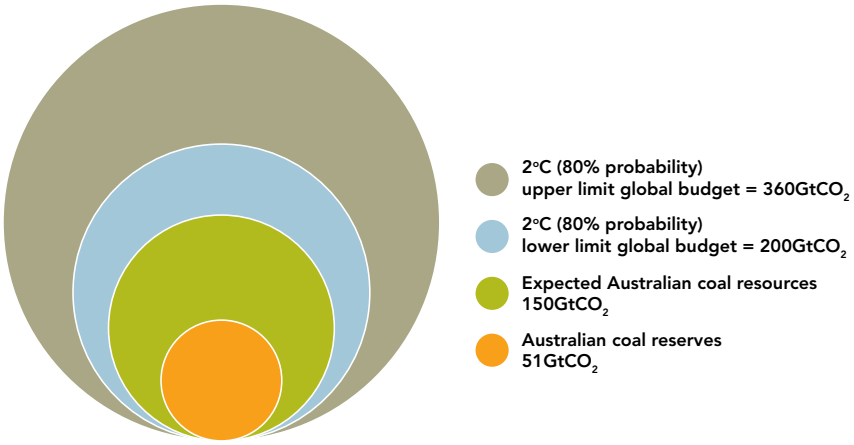


Figure B.3.11: Australian coal and global budgets

Coal resources are those coal stocks yet to be developed and with at least a 50% chance to be made economically viable. This gives an indication of what companies are trying to bring online.

Australia's total coal resources equal 300GtCO$_2$, so applying a conservative estimate that only 50%of this will be proven (150GtCO$_2$) reveals total holdings that take up 75% of the precautionary, lower limit global budget for coal.

Australia's exposure to international markets

The report noted that:

- Although the ASX 200 (Australian Securities Exchange) has a disproportionately high exposure to Australian coal in a carbon-constrained future, 61% of this coal is listed on international stock exchanges. This leaves Australian coal highly vulnerable to the behaviour and decisions in which they have no say at all.

And the report further explained:

- The UK has as much Australian coal listed on it as the ASX, and recently pressure has been rising on the Financial Policy Committee to mitigate the risk these 'sub-prime' fossil fuel assets pose to economic stability.
- Australia's coal is exported for a total value of A$48 billion, but most of its key export markets are implementing significant climate regulations.

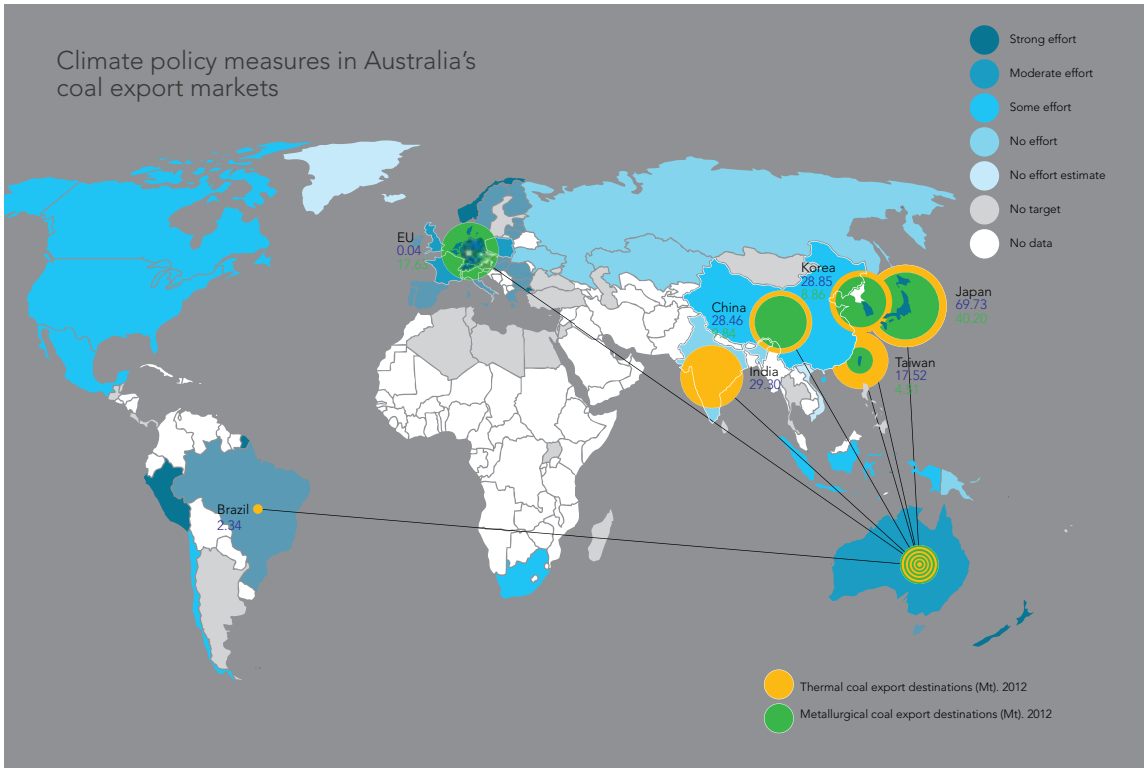


Figure B.3.12: Climate policy in Australia's export markets

As the comparison to global coal budgets illustrate, Australia will have a vast oversupply of coal assets in a carbon-constrained world, therefore running the risk of being left with significant stranded assets.

3.4 Is a Modern (renewable) Energy System possible in Victoria?

Against this background of national and sub-national policy settings and industry engagement, along with science and advance investment risk profiles: The question is: **Could 100% of Victoria's energy needs be met by renewable sources at some time in the future?**

This is the question the Department of Environment and Primary Industries of Victoria asked, and the following are the results of an independent assessment undertaken by consultants SKM.

Our findings show that Victoria has more than sufficient useable renewable resources, both on an absolute basis and on an 'energy use per person' basis, to conceivably meet all our energy needs from renewable sources. The figure below shows the comparison between useable renewable energy resources and consumption levels now and projected in 2030.

Figure B3.13: Useable renewable energy resources and energy consumption in Victoria

	Theoretical PJ/y	Usable PJ/y	Theoretical GWh/y	Usable GWh/y
Wind	15,930	5,631	4,425,115	1,564,118
Solar	32,781	2,515	9,105,794	698,656
Geothermal	>>271	181	>>75,369	50,141
Hydro	57	3	15,000	934
Biomass	>>57	33	>>15,863	9,294
Wave	>>27	27	>>7,438	7,438
Tidal	>>0.1	0.1	>>39	39
TOTAL	**>>49,121**	**8,390**	**>>13,644,618**	**2,330,619**

Wind and solar energy resource potentials make up the bulk of the useable energy amounts. Accepting very high levels of either or both of these technologies would require:

- acceptance of the cost of these technologies relative to alternative sources (economic trade-offs)
- acceptance of the environmental impacts of these technologies, such as the impacts upon flora and fauna, relative to the impacts of alternatives
- acceptance of the social impacts such as visual impacts and changed employment patterns relative to alternatives.

These are clearly issues for consideration. However, they should not be considered in isolation, nor should they be seen as insurmountable. Technological advances, changes in international policy and world markets require a change in policy settings.

Figure B.3.14 shows the areas of Victoria with the greatest useable renewable energy potential. The renewable resources shown here reflect all the resource types considered, but are dominated by wind and solar resources. The areas with the greatest resources tend to be in the east and west of the state rather than near the main consumption centres in the Melbourne–Geelong area.

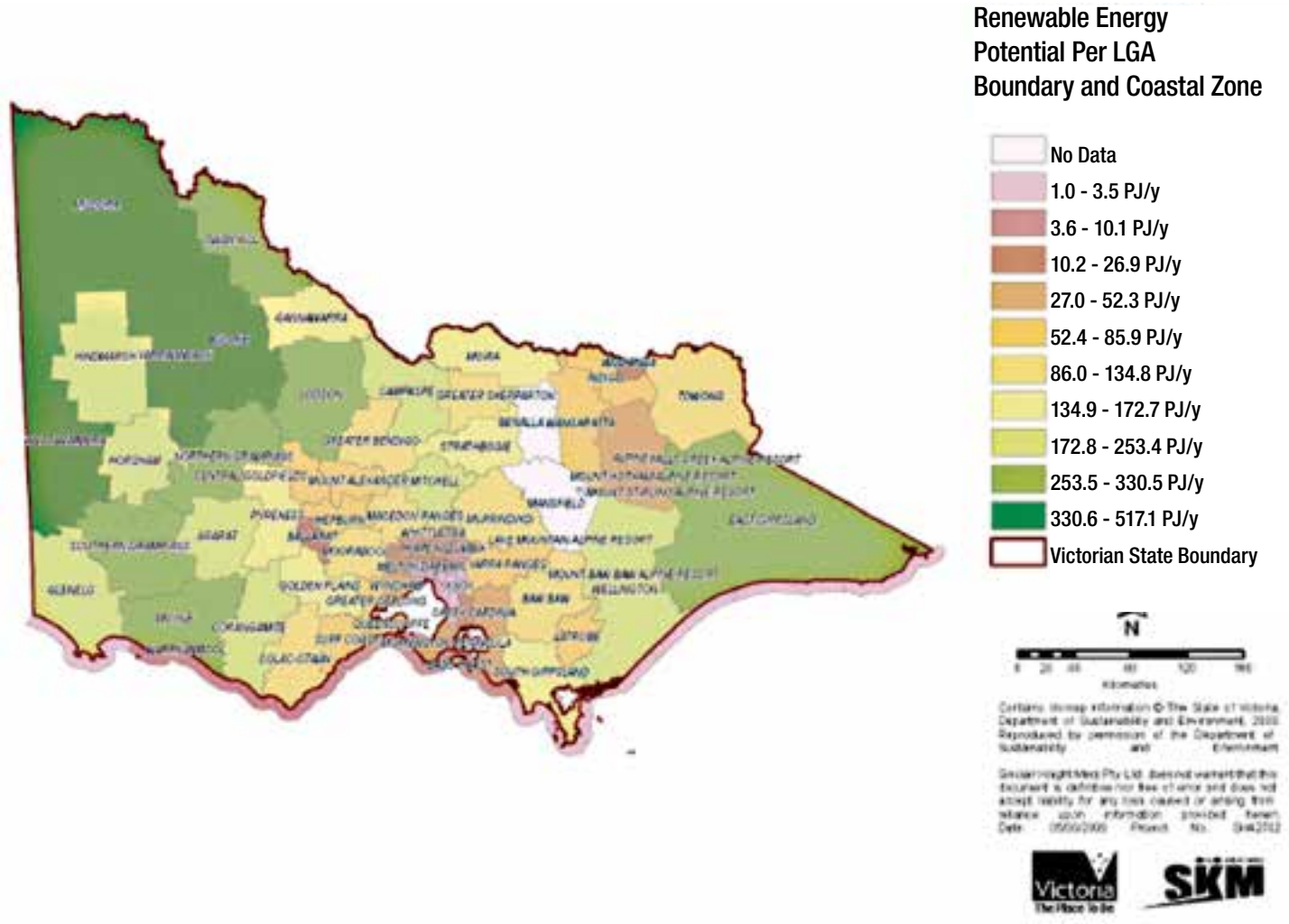


Figure B.3.14: Renewable energy potential for Victoria – LGA administrative boundaries and coastal zones renewable energy potential per LGA

The SKM report states that 'Because of the extent of Victoria's renewable energy resource, Victoria can dream of a future where all its energy needs are met by renewable energy sources.' But, it also notes that a commitment to follow a complete renewable energy pathway would almost certainly require an economic commitment of such a significant scale that it would impact on the achievement of many other of society's economic needs and goals.

We now face a period of history where not making strategic economic decisions of a transformational scale would in fact be a failure that results in our goals and aspirations being denied and our prosperity challenged.

3.5 A 'Process' for a Plan

The development of a Modern Energy System is a major undertaking, vital for Victoria's continued prosperity. The construction of a plan requires industry consultation, broad community engagement and funding for relevant scenario modelling and supporting research, so that the best data and information is available for decision makers.

Government policy development and consultation processes should be enhanced to ensure a whole-of-system approach. CSIRO's Futures Forum, which it has successfully applied in the aviation, energy and fuel sectors, provides a model for the required engagement process.[67]

Swan Hill eco house, water senstive garden and wind turbine

The Futures Forum Process consists of a structured series of eight facilitated government, industry and community forums over approximately 12 to 18 months. For the development of a Modern Energy System plan the workshops would proceed as follows:

- At the first workshop, forum participants will share knowledge through a series of presentations and discussions, and then work together to define the scenarios and options to be examined by modelling capability. (Quantitative analysis and modelling will be a partnership undertaking between government, selected groups, consultants and academics as necessary).
- At the second and third workshops modelling results will be presented and forum participants will direct changes to the scenarios or model assumptions to improve and revise the model outputs.

RECOMMENDATION 18

It is recommended that the Victorian Government use the CSIRO's Futures Forum model to develop a plan for a Modern Energy System.

ATTRIBUTES

Applied to the development of a Modern Energy System the Futures Forum model would deliver a plan which includes the following:

- **an agreed view of the various options to be considered**
- **identification of regulatory barriers, risks, benefits and trade-offs**
- **an action agenda required to move those options forward towards identification of the roles of each stakeholder in achieving that goal.**

- At the fourth and fifth workshops participants will provide a collective view of the challenges, opportunities and potential solutions (including policy and regulation options) for a Modern Energy Plan System sector that have been identified during group discussions and in the modelling outputs.
- In the remaining workshops forum participants will provide input to a the draft plan for a Modern Energy System that has been developed by the government project secretariat to capture and communicate the forum's findings.

The CSIRO forum process does not seek to arrive at a consensus on specific recommendations for government policy or investment.

The draft plan can be used by the Victorian Government for consideration and decision. Depending on the issues raised and the suggested actions for development, the government might consider deferring decisions and using the draft plan as a basis for broad community consultation via a traditional 'green' and 'white' paper process.

CSIRO's Futures Forums are used in the delivery of large, multi-stakeholder industry roadmap projects. The development needed for Victoria to have a Modern Energy System will require an 'industry roadmap'.

Reflecting CSIRO's process the Victorian Government should coordinate the project and provide support for a steering committee that includes representatives from across industry and community sectors. The process needs to be supported by actively engaging the sector, with a high level of consultation with all participants throughout. CSIRO sets out core roles and responsibilities of participants and the general functioning of the steering committee in a participant agreement to ensure clarity.

The CSIRO Futures Forum method is recommended, as it accommodates the complexity of issues and provides for:

- the balance of interests across sectors
- a whole-of-system evaluation
- the use of scenarios
- a comprehensive analytical framework.

GOAL **FOUR** SUSTAINABLE COMMUNITIES

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GOAL **FOUR** SUSTAINABLE COMMUNITIES

4.1 Urban Expansion: Our Cities and Towns

Proposition

The protection of ecosystem services is integral to our quest for liveability and the sustainability of our cities and towns. To build resilient, thriving communities we need our planning systems to provide a coherent, certain and strategic vision for human settlements. This 'vision' will need to reflect environmental protection imperatives, and an understanding of the value of ecosystem services and their integration with our social and economic activities.

'Allowing us to grow further and further out, to actually perpetuate sprawl, is creating an incredibly unaffordable, unsustainable and impractical future.'[34]

Professor Roz Hansen, Chair of the Ministerial Advisory Committee on Victorian Metropolitan Planning

Bus transit looking east across to Melbourne

Context

Commentary about urban settlements has appeared routinely in Victorian State of the Environment reports since the first report in 1986. Ongoing interest is a function of the increasing importance of cities as:

- population centres
- engine drivers of economies
- centres of social activity and interaction
- contributors to biodiversity loss
- greenhouse gas generators.

Our Water Foundation Paper outlines work being undertaken in respect of integrated water cycle management and water-sensitive urban design[6] and our Climate Change Foundation Paper provides insights into impacts.[7]

Cities are intensely challenging as environmental focal points: 'approximately one-fifth of all GHG emissions from end use energy consumption can be directly attributed to domestic transport-and-housing-centred activities'.[4]

Melbourne is growing faster than Sydney.[8] Across the country, construction, with all its resource-use intensity, is our third-biggest industry after finance and manufacturing.[4] We know that cities generate 80% of our GDP and that two-thirds of Australia's population live in our major capital cities.

Melbourne as a renewal and construction site

'The way that a city, its suburbs and buildings are designed and built can have a large impact on long-term environmental sustainability, how its inhabitants live, work, commute and participate in recreational activities. The potential for urban growth to exceed a city's capacity and expand into the surrounding natural environment or rural land in the absence of sustainable precinct planning, has been common in the recent past. This has led to widespread, low density urban areas where people are predominantly car dependent to access employment and services. In urban sprawl areas, often there is a focus on road building over improving infrastructure for public transport, cycling and walking. It also results in a loss of the rural land and open space that surrounds a city and is important for its aesthetic, recreational and productive value.'

City of Whittlesea[1]

4.1.1 Integration and alignment: equates to liveable and sustainable

Depending on the criteria used, Melbourne has either the highest city liveability ranking (for three years in a row)[37] or, taking a range of different sustainability indicators, the city can be ranked 17th (Mercer Quality of Living Survey)[38] or 34th (City Infrastructure Ranking).[39, 40] We clearly wish to retain the mantle of liveability, which rests upon good environmental quality as much as social and economic foundations.[41] The protection of the environment and the provision of its ecosystem services are fundamental to our aspirations.

If the question is: What to do to engender environmentally sustainable outcomes for our cities? Crudely, the answer is: integration and alignment.

Plan Melbourne

On 9 Oct 2013, Plan Melbourne, the Victorian Government's metropolitan planning strategy for the next 40 years was released for comment.

The strategy is intended to guide Melbourne's development and growth by bringing together for the first time infrastructure, housing, employment, transport and environment in the one integrated plan.

The key aspects of *Plan Melbourne* include:

- A permanent urban growth boundary will be put in place to curb urban sprawl by distributing population growth to our regions. A 'State of Cities' will be created as new major population and employment towns for growth across Victoria. This includes Bacchus Marsh, Ballan, Broadford, Kilmore, Warragul-Drouin and Wonthaggi.
- At least half of Melbourne's residential zoned land will be protected from high-rise apartment development with a Neighbourhood Residential Zone.
- Driving the growth of the City of Melbourne as Australia's largest jobs hub by 2040 as major new urban renewal precincts including Fishermans Bend, E-Gate and Arden Macaulay begin and Docklands is completed.
- Implementing the Metropolitan Planning Authority which will play a critical role in managing and delivering Plan Melbourne along with the largest urban renewal pipeline in Victoria's history. The Authority will be charged with working with local governments, landowners and other stakeholders in delivering many of the initiatives of Plan Melbourne as well as the structure planning of a number of new precincts.
- Investigating a third airport for Melbourne's South East to serve Gippsland and Melbourne's South East. The airport would serve one-third of Victoria's population including the 300,000 residents of Gippsland.

Releasing the plan, the Premier Dr Denis Napthine said:

'This is an integrated land, transport and economic strategy that will change our thinking about better using city-shaping policies and infrastructure projects to enhance the city's liveability and attract investment and jobs.'

Submissions and feedback on Plan Melbourne will be accepted until Friday 6 December 2013.

Refer to: http://www.premier.vic.gov.au/media-centre/media-releases/8035-plan-melbourne-ensuring-we-remain-the-world-s-most-liveable-city.html

RECOMMENDATION 19

It is recommended that the Victorian Government establish an independent statutory planning authority.

ATTRIBUTES

The proposed planning authority would have statutory powers, functions and accountabilities to:

- **strategically integrate land use planning**
- **issue land release policies in relation to infill and greenfield development**
- **develop precinct plans for environmentally sustainable land use and development, aligning transport and other infrastructure needs**
- **develop a Sustainable Development Practice Direction and a Sustainability Policy as a component of the State Planning Policy Framework.**

4.1.2 Cities driving change: research, views and exemplars

As Victoria reviews its planning systems, it is instructive, as to the complexity and importance of planning cities, to consider some research and programs already initiated by national, state and local governments.

A time line outlining recent national level cities' interventions and research illustrates some of the key themes and challenges:

- 2009: COAG agreed to city reporting arrangements and the Major Cities Unit was created
- 2010: The *State of Australian Cities Report* was published and the Federal Treasury observed 'getting it wrong [in relation to cities] is likely to be very costly economically, socially and environmentally'.
- 2011: A Sustainable Population Strategy was developed and Our Cities, Our Future: A National Urban Policy for Australia was developed.
- 2012: The COAG Reform Council produced recommendations in its *Review of Capital Cities Strategic Planning Systems*, the Urban Policy Forum was convened and SEWPaC developed sustainability indicators.
- 2013: The *State of Australian Cities Report* advances a cities agenda[10] and notes that the number of heatwave-related deaths in Australia's major cities is set to quadruple by mid-century.[13]

The governance landscape is complicated. At the federal level 11 ministers, 13 departments, 30 committees and 60 programs deal with city-scale issues, and similar interfaces are found in state and local government operations.[11] The Australian Sustainable Built Environment Council and others have suggested the need for a cities minister.[12]

Agencies and business are exploring sustainability issues. Infrastructure Australia[14] and the Business Council of Australia[15] are leading a growing chorus for a focus on cities.

In this accelerating atmosphere, strategic planning, more than ever, is necessary to arrest environmental impacts and optimise outcomes. A wide range of issues need to be considered, and best outcomes will flow from integration of planning, design, transport and climate change adaptation responses.

4.1.2.1 Performance benchmarking: planning zones and development assessments

The Productivity Commission has reported on the level of complexity and the issues that the growth of cities raises in respect of:

- clarity of strategic city plans
- coherence of laws and regulations
- and jurisdictional multiplicity.[16]

Many of the Productivity Commission's recommendations as to fast tracking and relieving the regulatory burden have been supported by the Urban Development Institute Australia and opposed by organisations including the Environment Defenders Office.[16]

Reflecting environmental concerns, the Australian Institute of Architects in its submission to the Productivity Commission observed:

'It is clear that our cities are rapidly reaching a critical point in history where the *imperative for solid leadership and action is now*. Australia is one of the most highly urbanised nations on the planet, we face a growing population, one that is ageing, and we are witnessing many stresses on our cities, from traffic congestion to *climate change and environmental impacts*, through to housing affordability and infrastructure decline [italics added].'

4.1.2.2 Driving sustainability

The importance of cities in driving and reflecting environmental sustainability is recognised internationally. PlanNYC, the plan for New York City, considers the implications of transportation, housing, energy, parks, brownfield, air quality, waterways, solid waste, water supply and climate change.[17] In Europe the Carbon Disclosure Project has reported on the potential in using sustainability to drive competitiveness in its reports *Seven Climate Change Lessons from Cities of Europe* (2012) and *Wealthier, Healthier Cities: How Climate Change Action is Giving us Healthier, Wealthier Cities* (2013).

Highline railway line New York

PricewaterhouseCoopers in *Cities of Opportunity* (2012) reports on the 'natural environment', adding this indicator to the list sustainability indicators.[18] Siemens in the *Green Cities Index* observes:

- urbanisation has environmental consequences
- cities contribute 70% of our greenhouse gas (GHG) emissions
- we must respond in an *integrated* manner (emphasis added).

The London School of Economics in *Going Green: How Cities are Leading The Next Economy*[19] discusses, with supporting case studies, how cities can build a greener world from an integrated and aligned platform of actions.

Reflecting this work, the Australian Sustainable Built Environment Council has developed a framework to address the need for a sustainable built environment, examining:

- economic prosperity
- sustainable land use and transport
- natural resources
- ecosystem health
- liveability
- social inclusion
- good governance.[20]

4.1.2.3 Local government leading

At the municipal level there is continued recognition for the need for integration, and of the increasing role of local government in addressing environmental sustainability issues.[20] The Municipal Association Victoria, together with a number of councils, has formed the Council Alliance for a Sustainable Built Environment, with ecologically sustainable development (ESD) as the focus. The MAV's website carries a list of participants, tools, guides and links that enable networking and promote sustainable change. These include:

- Sustainable Buildings Guide
- Sustainable Design Assessment in the Planning Process
- Sustainable Assessment Framework
- Sustainable Urban Development Framework
- Sustainable rating tools, including STEPS
- Sustainable Design Scorecard
- Music and Storm
- NatHERS
- Green Star
- NABERS.

The work done at Boroondara City Council on a Sustainable Buildings Policy; at the City of Port Phillip on a sustainable design policy; and the City of Melbourne on energy, water and waste policies is instructive. The City of Melbourne[21] joins Yarra[22] and Moreland[23] in attaining carbon neutrality, and it is seen as an example of best practice environmentally, economically and socially and internationally, having just received the C40/Siemens Climate Leadership Award in the category Energy Efficient Built Environment (for which Berlin and New York were shortlisted).[24] In the same awards ceremony Bogota was recognised for Urban Transport and Singapore for Intelligent City Infrastructure.

At Ringwood, the council's carefully considered Activity Centre Policy describes and authorises better outcomes around:

- high-density dwellings
- car parking that does not preclude public transport or pedestrian movement
- street tree plantings.

Moreland City Council's Higher Density Design Code (Draft)[25] reflects interest in improvements and illustrates the breadth of issues impacting environmental sustainability.

The complexities are evident.[26] Added to the considerations already outlined, the issues of demographics and travel are also considerations for local governments. The demographics are shifting. Baby Boomers' housing preferences and requirements are unclear and will need to be researched.[27] Younger people are showing a marked preference for greater-density housing and reduced car ownership.[4]

Trip orientation and employment adds another layer of complexity.[28] Employees and businesses in Pakenham do not necessarily have the same transport needs as those in Frankston or Sunshine, and periphery-to-centre travel requires careful consideration.[29]

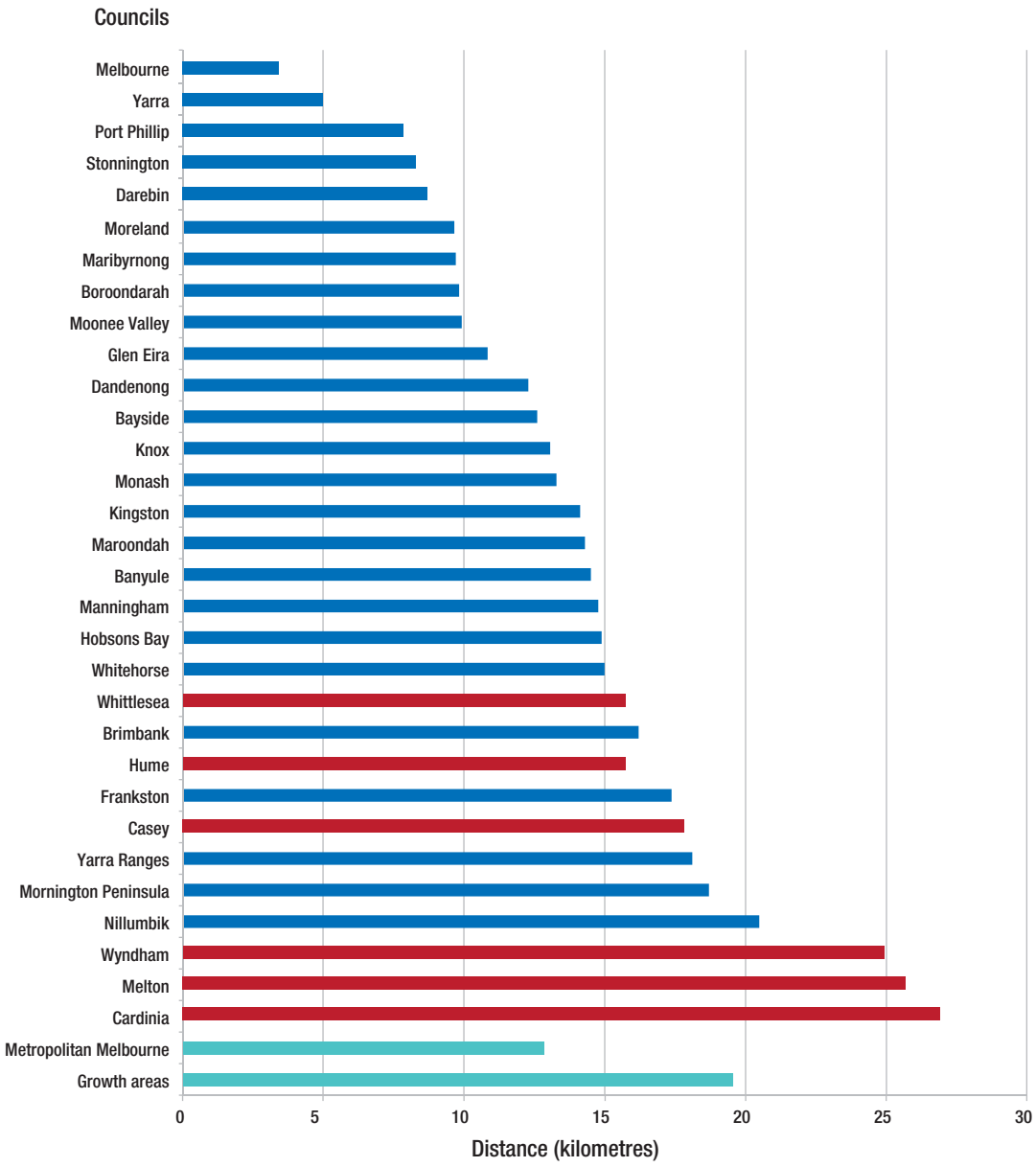

Figure B.4.1.1: Median distance travelled for journey to work across Melbourne, 2009–10

Note: Metropolitan growth area councils shown in red. Data not available for Mitchell.[30]

Reflecting interface council pressures, the CEO of Cardinia Shire Gary McQuillan told the Outer Suburban/Interface Services and Development Parliamentary Committee that '... over the next 15 years interface councils will accommodate 60% of Melbourne's population growth, so the interface councils will be doing much of the heavy lifting to accommodate the state's future population.'[31]

Presently burdens and benefits are inequitably distributed (as the Vampire Index graphically illustrates),[32] and planning decisions continue to impact the environment and the ecosystem services the environment provides. We need to organise, implement and consistently and thoroughly evaluate implementation with care. Business-as-usual urban planning processes predicated on the continuing expansion of the city's footprint do not presently deliver environmentally sustainable outcomes, and conflict and confusion is endemic.[33]

4.1.3 Interventions to date

A range of planning interventions has been occurring since the Victorian State of the Environment report was published in 2008. Instruments including Melbourne 2030 and Melbourne@5 million, the Good Design Guide for medium-density housing and residential, industrial, commercial and rural zoning are all undergoing significant changes. New organisational structures are also being established. At the organisational and structural level, for example, the Victorian Building Authority was launched in July 2013 to replace the Building Commission and the Plumbing Industry Commission. All of these aspects need to be integrated and aligned.

Sustainability and green growth

Expert commentator Professor Roz Hansen, advises '... *effective* spatial planning promoting *compact* city development is a fundamental support system for *green growth* [italics added].'[35]

The Victorian *State Planning Policy Framework* (Sections 11.04-5 and 6) calls for the protection of 'non-urban areas' and the 'consolidation of new residential development within existing settlements and in locations where planned services are available and Green Wedge area values can be protected.'[36] These requirements continue to be highly significant, particularly in an atmosphere of planning reform.

Melbourne and Victoria are at present undergoing a marked shift in planning policy. The *Planning and Environment Act 1987* has been amended, changing machinery of planning in relation to referral authorities, time limits on planning permits, applications to VCAT about extensions of time, tribunal proceedings, permits, legal review, the establishment of a planning application committee, Growth Areas Authority powers about declarations, advice requests and provision, and directors' liability. Further amendments commenced in October 2103 to reduce delays and streamline planning scheme amendments. Ministerial Advisory Council recommendations about planning will also change the planning and development landscape (see below).

We face a range of ongoing and significant environmental, social and economic challenges. Notwithstanding the development of the *Biodiversity Conservation Strategy for Melbourne's Growth Corridors,*[42] land excised for housing and associated development continues to consume natural assets and undermine the ecosystem services[6, 43] upon which we all depend.

The social, environmental and economic impacts of a development pattern which is unsustainable include:

- car dependency
- excessive and costly energy consumption
- social isolation
- public health problems
- productivity losses and mortgage vulnerability[44]
- habitat and native vegetation loss, notwithstanding recourse to offsets[45]
- ecosystem fragmentation due to a number of factors, including transport corridor construction[46]
- the erosion of ecosystem services where consumption and waste are elevated, and in some instances the loss of agriculturally productive land.[47]

Traffic congestion and its impacts are increasing[48] and our greenhouse footprint, even with increased efficiencies in fleet, remain a challenge.[49] Public transport will continue to stretch to meet growing public transport needs and changing usage patterns.[50] Road construction results in the loss of green spaces, noise and emissions, and impacts on habitat and ecosystem services.[51]

In the face of these challenges, governments that plan for sustainable cities will promote resilience and be better prepared for population and climate change eventualities.[52] In developing resilience, cities will be more environmentally and socially sustainable.[53] While the most challenging natural disaster threat in our cities is heatwaves,[54] we will confront other less immediately pressing matters, which will also be better resolved by resilient environmental and social communities.

To be leaders in generating green growth in our cities and regional towns, we need to ensure an integrated[56] and strategic approach to planning.[57]

4.1.4 Strategic urban planning for environmental outcomes

The way cities develop impacts the ecological footprint of residents. Architects, engineers, landscape architects, planners and a range of other professions tell us that we can affect this outcome with strategic planning.[59] Environmental planning policies that are fundamental to better environmental outcomes will:

- involve the public
- involve the whole planning community
- be well understood
- be consistently applied
- reflect informed community choices.

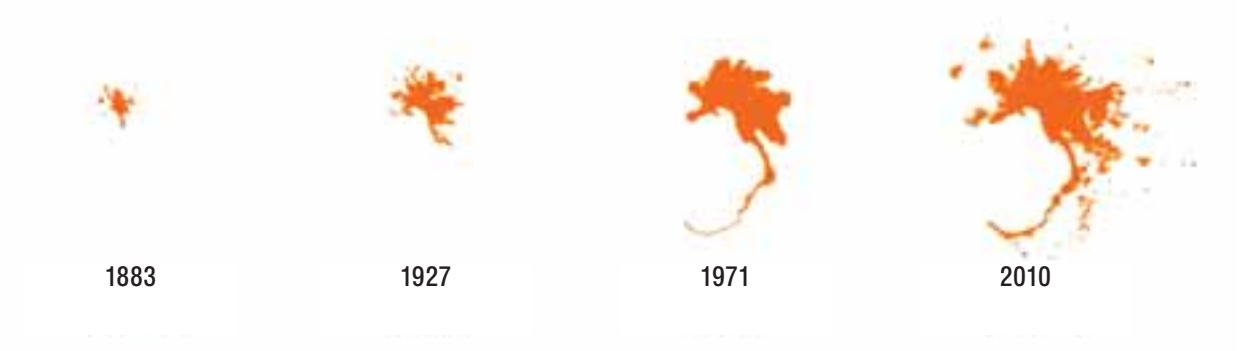

Figure B.4.1.2: Melbourne's outward expansion over time[60]

4.1.4.1 The environmental footprint of urban expansion

Urban development and the natural environment have an inherently contentious relationship due to the impacts of the built environment and infrastructure on the mobility and dispersion of flora and fauna. It has been estimated that 50 per cent of Australia's threatened species occur on the urban fringe.[61]

The Victorian Biodiversity Conservation Strategy has been established in an effort to address this issue. Thirty-six conservation areas within the growth corridors are listed to be protected and managed in perpetuity.[42] Offsets form part of the strategic response. The challenge is considerable.

As a city extends away from its core, it will impact ecosystem services[55] in ways that are not always well understood,[62] but in respect of which the scholarship is growing.[63] The Convention on Biological Diversity has recognised the important role of cities in impacting biodiversity since the 2008 Ninth Conference of the Parties and that view was reinforced in 2010 with the establishment of the Plan of Action on Sub-national Governments, Cities and Other Local Authorities for Biodiversity.[58]

Species within urban boundaries will be impacted as a function of consumption and waste patterns. Illustrating the potential impact, cities occupy 2% of the land mass, but consume 75% of the world's resources.[64] Impacts of an expanding city will include:

- the surrounding natural environment and ecosystem services becoming vulnerable through introduction of weeds and vermin along rivers or via cropping,[65, 66] generally, and along transport routes[67]
- travel distances to work, school, recreation and services increasing with commensurate increases in greenhouse emissions which impact biodiversity[68]
- food and goods being freighted further, with implications as above
- increased infrastructure provision, which without proactive and effective planning, is productive of more impervious surfaces, depleting green spaces, and promoting the urban heat island effect and its impacts on biodiversity.[69]

Economic and environmental concerns about expansion appear to align. Infrastructure Australia reports that greenfield developments, which contribute to urban sprawl, actually cost more than twice as much as infill in terms of development and transport.[70]

Arresting the impacts

There is a potential to arrest these impacts. First movers in innovative city planning are adopting new planning methods and seizing opportunities for green growth. The London School of Economics, ICLEI and Global Green Growth Institute have just released a report (2013) complete with case studies and commentary – *Going Green: How Cities are Leading the Next Economy*[35] describing the best of the efforts underway.

4.1.5 Melbourne's planning machinery

Melbourne's planning machinery is complex and requires streamlining for better environmental, social and economic outcomes.

Melbourne's Urban Growth Boundary

Melbourne's Urban Growth Boundary (UGB), intending to entrench limitations to urban expansion, was established as an amendment to the *Planning and Environment Act 1987* in 2002.

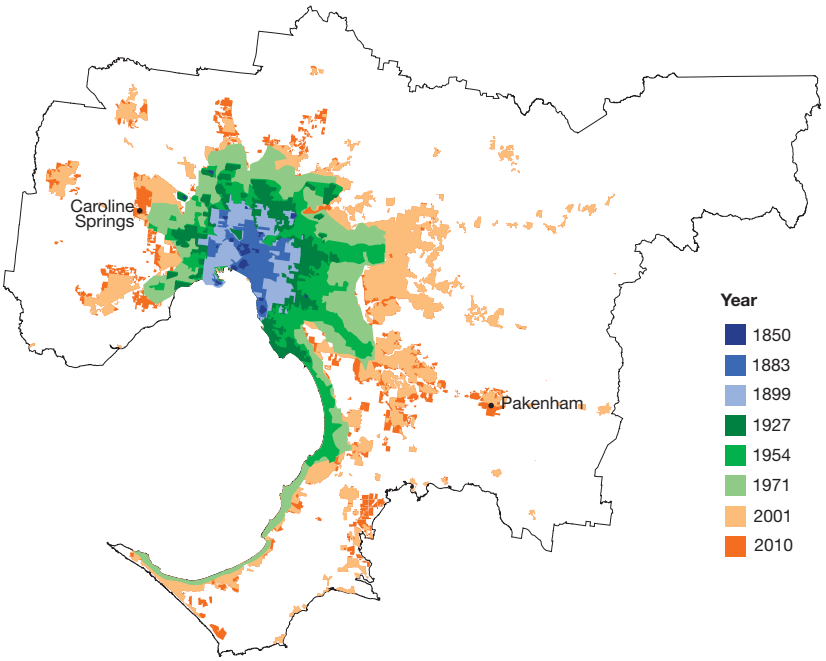

Figure B.4.1.3: Map of original UGB compared with map of current development

Both Houses of Parliament are required to agree to shift the boundary. The boundary has been expanded to subsume open space and farming land. It was expanded in 2010, adding 43,600 hectares.

A Logical Inclusions process, increasing metropolitan land supply, was announced in May 2011.[71] In 2012 the boundary was further expanded by 5,858 hectares.[72] This was the fourth shift of the boundary in 10 years. Approximately 100,000 hectares has been added to Melbourne's footprint since the establishment of the UGB.[73]

The Logical Inclusions Advisory Committee (LIAC) makes recommendations to the planning minister. Members are appointed on the basis of backgrounds in strategic planning, metropolitan planning and land development.[74]

The UGB is reviewed every two years and private landowners and local councils are asked to nominate land for inclusion. Difficulties and questions have ensued. For example, portions of the Western Grasslands Reserve[75] were nominated for inclusion,[76] even though the land was already committed as an offset for clearing elsewhere.[77]

Growth Areas Authority

The Growth Areas Authority (GAA) is a statutory body, established in 2006.[78] The GAA manages development on Melbourne's urban fringe. It is tasked with improving certainty and coordination and expediting decision making about growth area developments.[79] Growth Area Framework Plans and Growth Corridor Plans accord with the State Planning Policy Framework. The role of the GAA was expanded in 2013.[80]

Point Cook to Melbourne view

The GAA advises the State Government on land inclusions in any potential expansion of the UGB. Its work, including Precinct Structure Plans and Growth Corridor Plans, is exhibited publicly. Precinct Structure Plans and their role in engendering a commitment to improved water cycle management in new developments were discussed in our water foundation paper.[6]

In the context of growth area development, the GAA aims to deliver compact and well-connected communities that are economically affordable, while ensuring that the land being developed is used efficiently. VAGO has, however, suggested that access to public transport is not being delivered in growth areas.

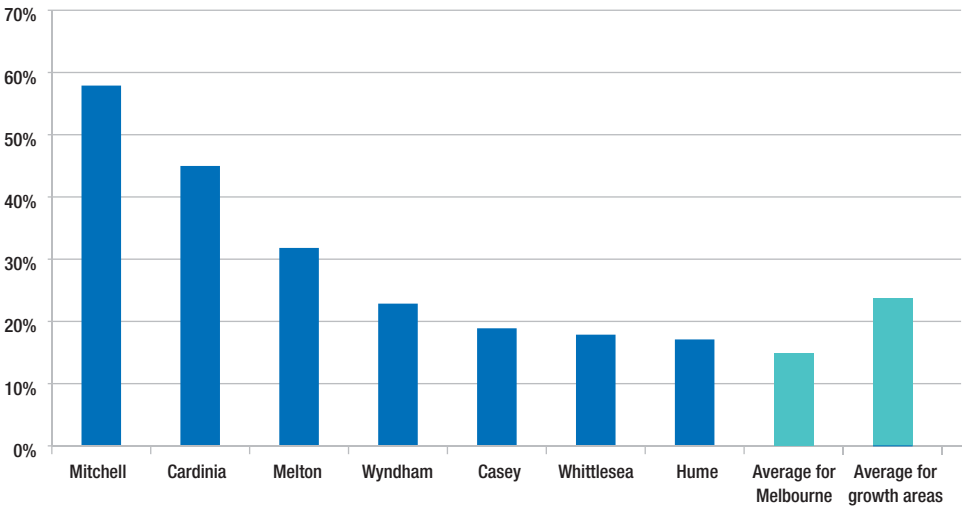

Figure B.4.1.4: Percentage of households not within 400 metres of a public transport stop, by growth area council

Note: Average for metropolitan Melbourne includes growth areas.[30]

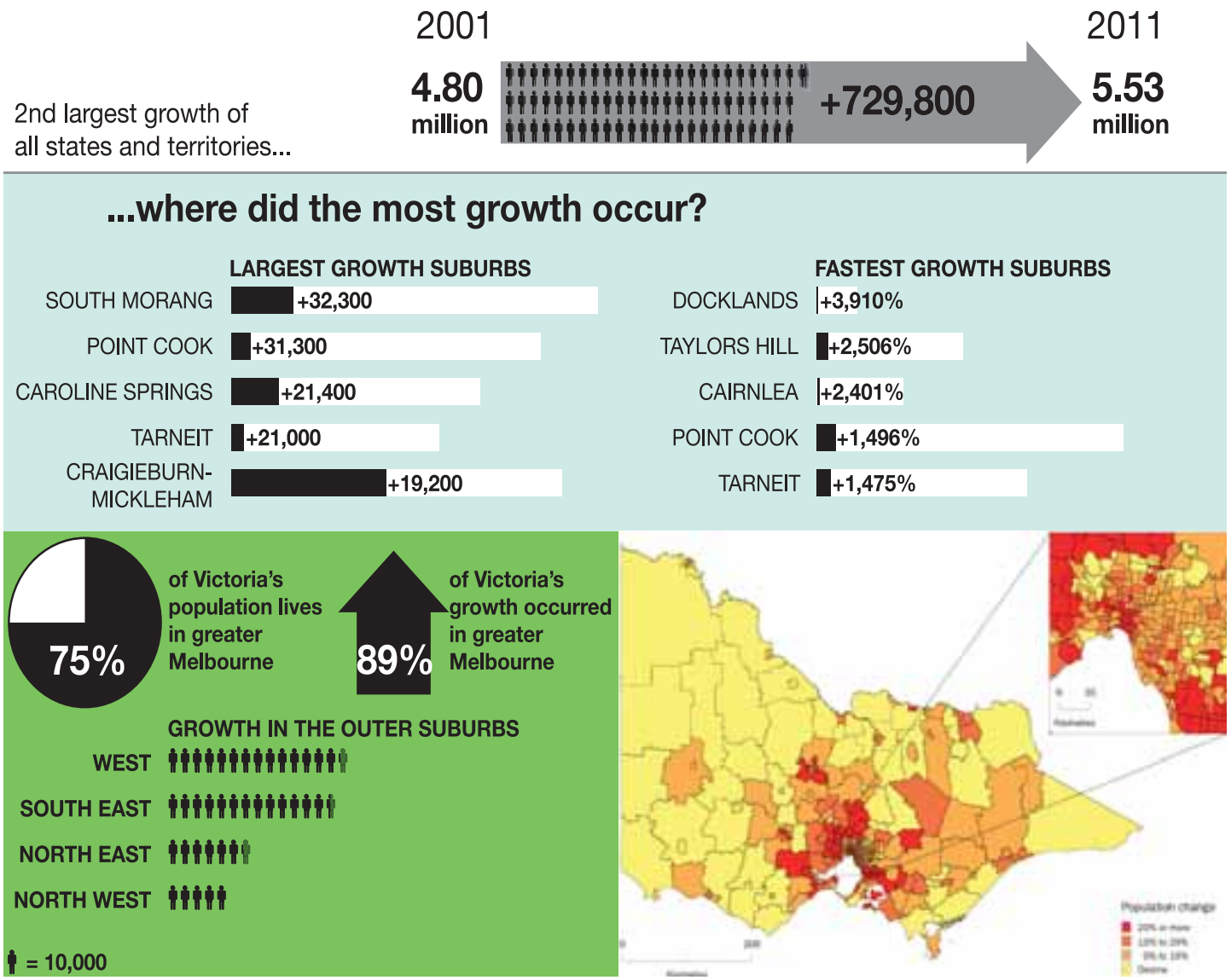

Figure B.4.1.5: Victoria's population growth

Source ABS

4.1.6 Biodiversity Conservation Strategy

Work on Growth Areas and Growth Corridors has been informed by the biodiversity studies associated with *Delivering Melbourne's Newest Sustainable Communities Strategic Impact Assessment Report* (DSE 2009) and the application of *Native Vegetation Management: A Framework for Action* (DNRE 2002). The Biodiversity Conservation Strategy, predicated on the work of biodiversity consultants across the four growth corridors, has recently been released.[42]

Victoria is leading other states in that a strategy has been developed. Its application and implementation will need to be monitored and evaluated.

View from Mt Cottrell

The strategy has identified 36 conservation areas within growth corridors that are to be managed in perpetuity. The plan includes establishing new reserves outside the urban growth boundary, the Western Grasslands Reserve, a grassy woodland reserve.

It also involves sub-regional species strategies for the Growling Grass Frog and the Golden Sun Moth, with a Southern Brown Bandicoot sub-regional strategy in preparation.[42] The strategy will involve a range of staggered interventions including long-term data management and storage issues, research, environmental adaptive management, faunal reintroduction, ecological restoration of vegetation, dealing with native pests, ecological quarantine, consideration of the future of grazing, and the role of burning.[81]

Mechanisms for managing planning decisions

Under these planning structures, policies and new interventions sit an array of other instruments and organisational structures. These include:

- multiple local governments with their own planning departments and guidelines
- an administrative review process, which is conducted by the Victorian Civil and Administrative Tribunal.[84]

Final legal oversight about matters of law is the purview of the Supreme Court of Victoria.[84] Victoria does not have a land and environment court, as is the case in NSW.[85]

4.1.6.1 Approaches of local government

Local governments with responsibility for Green Wedge planning[86] have an enormous responsibility to provide public commentary, seek input and consider complex issues in the context of their planning responsibilities.

City of Greater Dandenong

The City of Greater Dandenong has recently drafted and put out for comment its Green Wedge Management Plan (GWMP).[87] This document covers:

- land use
- drainage and water management
- environmental values and biodiversity
- access and movement
- the built form and heritage.

The plan has been developed as reform of zoning is underway (i.e. Residential, Industrial, Commercial, Public Use, Urban Floodway, Special Use) and in the light of the UGB *Anomalies Advisory Committee Report* (May 2013).

Issues considered in the GWMP 2013 draft include:

- agricultural land (about which there are diverse views)[88]
- pressures for expansion of existing uses
- land fragmentation and degradation
- land banking
- residential rezoning.

City of Kingston

The City of Kingston produced its Green Wedge Management Plan draft in 2012.

The council concerned itself with:

- the 'chain of parks'
- protecting and improving environmental quality
- landfill management
- declining market garden viability
- promotion of other agricultural uses.[89]

The City commissioned a Kingston Green Wedge Ecological Evaluation to inform this process.[90]

The environment, provision of ecosystem services, and a broad range of ancillary impacts of expansion and sustainability issues persistently challenge local government.

State of the environment reporting has been only one of the mechanisms used to respond to these issues.[91] The City of Whittlesea has developed its draft sustainability report as an illustration of the issues and responses being considered.[1]

The role of local government is further complicated by State Government-inspired revision of policies and strategies, particularly if there are time lines attached to work that is required under planning provisions.

As the Ministerial Advisory Committee on Victorian Metropolitan Planning took submissions from the public and the various instrumentalities with an interest in planning and the environment in urban settings (2013), it became clear that there was great interest in doing things better, protecting the environment and including the community in these discussions. Interest in attaining triple-bottom-line outcomes was a feature of the discussion paper produced by the Melbourne Planning Strategy work.[146]

In the case study that follows, we discuss one representative local government submission, that of the *Stonnington City Council.*[147]

Case Study: Stonnington City Council

Environmental considerations and inclusive practices in planning determinations

Stonnington City Council raised the following issues as necessary considerations in the development of a Metropolitan Planning Strategy:

- place making or localism
- the need for a collective vision
- the need for design guidelines
- the imperative of ecologically sustainable development[148]
- water-sensitive urban design[149]
- investment in public transport
- distributive networks
- linkages and intra-council partnerships.

Stonnington expressed concern that adaptable design was not considered in the Strategy Discussion Paper. In particular, Stonnington was concerned with the absence of a discussion about air, noise and light pollution.

Stonnington advocated the need for environmental sustainability considerations in driving resilience and providing for first-mover advantage. Particular issues included:

- promoting the potential for walkable urbanism in design
- addressing the 'urban heat island effect' by green roofs and walls[150]
- and the increased need for permeable surfaces.

Stonnington and others saw the need for

- a sustainable development practice note
- a specific sustainability policy in the State Planning Policy Framework (SPPF).

Beyond issues of biodiversity and more 'historical' pollution problems both Stonnington and the Property Council raised questions of:

- distributed energy
- embedded energy (in construction and other sectors)
- retrofitting
- precinct-wide planning.

The Stonnington submission actively incorporated concerns about carbon pollution, the 'newest' pollution issue, with its deep roots in many urban planning issues. In doing so it reflected a growing international concern about these matters at the city scale, and work done by other local government institutions in Victoria, including City of Melbourne and Moreland and Yarra City Councils (to mention only a trio). The Australian Housing Urban Research Institute has consistently raised these issues for consideration and resolution.[152]

Submissions across the spectrum raised the need for environmental protection policies, processes and directives in planning instruments and policies, and the value of collaboration, simplification and clarity in directives.

4.1.7 Strategic planning shifts

Significant shifts in planning arrangements are currently underway in Victoria. The recent report of the Built Environment Meets Parliament – KPMG Discussion Paper *Spotlight on Australia's Capital Cities: An Independent Assessment of City Planning Systems (2010)*, afforded Melbourne the highest overall ranking for COAG capital city planning reform criteria against other capitals.[92]

The reform agenda reflects government strategies and a number of issues outlined in external reports and discussions. In the BEMP–KPMG report, our overall capital city ranking was not exemplary in respect of how we dealt with budgetary alignment, population management, housing affordability and congestion (see below). On those issues only Perth and Sydney did worse than Melbourne. KPMG's analysis suggested that congestion cost Melbourne $835 per capita in 2006 and would cost $1,241 in 2020.

Although the KPMG work was undertaken at a time when Melbourne 2030 and Melbourne@ 5 million operated as the planning framework,[83] our current reform agenda is necessary:

Melbourne needs to consider the creation of a program of regular performance monitoring on key national policy issues, given the substantial challenges of implementing large-scale urban renewal to meet growth targets.[92]

In April 2013 the Victorian Auditor-General reported on issues associated with traffic congestion (principally because of the economic cost associated with this inefficiency), urging the Department of Transport 'reconsider its initial proposal for the Network and Service Strategy to operate as a stand-alone dedicated transport plan'.[93] VAGO's commentary is based on the understanding that integration through the auspices of a Metropolitan Planning Strategy will optimise efficiencies and promote better environmental outcomes.

4.1.7.1 Melbourne Planning Strategy

The Melbourne Planning Strategy, replacing Melbourne 2030[94] is scheduled for release in late 2013. From our consultations with experts in planning, this is timely. Our planning machinery requires a significant overhaul to shift Melbourne and our regional cities into the 'first movers' arena, where we can protect our ecosystems and ecosystem services even as we deal with population increases and climate change realities.

The strategy offers the chance to link metropolitan developments with regional growth plans and embed environmental protections. An advisory council has been established to formulate mechanisms for adopting this strategy.

Building on the Yarra

4.1.8 Melbourne Planning Authority

A Melbourne Planning Authority (MPA), optimally designed and administrated, would serve as an implementing agent for the Metropolitan Planning Strategy. The establishment of an MPA, necessary to assist in dealing with rapid change and intended to 'depoliticise'[95] the planning debate, presents an opportunity for a reconsideration of the environmental impacts of growth and mechanisms to address them. Its establishment is supported by industry and professional groups whose views are most recently echoed in the BEMP 2010 capital city planning audit of COAG reform initiatives.[92]

Preliminary information[112] has indicated that an MPA would:[95]

- be enacted under the GAA legislative framework
- work with local councils on implementing the strategy
- enable a whole-of-government approach to planning
- assist local government to develop strategy-compliant planning schemes, activity centres and growth areas.

Enforcement and other mechanisms associated with the UGB are yet to be determined.

In order for the Melbourne Planning Authority to be an effective organisation and address the gaps and uncertainty in our current planning system, the Victorian Government will need to adopt best practice in planning and facilitate the operation of the proposed planning authority as a 'dedicated, independent planning authority with permanent analytical capacity tend[ing] towards a more substantial treatment of planning problems and their solutions'.[96] A rigorous and inclusive approach would facilitate the establishment of an evidence base to ensure that maximum environmental, social and economic benefit is generated through the reforms.

Best practice

Best practice would reflect the following:

- Be independent – autonomy avoids conflicts of interest and promotes authority and confidence and ensures public trust in planning, it also promotes the best use of independent and authoritative planning expertise. Portland, Oregon enshrined metropolitan governance in legislation to ensure this.
- Ensure enforcement – the use of a range of instruments including sanctions and incentives can enable and ensure compliance and cooperation. Seattle's Puget Sound Regional Council addressed an incoherent enforcement strategy by the establishment of targets and also the imposition of penalties for infractions or failure.[22] Fragmentation of enforcement activities among authorities, local governments and agencies is not optimal and should be avoided.
- Promote engagement – involvement of residents, councils, businesses and non-profit organisations must be continuous and responsive. Community awareness, participation and buy-in is critical to the formation, success and future-proofing of an effective strategy and the development and implementation of an environmentally sustainable Melbourne.
- Promote integration – land use, housing development, transport policy and infrastructure provision cannot be viewed as separate challenges. Coordination with other authorities is essential for positive environmental, social and development outcomes.[97] A coordinated approach to determining where – and where not – to provide roads, public transport, drainage, sewerage, utilities and telecommunications can avoid the loss of critical ecosystem services and create a firmer urban edge to Melbourne, reducing unnecessary expansion and adverse environmental outcomes.
- Rationalising revenue arrangements – the development of revenue distribution policies across council boundaries could engender collaboration and greater integration. Globally, most metropolitan governments generate funds from a combination of three main sources:
  - transfers from higher orders of government (44%)
  - local rates and taxes (35%)
  - municipal transfers (21%).[99]

If funding arrangements were streamlined the implications for efficiencies in decision making arrangements might be significant and environmental benefits more coordinated.

Vancouver is held up as a best-practice example of proactively engaging with the community in planning settings – 4% of the population had direct involvement and 20% contributed in some way to the development of the city plan.[22]

Seattle spent nearly three-quarters of its planning budget on engagement as the process commenced.[60]

The Growth Areas Authority works on developing and firming up partnership approaches once growth areas are determined. Early intervention through a Metropolitan Planning Authority in partnership with others could be conducive of improved decision making.

While planning decisions about land development for settlement, education, employment, mobility and infrastructure may be confined to a single council, the implications of these decisions are rarely isolated. In certain circumstances, planning decisions by one council can have adverse environmental, social or economic impacts on surrounding councils. For example, rapid development in one suburb may promote stormwater, drainage and water quality issues in an adjacent suburb.

Collaborative governance models do exist even as they respond to particular contexts. In South East Queensland the Council of Mayors acts to coordinate local interests in a formal way.[98] Peak bodies such as the MAV, VLGA and ALGA and ICLEI provide examples of collaborative processes that promote clarity and consistency, coordination, alignment and integration.

Planning for Melbourne: a model

As all of these discussions and policy formulations take place, the Melbourne and Metropolitan Board of Works continues to be advanced as a useful model of a collaborative and independent planning mechanism that can optimise planning outcomes.

Tram near RMIT on Swanston Street

Case Study: Melbourne and Metropolitan Board of Works (MMBW)

At the urban planning and infrastructure scale, the Melbourne and Metropolitan Board of Works (1891–1991) operated as an independent planning authority with representatives from each of metropolitan Melbourne's councils (as many as 54) prior to council amalgamation.

The MMBW facilitated dialogue and participation and management between the State Government and councils, promoting comprehensive planning outcomes. Planning scheme powers remained the responsibility of councils, but issues of metropolitan significance including land release on the urban fringe, key employment locations and major waterway corridor planning were addressed by the MMBW.[96]

The MMBW 'shaped' the delivery of infrastructure – 'some of Melbourne's best planning was delivered under the auspices of the MMBW', and in some ways it resembled the current Greater London Authority, which is making real shifts to environmental sustainability policy implementation in London.[96] The MMBW had the power to rate and also issue infrastructure bonds.

The key differences between land management under the MMBW and the current system are:

- Land release was determined completely independently of government.
- The system provided certainty.
- Decision making was less influenced by short-term political cycles.

An important benefit of the MMBW approach was the integrated management of infrastructure and land-use management and decision making. As the MMBW's wide-ranging powers extended to the planning, financing and delivery of sewerage and highways,[96] development patterns were infrastructure-led, rather than development-led. Development was clustered around infrastructure, manifested through the development corridors that radiated outward from Melbourne.

The MMBW was dismantled in 1991 and its powers were redistributed. However, the model retains its merit and it continues to receive support from urban planning specialists and researchers.[100]

Comparative examples of good practice include both the Greater London Authority[101] and the Greater Vancouver Regional District.[96] The Greater London Authority drives changes across the city in carbon accounting, retrofitting, parks management and establishment, street trees, air quality, waste management, climate change mitigation and adaptation, decentralisation of power and traffic management.[102]

In the current planning reform environment there is the prospect of staging the re-emergence of an whole-of-city planning authority, and careful consideration of this could assist in driving the innovations necessary to generate environmentally sustainable outcomes.[96]

Art Deco in the Bourke St Mall

4.1.9 Planning in the regions

In a review of previous planning strategies prepared for Department of Transport, Planning and Local Infrastructure (DTPLI), it is acknowledged that state-led regional planning has historically 'been conceived of as [the function of the] "capital city" and remained firmly planted in inner Melbourne.'[119]

This, combined with a need to depoliticise urban development, a need acknowledged by the Victorian Government,[95, 120] justifies the exploration of a regional planning governance structure that is autonomous, non-partisan and independent.

Essential Economics recently reported that the largest 10 Victorian regional cities could grow by almost 300,000 people by 2031.[121] A major concern is that, given current design and development criteria, existing residential land may only meet 75% of the required land to accommodate this growth. From this study it would seem that Victoria's natural environment and the erosion of ecosystem services in the regions is a risk unless there is coordinated strategic intervention.

We are presented with a once-in-a-generation opportunity to plan for human settlements, which we know will expand and which we know will have poor environmental and social outcomes unless properly provisioned with fit-for-purpose infrastructure.

We can plan for whole-of-state interventions in a coordinated and measured, purposeful way, and in doing so we can protect the environment and the ecosystem services upon which are so reliant.

Regional cities throughout Victoria do not have formal growth boundaries like Melbourne, and agricultural and open space can be developed through the use of rezoning and amendments to local planning schemes. The recent Rural Zone Conservation controversies give an indication of the level of interest and potential polarisation.[122] The minister retains call-in powers[123] that allow for override of local council decision making and the minister can also exempt decisions from VCAT hearings.[124]

There is a recognition of the need for changes in regional planning processes, arrangements and structural formulas. The Department of Transport, Planning and Local Infrastructure has developed regional growth plans to supersede the regional plans of 2010. The *Reformed Zones Ministerial Advisory Council Rural Zones Report* recommendations have addressed issues relative to the Rural and Green Wedge Zones.[145] Recommendations support agricultural activity, promote tourism, support rural industry, encourage population retention and promote flexibility for councils.

Shepparton water-sensitive urban design

4.1.10 Alignment, integration and community participation

It has been concluded that there is a need to develop a 'simple framework for monitoring and evaluating the reformed zones', which should be continuously applied. The establishment of this framework is endorsed as a mechanism to ensure the continuous evaluation of zoning issues providing it adequately reflects environmental considerations.

As the government has just announced a review of the SPPF to deliver the Metropolitan Planning Strategy and Regional Growth Plans, there is presently a real opportunity for attainment of some of these proposals.[151]

Case Study: EPA – Integration, Alignment and Community Engagement

A methodology: statutory planning and environmental issues – the EPA–DEPI review of SEPPs[153]

The recent EPA–DEPI review of the Statutory Environmental Planning Policies considers reforming environmental and planning instruments and endeavours to find a new and highly consultative way to effect strategic changes. Mechanisms suggested are organisation-appropriate for environmental protection but show the benefits of clear and purposeful planning and the utility of a staged approach augmented by the use of tools and guidelines.

EPA has been implementing a Planning Strategy, which aims to:

- improve the organisation's reputation among planners
- improve the organisation's understanding of its statutory and discretionary role in planning decisions
- build an approach to planning proportionate to risk
- prioritise strategic planning and early application of expertise
- increase and improve published guidance and advice
- promote participation in planning reform within government.

A three-stage approach

The Implementation Program sets out three key stages in this process. The staged approach recognises a necessary shift in resourcing to orchestrate change. Implementation will entail a shift from reactively responding to individual planning referrals to ensuring the development of transformative frameworks, guidance and relationships. A strategic, proactive model is the goal. The three-stage approach will:

1. embed a consistent, coordinated, risk-based and proactive approach to planning across all regions
2. communicate the organisation's role and priorities to external planners, and focus resources on providing high-quality, targeted advice on the critical planning matters of most importance
3. empower of the organisation's planners and external planners to build a planning system that addresses critical environmental issues, through the establishment of a reform agenda and relationships.

In 2012–13, the focus of EPA's activity has been on Stage 1 of the Implementation Program, embedding a consistent, coordinated, risk-based and proactive approach to planning.

This has commenced with the development and implementation of a Planning Referrals Risk Prioritisation Tool, which:

- assists in management of the treatment, prioritisation and response type of planning referrals
- provides a tool to assess the environmental and amenity risk of planning referrals, assess where input is most valuable, and increase early strategic planning decision making.

The policy also provides for the appropriate response for different levels of risk. It has enabled EPA to identify more efficient ways of responding to lower risk referrals and increased the ability to spend time on highest risk issues. In general, priority referrals are those that relate to strategic planning (structure plans, planning scheme amendments), section 55 referrals under the *Planning and Environment Act 1987* (EPA has a statutory duty to respond to this) and all statutory and strategic referrals of high environmental risk.

The risk tool will also enable improvements in reporting on the increase in time spent on higher-risk planning work. This structured, practical, strategic and inclusive approach will also help identify:

- training and development needs for staff and external planners
- priority councils for engagement and professional development and education as to EPA's priorities and information needs
- planning system reform needs (for example, having input into proposed changes to Clause 52.10 of the Victoria Planning Provisions)
- policy and guidance needs.

Other actions undertaken as a function of the recalibration of the Planning Strategy Implementation Program will cover a range of strategies, operationalised in an orderly and consistent fashion. Publications, such as the guide outlining the *Recommended Separation Distances for Industrial Residual Air Emissions – Guideline* (Publication 1518) will be provided.

Identification of top environmental priority actions, such as 'encroachment', will present as targeted initiatives promoting work on health and amenity impacts on the community and the impacts on industry viability.

The EPA will consider potential legislative reforms in planning matters on matters such as the proposed changes to Clause 52.10 of the Victoria Planning Provisions requiring planning referrals when areas near industry are rezoned to residential. EPA will commence development of procedures for the management of planning referrals, and this will include an *Annual Planning Blueprint* setting priorities for planning work for each financial year.

Increasing engagement with Growth Areas Authority and strategic planning divisions of councils will become a specific organisational goal, promoting integration and alignment as well as collaborations where appropriate.

Monitoring and evaluation will become the focus of a specific plan for Planning Strategy Implementation to enable greater understanding of impacts and a capacity to intervene on the basis of evidence-based information.

The sharing of knowledge and resourcing needs will be promoted as a function of a renewal of EPA's Planning Network.

4.2 The Environment and Sustainable Housing Proposition

The concentration of urban development is a significant factor in liveability and environmental sustainability, and opinions vary with regard to optimal outcomes. Melbourne has a population density that is less than half that of Paris, a third of London and a twentieth of Hong Kong.[103] Any discussion about environmental sustainability and our built environment and resource use is incomplete without discussing both development density and design – questions of 'form' as distinct from the 'structural' issues.

Context

Governments and the private building, planning and construction professions have a role in helping the community achieve a greener city and a greener economy through collaborations and knowledge sharing. The involvement of the public and private developers[80] in a wide range of collaborations, including transport corridor developments[79] and other broad-scale eco-developments, are needed to promote better outcomes.[9]

4.2.1 Victoria's current housing development pattern: the challenge

Housing development presents with its own unique set of challenges. The UN Habitat report *State of the World's Cities 2012/2013* identifies low-density suburbanisation of cities in developed and developing countries as a primary driver of greenhouse gas emissions, climate change and social inequality.[81]

Where, how and in what conditions people live contributes significantly to liveability and sustainability. In a trend expected to continue[5] housing occupation rates have reduced from 3.0 to 2.6 persons per household between 1981 and 2006 in Victoria.[84] At the same time average house size has increased from 216 m^2 to 252 m^2 between 2000–01 and 2008–09.[85]

Studies suggest that housing provision does not appear to match personal and family requirements, demographic trends or even environmental perspectives.[86]

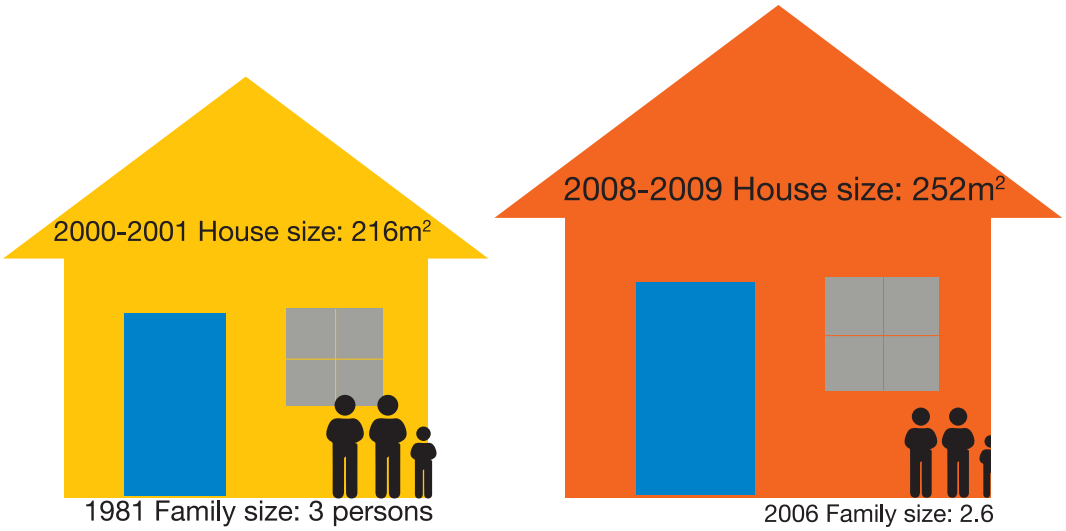

Figure B.4.2.1: Infographic of increasing house size and decreasing household size

The Property Council in commentary cited by City of Melbourne,[78] has expressed the view that 'the needs of the ultimate occupiers (i.e. renters) are not the primary consideration for developers, purchasers or financiers'.[104]

The Grattan Institute reports a mismatch[86] between the housing that is wanted[29] and that which is actually constructed. The picture is complicated. Multiple stakeholders, a range of factors and formal and informal barriers influence this distribution and polarised positions. Developers point to the barriers that prevent them from building in established areas.

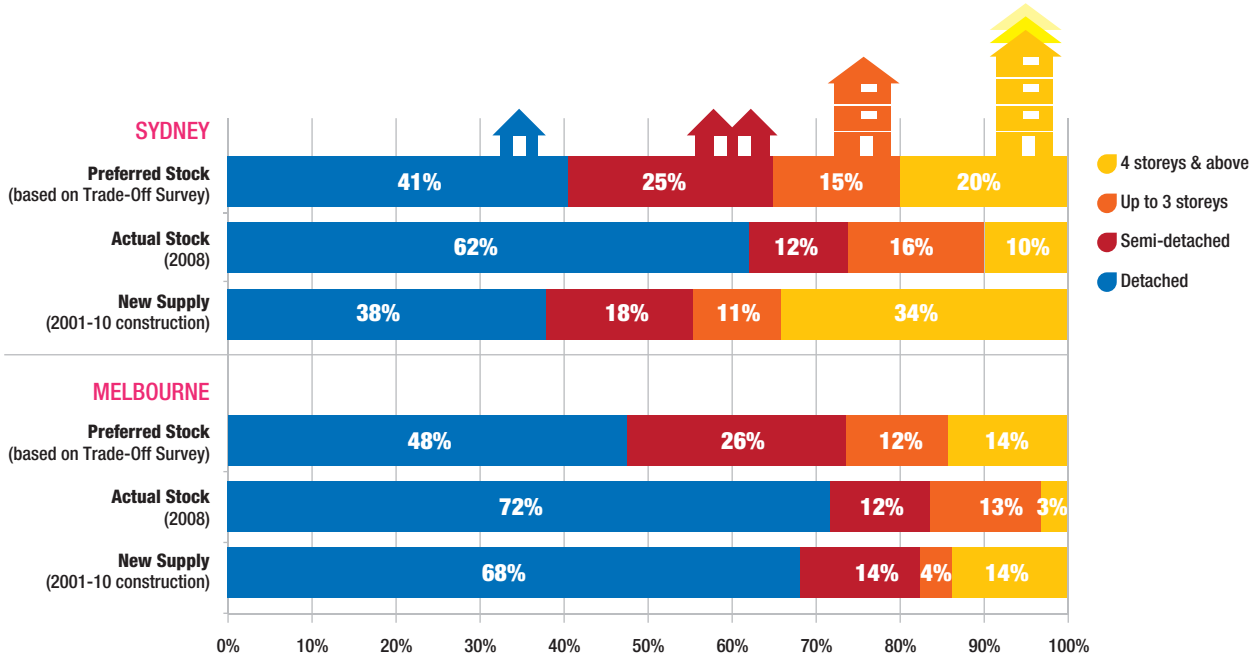

Figure B.4.2.2: Preferred and Actual Housing Stock

Residents, denied a real say in how their neighbourhood develops, often feel they have little choice but to oppose all planning applications and all change. State and local governments are caught in the middle, and no one wins.'[29]

The existing system does not appear to be engendering a proactive interest in urban form or a housing market that promotes a lower environmental impact, community resilience, or the social connectivity required to support more sustainable outcomes. It has been suggested that there is a need to improve our understanding of the barriers to change and the actual 'mix' of housing and land-use development which the public/consumer requires.[105] Development and urban renewal projects are beginning to address some of the issues, the Fishermans Bend Urban Renewal Project being an example.

Case Study: Fishermans Bend Urban Renewal Project[106]

In September 2013 the Victorian Government opened the public consultation period on the vision for Fishermans Bend, one of the largest urban renewal projects in Australia.

The approximately 250-hectare area is expected to become home to 80,000 residents and 40,000 high-productivity jobs over the next 30 to 50 years. Three kilometres south-west of the Melbourne CBD, Fishermans Bend will provide an alternative to the continued outward growth of the city, giving more people the choice to live closer to existing jobs, services, public spaces and transport connections.

The Fishermans Bend Draft Vision outlines the overarching strategic directions and key moves needed to transform the existing industrial area into a thriving inner-city environment. The Interim Fishermans Bend Design Guidelines provide guidance to interested developers, architects and planners to encourage good design and provision of adequate public space, facilities and access to public transport. Additionally, there are a number of ways for the community to learn more about Fishermans Bend and provide input into planning for the area's future, including community information sessions.

In opening the consultation period the Minister for Planning commented that:

'The Fishermans Bend project will set the standard for urban renewal across Melbourne and Australia over the next three decades, bringing thousands of new residents to areas close to jobs, transport and Australia's greatest cultural heart.

When looking at the plan it is clear that a number of precincts will develop to include low rise family friendly housing, medium scale development, and high density development around a future transport corridor and new employment hubs.

The plan supports the delivery of a comprehensive open space network, new walking and cycling routes and mechanisms for the delivery of affordable housing.'

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Figure B.4.2.3: Fishermans Bend urban renewal map

Westgate Park looking back to the city of Melbourne

4.2.1.1 Impacts of location and population on liveability and sustainability

The enormous complexity of the linkages and impacts of urban density and energy and transport use and greenhouse gas emissions were discussed authoritatively in a paper prepared by Gavin Alford and Jeremy Whiteman of the Department of Transport, Transport Policy Analysis and Research Unit in 2008–09.[87] Many of their observations remain relevant today. Recently, in international contexts the World Bank is among those leading the discussion of the need for change for better environmental and other outcomes for cities.[107]

Housing design for environmental sustainability in contemporary Melbourne

Many different mechanisms may promote environmental outcomes in respect of housing developments. As an indication of the interest in ESD, a number of proactive local councils are seeking amendments to local planning policies to facilitate the exercise of sustainability design guides. Examples can be found in the Maroondah City Council[74] and Moreland Council.[75] In response to this interest the Property Council is urging individual council's ESD design guides to be uniform and standards to be regionally based.[76]

Cities and states are addressing the need for better design outcomes. As the City of Melbourne illustrates in its 2013 publication *Future Living*, good design is fundamental for a sustainable city.[78] The City of Melbourne also argues that regulation and incentives can assist in achieving this goal. Other examples are found in the Brisbane City Council *Residential Design Guidelines*, the NSW *Residential Flat Design Code* and the *City of Perth Urban Design Framework.* Organisational structures have been used and examples include the East Perth Redevelopment Authority, and Sydney Metropolitan Development Authority. *Making Room: New Models for Housing New Yorkers*, architectural solutions to address emerging housing needs is a novel initiative.[108]

4.2.2 Design

The Victorian State Architect Geoffrey London suggests a role for a range of mechanisms to produce housing that is both liveable and environmentally sustainable. Sharing design insights across jurisdictions is an important part of the process. Geoffrey London made these comments in the foreword of our 2011 Strategic Audit.

'It is possible to legislate for better design and sustainability outcomes. The example of SEPP 65 in New South Wales is a compelling instance of legislation lifting the bar on apartment designs in Sydney and specifying a number of performance standards that result in better environmental performance.

The State Environment Planning Policy No. 65 – Design Quality of Residential Flat Development was introduced in 2002 and was intended to elevate design as an important measure in planning decisions.

SEPP 65 sets out levels of amenity which must be achieved, including solar access, cross-ventilation and sound separation between apartments. Included within the SEPP is a process for expert advisory panels to assist local councils with assessments of proposals, bringing informed design judgment to the process.

Achieving high quality architectural outcomes and associated high levels of environmental performance involves processes that require ongoing scrutiny (Geoffrey London, Victorian State Architect 2011).'[77]

Collaboration

The Victorian Government Architect has hosted forums for government and the private sphere, including a 'Housing Melbourne Symposium', which partnered with The Prince of Wales' Trust, as an illustration of the utility of peer-to-peer knowledge sharing.[81]

Sustainability Victoria is rolling out programs which assist and inform the public in a number of ways.[109] The EPA's efforts to involve the community in its SEPP work is outlined in the section above.

4.2.2.1 Infill in the middle – the greyfields: designing for change[122, 123]

Research into design and the built environment is increasingly focusing on the bigger picture, on medium density and a precinct-scale approach, in an effort to encourage transition to low-carbon living and reduce recourse to an ever expanding metropolitan footprint for development of population centres and housing.[110] This work clearly reflects the improved consciousness of our resource-constrained world.[111]

In response to a commission from the Office of the Victorian Government Architect and in collaboration with Swinburne University, the Monash University Department of Architecture has reported on the potential that architectural design may have for infill development in the middle suburbs at the precinct scale.[145] This research builds on that being undertaken by the CRC for Low Carbon Living.[146] An instructive positioning paper, developed under the rubric of AHURI and the aegis of project leader Professor Shane Murray (Monash University), provides stimulating design modelling and specific project outcomes in respect of infill.[112] In this instance a Commonwealth government initiative, the stimulus plan provided the resourcing for reconfiguring development in a design framework.

Specifically, this commissioned research concluded that there is significant environmental sustainability potential if redevelopment sites are considered for their width, depth and orientation and not simply site area. Best outcomes in infill development in the middle suburbs could be attained if the following attributes existed:

- the site was 7–25 km from the CBD
- the housing to be replaced was 1950s–1970s developments
- proximity to good public transport
- an absence of heritage considerations.

Design briefs, if used effectively in this context, would be able to address constraints associated with site, amenity and regulatory issues by means of:

- flexible compact dwelling design
- improved open space and amenity
- more effective site use and the extension of community benefits
- adaptive housing design
- innovative construction techniques including the take of prefabrication opportunities
- replicable design models.

It was concluded that barriers to middle suburb infill could be overcome with insights provided by design techniques. The following issues could be addressed:

- Where regulated building setbacks acted as a limiting agent, good design and selection of the places to be developed meant that reduced setbacks were not a problem.
- If ResCode, with its focus on neighbourhood character, limited the construction of buildings greater than two storeys, this limiting factor was also capable or being addressed through design.
- In circumstances where excessive overlooking constraints were a community consideration, good design could also limit impacts.

The researchers concluded that to overcome perceptions and market expectations of an en suite in every bedroom and separate double-car garages, good demonstration sites would be necessary.

Photo courtesy of Patrick Rodriguez

Heller Street, Heidleberg
Photo courtesy of Six Degrees Architects

The research showed that although large redevelopment projects resulted in significant changes to the housing stock, it was smaller projects that generally made up the majority of new or revitalised housing stock.[29] Design presents multiple opportunities, and good examples of practice are found across the state. The Office of the Victorian Government Architect has been instrumental in providing commentary on design briefs, and this has improved outcomes.

The OVGA Design Review Panel has played a powerful role in improving outcomes, providing dedicated architects who offer structured reviews, briefings and formal advice to proponents.[113] Site, complexity, context or precedent drive engagement, and oversight can be sought in relation to 'masterplans, major infrastructure, buildings, streets and public spaces'. Local government is now able to avail itself of the service. The OVGA exercises its discretion in selecting projects.

Since the start of the review process in April 2012, more than 55 design review sessions have been held, $1.9 billion of projects have been scrutinised and more than '400 people, including Client Departments, Responsible Authorities and design teams' have joined the process. Projects have included:

- major transport interchanges
- transport infrastructure projects including level crossing removals
- major housing projects
- hospitals
- parks
- aquatic centres
- cultural and sports buildings
- commercial headquarters
- and town centre masterplan.

Figure B.4.2.4: Environmental outcome

4.2.3 Density

Hong Kong and London, both with population densities significantly higher than Melbourne's have just been cited in the *LSE Green Growth Cities* work, illustrating the potential for greening cities of greater population densities.[9] It is clear that liveability can be maintained with greater concentrations of population. A more concentrated settlement pattern can be a means to achieving better environmental and social outcomes.[180] Increased density supports sustainable transport behaviour, as land use and transport are interconnected, if not co-dependent.[181]

4.2.3.1 Market affordable living over affordable housing

After World War II, Melbourne experienced a severe decline in public transport use, although use of public transport is currently increasing markedly.[88] Low population density is one of the most commonly cited reasons for a failure to use public transport.[89] Modelling of integrated transport and land use was undertaken for metropolitan Melbourne by the Victorian Department of Transport, Planning and Local Government in 2008–09. The impact of a growing population under different settlement, development and transport infrastructure scenarios for 2031 was analysed. It was found that urban form and transport infrastructure provision are key drivers of transport-related energy use and greenhouse gas emissions. Consolidating development by decentralisation through new Central Activity Districts (CAD) could minimise impacts single-family housing development on the urban fringe is a key environmental sustainability challenge.[90]

Given these observations, it is apparent that in order to achieve a less environmentally intrusive urban settlement pattern across Melbourne and Victoria and retain ecosystem services on the urban fringe, compact development and other new development should be encouraged along public transport corridors, proximate to jobs and services.[116] New residential development should not take place without first considering travel patterns as transport issues are integral to better urban planning considerations.[117]

In order to ensure potential homebuyers and renters are aware of the cumulative financial and ecological costs of specific housing choices, mechanisms for demonstrating affordability beyond a simple cost-benefit analysis – including environmental impacts – should be more robust.

A potential option would be to develop and market a web-based interactive tool that enables potential new home buyers and renters to evaluate marketed housing and rental units based on actual living costs and environmental impacts. This tool would assist in assessing average energy use and transport costs and other elements that are not apparent at the point-of-sale or lease. This could be valuable in improving housing-related decision making, support better understanding of government policy and planning, and potentially guide investment related to housing.

The EPA and RMIT provided a Greenhouse Calculator for public use in 2012, and a tool such as this could be further developed for broader application.[118]

The US Federal Department of Housing and Urban Development is currently developing metrics to calculate the true costs of housing and transport. Public transport access, residential density and other location efficient factors will be incorporated into scoring grant applications for public housing.[177]

Transport

The Victorian Auditor-General has recently illustrated in *Developing Transport Infrastructure and Services for Population Growth Areas* that any such guide or affordable/sustainable living tool would only be as good as the actual provision of services on the ground.

Transport availability Melbourne

The Auditor-General cites the example of the Aurora development, marketed as sustainable living. The community at Aurora still does not have a bus service, even though the bus stops were installed at the time the development was built.[125] The VAGO recommendations are endorsed.

VAGO recommendations

The Victorian Auditor-General's Office (VAGO) has recommended that:

- the Growth Areas Authority, in consultation with state transport agencies, finalise development of effective arrangements for transparently acquitting the Precinct Structure Plan guidelines and related transport requirements
- Public Transport Victoria develops minimum service standards to guide planning for the frequency and directness of public transport services
- the Department of Transport, Planning and Local Infrastructure, in conjunction with Public Transport Victoria, VicRoads and the Growth Areas Authority develop and implement:
  - a statewide framework for prioritising the delivery of transport infrastructure that reconciles broader statewide priorities against the needs of growth areas
  - an implementation and funding strategy incorporating alternative financing options and innovative solutions to systematically address the transport backlog and meet the future needs of growth areas
  - an associated monitoring and evaluation framework to assess whether the progressive delivery of transport infrastructure and services in growth areas is being achieved as planned and has been effective.

Bikes and trains in Melbourne

Energy use

Where people choose or are able to live impacts energy use and emissions. A study by the United States Environmental Protection Agency reveals that residents living in conventional suburban developments consume more household and transport energy than similar houses located in transit-oriented developments (TODs).[91] The study also found that in residential areas of very high density, household emissions and energy use were about half of those in very low-density areas. Households with public transport access produce about one-quarter of the emissions of households without good public transport access.[92]

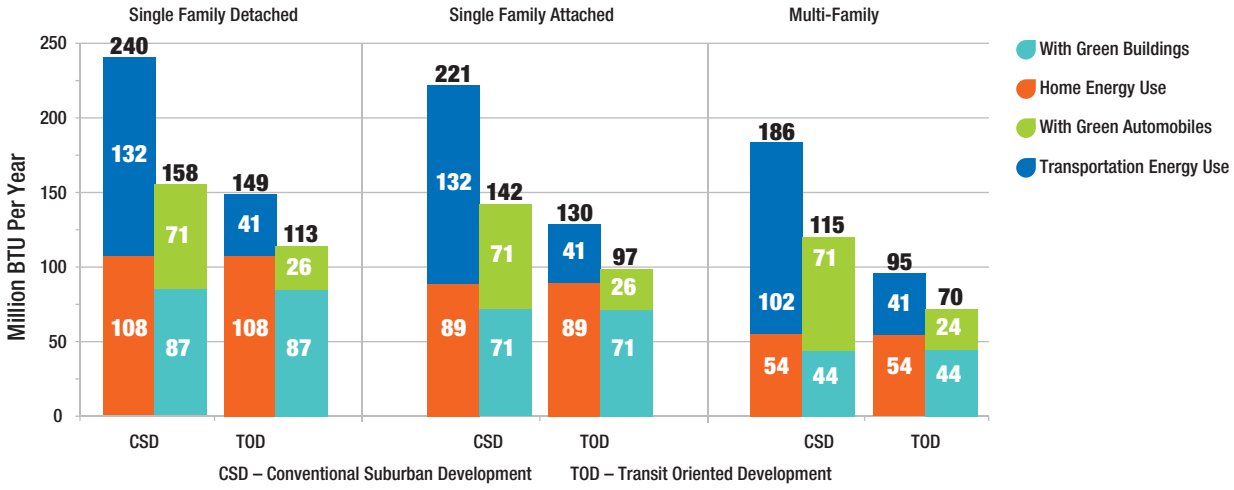


Figure B.4.2.5: Location Efficiency

A US EPA study shows impacts of location and housing type on energy use. A Deakin University study[93] has supported these findings, determining that housing location and housing size are critical factors in determining energy use and greenhouse gas emissions. Medium-density housing in the inner suburbs was found to consume and generate the least operational, embodied and overall energy and emissions of all housing types studied.

Again however, the picture is complex, as other research suggests that 'high rise dwellings do consume more energy per unit than detached dwellings' even as suburban dwellings 'generate much higher levels of automotive energy consumption per capita'[126] Accepting the environmental impacts of transport issues alone, we need to reconsider the design, type and location of the housing we build to ensure that we build for a greener economy and that the environment is less negatively impacted by the choices we make about the manner in which we live.

4.2.3.2 Targets

Some commentators regard the establishment of targets for construction of greater-density dwellings as a positive mechanism for effecting change.[158] It is notable that the OECD in its compact cities work does not list targets as a mechanism for change.[127] It is argued that the establishment of housing targets would provide greater clarity to developers on what and where they can build to enable local councils to exercise greater authority over the built environment within their jurisdiction provide a higher level of transparency and understanding to the public.

It is also often suggested that the establishment of targets promotes improved data acquisition and ensures better understanding of housing needs at a macro level, by which means targets drive more confident decision making in terms of land supply and zoning.

It is difficult to determine how targets would work in practice in this space. The new residential zoning rules establish density arrangements according to the urban fabric of an area. Targets that define the net increase or decrease in residential units for each council would require considerable work to avoid setting inappropriate and inflexible requirements. To suggest that population projections and regional approval processes overcome these difficulties is simplistic.

4.2.4 Actions and barriers: complexity and simplicity

Concentrating development and human Settlement in existing business and activity centres and inner and middle suburban areas would not only accommodate future growth, but it could also minimise environmental impacts.[93–96] It has been suggested that quite modest increases in heights and density could increase Melbourne's population by 3.8 million people while only modifying 7.5% of urban land uses.[95] This new residential capacity could promote the housing types that are actually desired by Victorians, minimise and rationalise transport demand, and reduce housing energy use and emissions.

Barriers to attaining these environmental, social and economic efficiencies and outcomes appear to be found in delays associated with promoting new or different patterns of development, regulatory environments that limit choice, and adverse public perceptions of medium- to high-density living resulting in a lack of support for even slight housing density increases. The question of how best to develop public awareness is discussed at greater length in Chapter 5, but it is important to acknowledge that a great deal of work is being done on this issue in planning, academic and climate change contexts.

The National Climate Change Adaptation Research Foundation submission to the Productivity Commission's reference on *Barriers to Effective Climate Change Adaptation* (2011) suggested that public awareness issues required significant research and input.[128] The provision of simple information, as distinct from an engaged process of considering diverse points of view and collaborative problem solving, is not conducive to resolution of complex questions like this.

Communication needs to be an active exercise, organisational barriers need to be eroded, and weak or inapt policies and legislation have to be strengthened or reformed. Incentives, both financial and procedural are a significant part of the solution.

RECOMMENDATION 20

It is recommended that the Victorian Government assume leadership by supporting industry and community in implementing sustainable urban development by developing guides and public awareness tools.

ATTRIBUTES

The scope of the task would involve industry and community consultation leading to guides and tools.

Urban rain garden

4.2.4.1 Financial issues, inefficiencies and externalities

Financial considerations contribute to a lack of enthusiasm for change at both ends of the development spectrum. National reports on affordability suggest developer construction costs feature in this equation.[129]

Land prices and building application costs are relatively higher for developers in built-up areas than on the fringe. This makes fringe development, where shorter approval times apply, more attractive. Infill multi-dwelling buildings can also require high pre-sale commitments for financing, and this operates as a disincentive for change.

At the other end of the spectrum, developer contributions, including payments, in-kind works and services or facilities provided for infrastructure have historically been under-priced for greenfield development, notwithstanding submissions to the contrary (see the Productivity Commission's reference on *Performance Benchmarking of Australian Business Regulation: Planning Zones and Development Assessments*).[130]

Pocket Park, North Melbourne

In its submission to the Productivity Commission the UDIA suggested that other methods of funding infrastructure be considered – including tax increment financing or government borrowing and that infill would be more readily explored if system-wide upgrades to infrastructure were sourced from government borrowings. The 'under-pricing' of infrastructure contributions in greenfield sites has been suggested as adding to the financial feasibility of construction in the fringe, but it has also been suggested that greenfield development imposes additional burdens on local government.

Development in the northern suburbs of Melbourne has provided an illustration of the issues. Since the growth areas infrastructure contribution was implemented in 2010, only $33.4 million has been generated. As this contribution was being collected the South Morang rail extension project, which brought public transport services to just a few of these growth areas, cost well over $500 million.[97]

A study of alternate development paths in Australian cities found that the upfront infrastructure costs for fringe development were actually $86 million more than urban redevelopment and the annualised transport costs over 50 years were roughly $250 million more in the fringe. Another $25 million could be added to the cost of fringe development for the health and wellbeing impacts related to GHG emissions and less active transport.[98]

There is work underway to review developer contributions in Victoria[131] and in other jurisdictions to standardise, benchmark and include regional and biodiversity considerations[132] as the breakdown is complex, and issues require clarification and resolution not just for economic and other efficiencies but also because of the potential benefits that will accrue to the environment. A Reserve Bank discussion paper (2011) remarks that beyond a simple cost-benefit analysis, other 'private or social benefits' flow from pricing infrastructure and in directing the developer to pay for this development.[133]

4.2.4.2 Changes to the taxation system: stamp duty and a land tax

Stamp duty arrangements for house and land sales were criticised in the Henry Tax Review as an inefficient tax, distorting the housing market.[156] It is recognised across the political spectrum that stamp duty adds to Australia's housing affordability problems and has other negative side effects, such as discouraging people from moving from regions of low employment to places where the job prospects are better. By reducing the transactional costs of moving house, the abolition of stamp duty would remove one significant impediment to downsizing with age. The Henry Review recommendations have not been not implemented. Tax reforms instituted since the review have for the most part not been conducive to increasing housing density or generating commitment to compact city planning.

In 1993 the South Australian government provided a stamp duty rebate for medium-density housing in Adelaide, but this initiative has ceased.[134] The Intergovernmental Agreement on Tax Arrangements promoted the abolition of stamp duty in NSW this year, but this reform has been deferred. No state or territory has adopted stamp duty changes.[157] The ACT is moving towards this initiative.

It has been argued that an annual property or land tax replacing stamp duty would reduce a major barrier to relocation from peri-urban areas to suburban and urban areas, providing for greater flexibility in choices of housing type and tenure as personal and family demands, employment location and statewide demographics shift. The data available suggest that shifts in demographics are not well understood but can be expected to impact on the sustainable housing choices.

It has also been suggested that the merits of a location-based tax system are worth exploring. This is reflected in suggestions of the utility of a property or land tax, relative to the amenity provided by the surrounding area. Where housing consumes a greater share of public resources and amenities, the suggestion of a levy or tax has been promoted as having merit. A land tax would also capture some of the windfall gains that accrue to home owners from sitting on a well-located property, and from government investments in civic improvements and better infrastructure. Yates has suggested that 'the arrival of an annual land tax bill might also prompt some older Australians to ask themselves whether they really want to be paying for the privilege of living in such a large house'.[135]

4.2.4.3 Incentives

Infrastructure Australia in its June 2013 National Infrastructure Plan calls for the use of incentives to improve land-use planning decisions and reduce costs and inefficiencies.[3] If used to effect, these changes will promote improved environmental outcomes. It is clear that the residents and the state, represented by the government, make significant funding contributions to the development of the growth areas. Incentive programs for different development programs and choices may in fact turn out to be cost-efficient.

An example of intervention is found in Seattle's Priority Green Incentive Program, which offers expedited review for projects that meet specific thresholds for energy, water and waste reductions. The 2–4 weeks expedited process is important in keeping building and other costs down.

Consideration could be given to creating a 'priority green expedited' permitting program to provide priority and expedited building permit review for developments that meet specified green building and environmentally sustainable standards. This sort of expedited response is presently being considered in London, with 'permitted development rights' under the National Planning Policy Framework being amended to drive residential builds in business premises, providing 'opt-out' provisions for councils.[154] Transparency is essential.

The standards required to obtain expedited outcomes should be stringent and promote meaningful environmental sustainability outcomes. Standards for determining priority should build on established voluntary certification programs such as the Green Building Council Australia's Green Star building rating and community rating tools. The co-benefit for the development industry of an expedited process with clear and concise environmental standards is the potential for reducing time frames and costs for sustainable housing design.

The business case for EnviroDevelopment Technical Standards illustrates co-benefit potential.[136] The benefits for developers are said to be:

- recognition
- marketing
- corporate image
- nil financial disadvantage
- greater sustainability and liveability.

The benefits for government are:

- increasing community awareness
- supporting the efficient use of resources
- reducing the pressure and demand upon infrastructure
- generating awareness of sustainability strategies.

Benefits for the public or consumer include reduced operating costs and streamlined access to and eligibility for rebates. A focus group canvassed about the benefits reported an 88.6% buy-in on the basis of reduced costs alone. A total of 50 projects have been rolled out across Australia meeting EnviroDevelopment certification processes. While the business case is outlined as providing positive economic outcomes for consumers, ASBEC formed a different view in its zero-emission development assessments in 2012 *(Net Zero Emission Homes: An Examination of Leading Practice and Pathways Forward)*, where it was suggested that low and zero net emissions homes were 'not yet cost-effective'.[137] The issues continue to be scale and ambition.

Case Study: Walkability research

The extent of the walkability challenge in designing at the precinct level is illustrated in the novel walkability research conducted by the Place, Health and Liveability Program team at the University of Melbourne in conjunction with the University of Western Australia's Centre for the Built Environment and Health and the Australian Urban Research Infrastructure Network which provides a highly instructive picture of the walkability in urban settings. This work should, over time, form the basis of responsive policy decisions.

Walkable environments produce a range of health and environmental co-benefits, including increased physical activity, social interaction, sustainable living and environmental protection.[141]

This research developed, trialled and validated a 'Walkability Index Tool': an automated geospatial tool capable of creating walkability indices for neighbourhoods at user-specified scales (i.e. suburb, Australian Bureau of Statistics (ABS) Statistical Areas (SA) and road network buffers generated around user uploaded points) for any Australian urban area. The tool is based on open-source software architecture, within the Australian Urban Research Infrastructure Network (AURIN) framework. Using this tool, user-specified areas can be compared using three key sub-components of walkability (street connectivity, dwelling or population density and land-use mix) as well as a composite index of walkability.

Figure 4.2.4 shows levels of walkability, adjusted for the land area (i.e. area of the SA1, which was the unit at which walkability was measured). It was created using three data sets: roads from the 2011 PSMA transport and topography dataset, dwellings from the 2011 Australian Bureau of Statistics mesh block data, and land-use categories from the 2010 Victorian Valuer-General's Office valuations database. In this map, the more walkable areas in Melbourne NW Region are indicated in shades of green, with the most walkable areas darkest green. Low walkable areas, on the other hand, are shown in shades of orange (i.e. less walkable) to red (i.e. least walkable). As can be seen, most of the outer growth areas of Melbourne generally exhibit low walkability, while inner Melbourne is generally shown in shades of green, indicating much higher levels of walkability. This suggests that for many outer suburban areas, consistent with the evidence[142] one would expect that compared with high walkable areas, the odds of walking and public transport use would be lower, while the odds of obesity and vehicle miles travelled would be higher. Previous research has shown that these areas are also mortgage- and oil-vulnerable suburbs. This is because when, fuel prices rise in response to peak oil, these suburbs have very poor access to public transport increasing their vulnerability to mortgage and oil-related stress.[143] Hence, outer suburban areas are doubly disadvantaged: residents have no public transport, nor are they easily able to walk to local shops and services. They have no choice but to drive, hence their vulnerably when fuel prices rise.

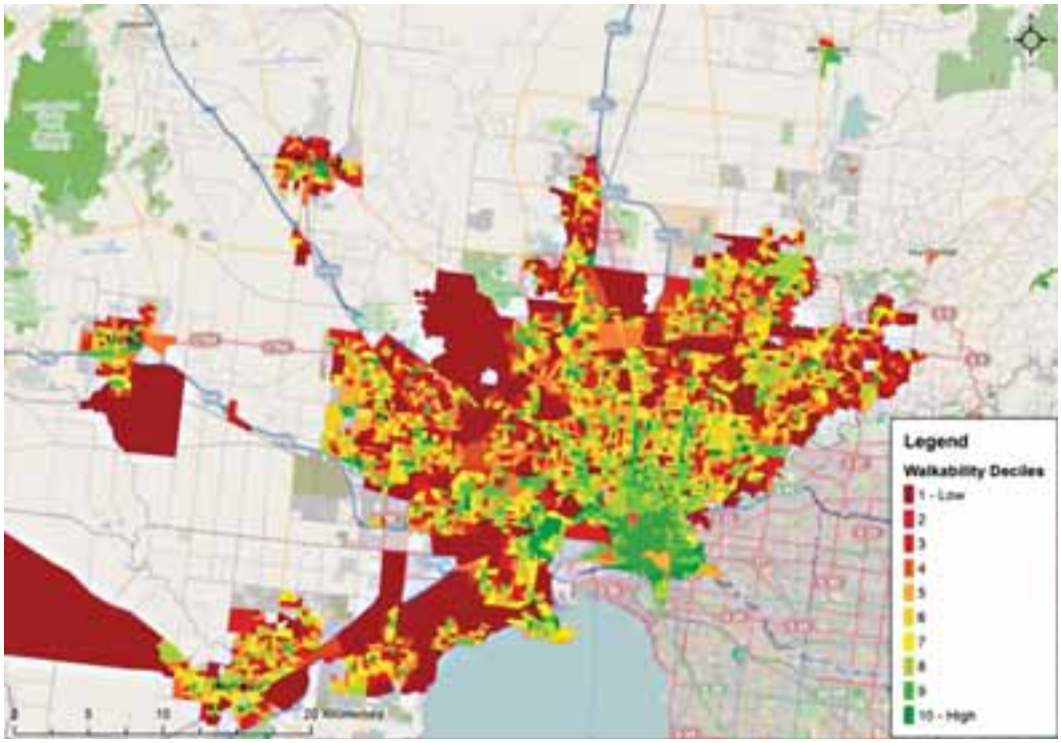


Figure B.4.2.6: North West Metropolitan Region walkability index

The Principal Pedestrian Network currently being trialled to improve transport planning around train stations, involving a partnership between the Australian Government, the Department of Transport, Frankston City Council, City of Boroondara, Shire of Yarra Ranges and City of Greater Geelong, is also offering some indication of improved sustainability possibilities.[144]

Interventions to deal with the issue of split incentives

In many cases where the homeowner is not present and does not pay for energy and water services there is little incentive to undertake energy-saving and water-saving improvements. In the Strategic Audit of 2012 we published a commentary on a social housing development in which government designed the development to reduce its own and its tenants' exposure to energy and other costs.[138] The process requires commitment, leadership and active planning at the local and precinct level.

RECOMMENDATION 21

It is recommended that the Victorian Government review taxes and incentives applying to the development industry, and based on this review, introduce a framework to support and promote sustainable housing design and development.

ATTRIBUTES

The review, and resulting framework to support and promote sustainable development would give consideration of the following:

- **broad community consultation**
- **innovative tax and incentive arrangements**
- **split incentives**
- **current regulatory barriers, including 'red tape'.**

4.2.5 Existing policy framework for sustainable development

The objectives of Clause 16 (Housing) of the State Planning Policy Framework (SPPF) are supportive of integrated, affordable and sustainable housing. The clause states that 'planning should provide for housing diversity and ensure the efficient provision of supporting infrastructure'.

New housing should have access to services and be planned for long-term sustainability, including walkability to activity centres,[119] public transport, schools and open space. Planning for housing should make provision for land for affordable housing.[120]

The SPPF is vague about how to effect change, leaving the management of change to those whose role it is to orchestrate planning decisions. The framework does not appear to provide certainty with regard to its objectives and strategies. Despite relevant strategies with regard to 'increased residential densities' and 'redevelopment opportunities within the established urban area to reduce the pressure on fringe development', it would seem that the provisions of Clause 16 are underutilised and unenforceable.[120]

4.2.5.1 Delays

Organised and individual community opposition to medium-density housing proposals can significantly slow progress compared with low-density greenfield proposals. In metropolitan Melbourne, referrals to VCAT occur for 42% of multi-dwelling residential developments compared to 23% for single-family units.[86] The administrative review system itself is also systemically problematic in generating delays, as the Property Council suggested in its submission on the discussion paper on the Melbourne Planning Strategy.[99]

Changes to the Neighbourhood Residential Zone announced in August 2013 will provide greater certainty as to developments that can proceed in certain areas, but the argument is already being mounted that in Glen Eira (for instance) the new zoning provision will reduce the number of available infill developments by 7000.[139]

4.2.5.3 Public perception: improving understanding of the potential and necessity of sustainable design features

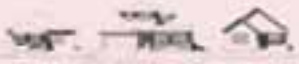
Residents in established low-density suburbs are frequently unsupportive of even slight density increases. This opposition is not well understood and the issue requires more research and commentary.[140] The public perceptions that targeted density increases are not conducive to living well[127] and that poor social and other outcomes will spill over into residential neighbourhoods are a real challenge in advancing a planning agenda promoting greater density.

Case studies and visualisation exercises can be used to demonstrate that medium density does not equate to 'high-rise' living, thereby working to overcome some adverse perceptions.[95] The Office of the Victorian Government Architect provides facts sheets on good design[124] that assist in increasing understanding of the role of design in generating better housing development outcomes.

	MUZ	RGZ	GRZ
	MIXED USE ZONE IMPROVED	**RESIDENTIAL GROWTH ZONE** NEW	**GENERAL RESIDENTIAL ZONE** NEW
WHAT IS THE ROLE OF THE ZONE?	Enables new housing and jobs growth in mixed use areas.	Enables new housing growth and diversity.	Respect and preserve urban character while enabling moderate housing growth and housing diversity.
WHERE WILL IT BE USED?	In areas with a mix of residential and non-residential development. In local neighbourhood centres undergoing renewal and around train stations, where appropriate.	In appropriate locations near activity areas, train stations and other areas suitable for increased housing activity.	In most residential areas where moderate growth and diversity of housing is provided, it is consistent with existing neighbourhood character.
DOES RESCODE APPLY?	**Yes** (up to and including 4 storeys)	**Yes** (up to and including 4 storeys)	**Yes**
WHAT SORT OF HOUSING CAN BE EXPECTED?	**High and medium density housing** A mixture of townhouses and apartment style housing up to three storeys, and higher where appropriate.	**Medium density housing** A mixture of townhouses and apartments with underground car parking.	**Single dwellings and some medium density housing** A mixture of single dwellings, dual occupancies with some villa units and in limited circumstances town houses, where appropriate.
DOES THE ZONE SET A MAXIMUM BUILDING HEIGHT FOR HOUSING?	**No** But a maximum building height can be specified.	**Yes, 13.5 metres** But a higher or lower maximum building height can be set by a council.	**Yes, 9 metres** But a higher or lower maximum building height can be set by a council.
CAN A PERMIT BE GRANTED TO EXCEED THE MAXIMUM BUILDING HEIGHT?	**Yes** When approved by a council.	**Yes** Except when a higher or lower maximum building height has been set which cannot be exceeded.	**Yes** Except when a higher or lower maximum building height has been set which cannot be exceeded.
IS A STRUCTURE PLAN OR DESIGN FRAMEWORK REQUIRED FOR THE ZONE TO BE APPLIED?	**No** The preferred future use of land and built form may be specified if necessary.	**No** The preferred future built form may be specified if necessary.	**No**

Figure B.4.2.7: Reformed Residential Zones for Victoria, July 2013

Source: DTPLI.

NRZ	TZ	LDRZ
NEIGHBOURHOOD RESIDENTIAL ZONE NEW	**TOWNSHIP ZONE** IMPROVED	**LOW DENSITY RESIDENTIAL ZONE** IMPROVED
		
Restricts housing growth in areas identified for urban preservation.	Provides for residential and other uses in small towns. Enables moderate housing growth.	Enables low density housing.
In areas where single dwellings prevail and change is not identified, such as areas of recognised neighbourhood character or environmental or landscape significance.	In townships.	On the fringe of urban areas and townships where sewerage may not be available.
Yes	**Yes**	**No**
Single dwellings and dual occupancies under some circumstances	**Single dwellings and some medium density housing** A mixture of single dwellings, dual occupancies, villa units and town houses.	**Single dwellings**
Yes, 8 metres mandatory Can be varied by council with approval from the Minister for Planning.	**Yes, 9 metres** But a higher or lower maximum building height can be set by a council.	**No**
No Except when a higher or lower maximum building height has been set which cannot be exceeded.	**Yes** Except when a higher or lower maximum building height has been set which cannot be exceeded.	**No**
No	**No**	**No**

Department of Transport, Planning and Local Infrastructure

4.2.5.4 Increasing the take-up of built environment sustainability solutions

Establishment of density thresholds

Establishment of clearly defined development corridors with density thresholds through the use of planning overlays in established public transport areas has the potential to ease concerns about medium-density spill-over into low-density areas. It would appear that the new residential zoning provisions may provide some clarity on this even as they foreclose on some of the potential opportunities (see above).

Neighbourhood Development Corporations (NDCs)

Large-scale brownfield and greyfield redevelopment projects have been managed by organisations such as the Growth Areas Authority and Regional Development Victoria. There is, however, a role for community and neighbourhood scale organisations to manage and deliver smaller projects that are contained within specific councils or neighbourhoods. The Port Phillip Houseing Co-operative provides an example.

Neighbourhood Development Corporations (NDC) have successfully delivered housing and development projects in communities worldwide[29] and have a demonstrated ability to ensure that council objectives and targets are met, while maintaining the local vision and character at the neighbourhood scale.[160]

By creating a funding mechanism through State and Federal governments (similar to the Living Victoria Fund), community housing arrangements, with prudential oversight, could be mandated to act in the best interest of the natural environment and the community and consumers. Because NDCs based on regulatory mechanisms such as Small Redevelopment Codes are represented and often run by members of the neighbourhood they can be a useful way to ensure that both macro- and micro-level goals are met.[161]

Public inner urban investment

More sustainable urban housing and development can be provided through public investment in inner urban areas to offset some of the developer risk. The development of The Nicholson by VicUrban/PlacesVictoria demonstrates the potential for this sort of development even though this development met with significant community opposition as a function of the failure to consult or inform the community and local residents of the proposed development.[121]

RECOMMENDATION 22

It is recommended that the Victorian Government include efficiency requirements in its design, development and refurbishment of all its social housing and other community buildings.

ATTRIBUTES

Efficiency considerations, in addition to affordability, could include:

- **green lease arrangements**
- **green building design, including open space**
- **decentralised energy.**

The Nicholson Coburg

4.2.6 Getting to change: guides and toolkits, enforcement and oversight

Guides and tools

Design tools, guides and processes as illustrated in the EnviroDevelopment Technical Standards[162] and Green Star (Australian Green Building Council)[164] and internationally in such processes as LEED-ND[163] are pivotal to changing the way we import environmental issues into planning decisions for better environmental outcomes. Strategic and regulatory tools, subject to independent verification and supported by business cases such as those outlined for the EnviroDevelopment Technical Standards, are necessary to generate interest in take-up of sustainable development and housing opportunities.

Multiple tools and complementary efforts will produce the changes needed. In its three-point plan for sustainable change, the Australian Green Building Council applies visionary leadership, retrofitting and improving buildings, and moving beyond buildings to communities and cities.[165]

Partnerships and cost sharing will also provide potential as the Smarter Resources Smarter Business – Energy Efficient Office Buildings program shows. Sustainability Victoria has opened the scheme to applications and the Victorian Government has committed $3.59 million to improve the energy efficiency of Victoria's commercial office buildings to support owners of mid-tier commercial office buildings who invest in energy efficiency upgrades.[166]

ClimateWorks Low Carbon Growth Plans at national, regional and sectoral levels illustrate the breadth and depth of our capacity to achieve environmentally sustainable, low-carbon, outcomes, even in an atmosphere of growth.[167]

In addition to the potential offered through formal design processes, other instruments can provide guidance. A wide range of tools and guides to facilitate better urban planning and design outcomes and promote environmental sustainability is developing. Portland (USA) has a *Buildable Lands Inventory,* Japan has a *Guideline for Building Low Carbon Cities* and a range of other efforts are discussed by the OECD in its *Compact City Policies: A Comparative Assessment* report.[168]

Achievements are proliferating in respect of energy and greenhouse issues where clear cost-benefits can be shown. The list of voluntary initiatives includes the NatHERS rating tool, Green Star and NABERS, and other best practice including the Energuide Rating System, the HomeEnergy Rating System Index, the UK Guide for Sustainable homes, Passivhaus Standard,[169] Swiss MINERGIE standards, the Canadian R-2000 and super-e standards, Climate Positive Development Program, and extends to include the work of the WBCSD.

Case Study: Toolkits for transition planning

Centre for Transit-Oriented Development: mixed-income transit-oriented developments

MITOD.org[148] is an online action guide to assist with the creation of mixed-income transit-oriented developments. The guide and tools were developed by Reconnecting America and the Center for Transit-Oriented Development for American Cities and Regions.[170]

MITOD is designed to work with communities through early visioning stages. It establishes existing conditions, collects data, identifies opportunities, transforms opportunities into strategies, and compresses the entire process into an implementable MITOD plan. A critical element of the MITOD tool is that it recognises and responds to the need to maintain affordable living, which is a key challenge of growth management and increasing density.

Reflecting on comments made in the previous sections, any transition planning toolkit should be developed in coordination with not-for-profit groups, architects, planners, landscape architects, engineers, lawyers and local councils. Toolkits should contain a multitude of strategies for encouraging affordable housing, smart growth, and appropriately scaled development in core transport and activity areas. Strategies could include:

- density incentives
- fee-waivers or fast-track programs for affordable and energy efficient housing and development concentrated around public transport[149]
- incentives for providing public amenities such as open space, parks, schools and other community facilities[150]
- smart growth zoning overlays or structure plans which focus mixed-use and medium-density development in appropriate areas[151]
- design guidelines
- explanatory memorandums regarding regulations for energy supply, use and efficiency[159]
- sustainability requirements for affordable housing.[153]

In the commercial building arena the City of Melbourne 1200 Buildings Program is working on delivering improved outcomes.[155] The Cbus superannuation fund involves itself in property developments and reports on a number of its 6 star and 7 star Green Star developments.[171] While green lease information can be difficult to source, there is evidence that commercial green lease arrangements are becoming more attractive and delivering co-benefits.[172] To facilitate change, a *Green Lease Guide* for commercial buildings has been published under the aegis of COAG and the National Strategy on Energy Efficiency (2012).[173]

Regulation

A great deal of confusion plays out in the community's understanding of the planning arrangements for higher-density, high-density, medium-density and low-density housing. An effort was made to describe the differences in a publication called *Save Ivanhoe*.[174] 'High' and 'higher density' required discussion for their relativities of scale. Regulatory requirements associated with medium-density (5–6 storey) developments are a found in many planning systems.

The planning system that operates in Melbourne is arguably presently more enabling of lower density housing typologies and less so of medium-density housing. A recent Reserve Bank discussion paper referring to the work of the Grattan Institute accepts the comment that:

'In the case of Melbourne, Kelly et al (2012) note that there have been significant amounts of greenfield development on the fringe and of new inner-city high-rise apartments, but that development in established areas (outside the inner city) has been constrained by planning complexity and high construction costs for apartments.'[175]

A planning system with clearly defined strategic goals (suggested by the OECD), as distinct from targets, could mitigate some of this difficulty. The formal planning used to effect changes to height limits along the Swanston Street tram corridor provided clear direction, authoritative guidance produced minimal impact on adjacent residential streets.[95]

Carlton housing Swanston Street

Enforcement

A key aspect of all standards and codes is administrative or judicial supervision. This is envisaged as one of the foundations of the adoption of a MMBW-type planning authority mechanism in some of the literature.[176] A supervisory and enforcement role could be assumed by the proposed regional planning authority.

If adopted, codes that guide processes need to be prescriptive and succinct in order to ensure certainty for developers and residents and provide for an efficient review process.

Such standards could be more rigorous than the Green Star system,[159] requiring specific elements for each facet of building design and construction such as energy, water use, materials, run-off, waste, connectivity and access to be addressed. This process could also be extended to introduce targets that support the environmental sustainability of buildings and neighbourhoods.

Docklands streetscape

4.3 Transport and the Environment

Proposition

Public and active transport as viable environmentally friendly transport modes are often of limited availability as a direct function of geography and the provision of services and infrastructure. Nevertheless it is important to improve Victoria's mobility and travel behaviour for better environmental outcomes.

Context

While public transport systems and networks will need to undergo significant change to promote sustainable outcomes, the effort will be well worth it for the co-benefits.[189] The concern about these issues is intergenerational and across sectors.

At a Victorian parliamentary inquiry the Youth Affairs Council of Victoria said young people wanted a sustainable environment with walking and bike paths and park lands. Transport solutions were raised 'repeatedly', as were recycling, reducing energy use, ethical consumption and awareness campaigns.[190]

An absence of a clear discussion of the investment framework necessary to deliver on public transport was observed as a major sustainable-cities issue in a number of submissions to this parliamentary inquiry.

A range of mechanisms can be used to address these issues, including planning, regulation and design.[191] The use of toolkits, guides and incentives is pivotal. Multiple policy levers should be explored. There are responses that can cut through the complexity, as the International Energy Agency has recently shown in its 2013 *Tale of Renewed Cities: A Policy Guide on How to Transform Cities by Improving Energy Efficiency in Urban Transport Systems.*[192]

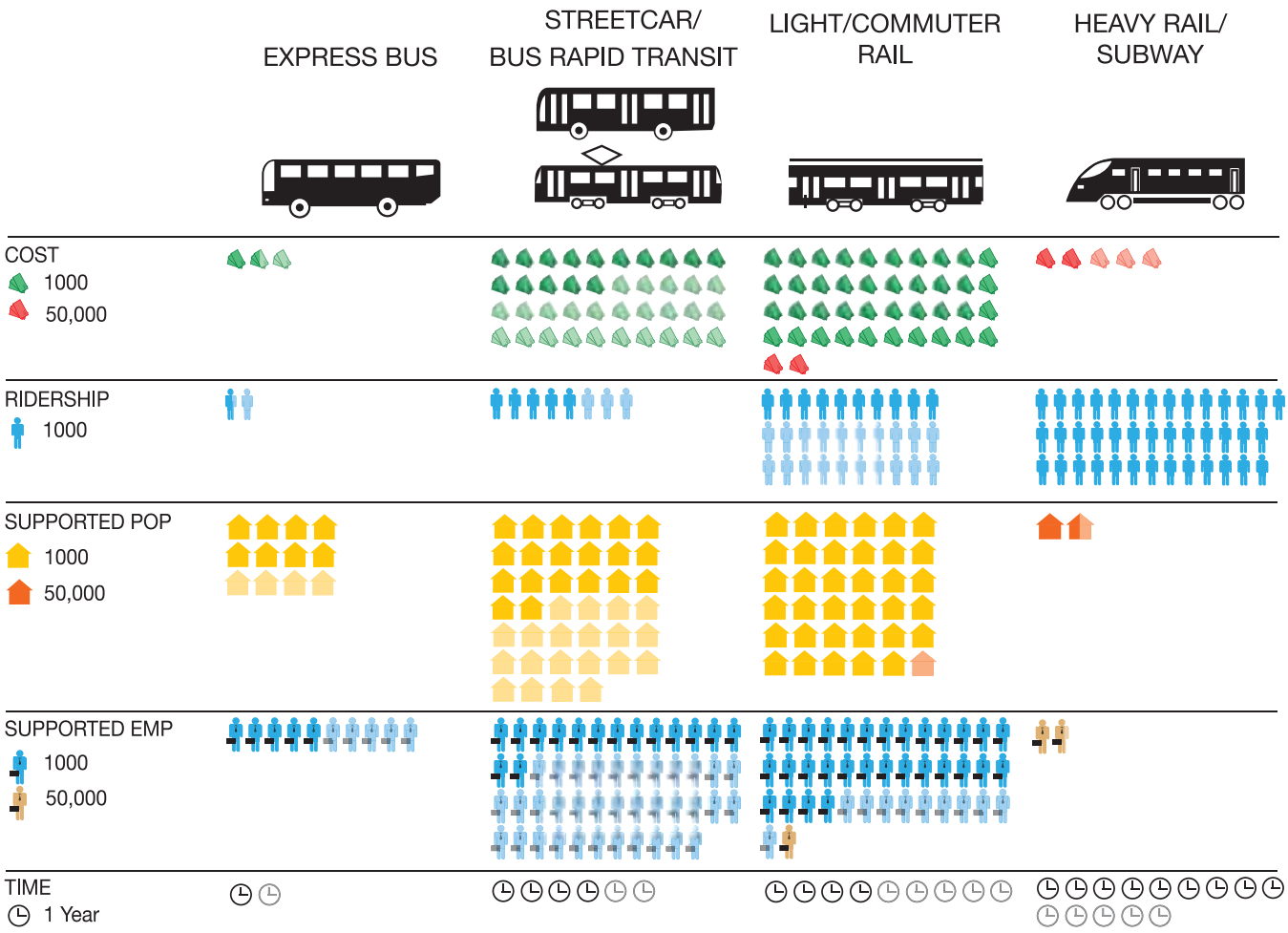


Figure B.4.3.1: Infographic: Transit modes at a glance – cost/ridership/completion time

4.3.1 Considered views

A study undertaken for the Reserve Bank tells us that: 'It is noteworthy that reports on the development process for Australian cities have pointed to transport problems being a major issue for development at the city fringe (e.g. Applied Economics (2010)'.[178, 179]

The Victorian Auditor-General has reported the shortfalls in providing transport infrastructure for growth areas (2013) and made a number of recommendations about strategic planning and monitoring as well as reporting on congestion issues.

Transport as an efficiency, productivity and environmental sustainability issue is exercising the minds of international policy think tanks. The International Energy Agency has recently published a Policy Pathway report on energy and transport exploring these issues and confirming the growing view that technological advances will not be enough to address transport provision issues.[147]

The *State of Australian Cities Report* (2013)[180] makes the following observations about public transport, bicycle and active travel in Melbourne:

> **'... consistent with [other capital cities] the share of journeys to work by public transport, bicycle or on foot declines with the distance from the city centre – 29.5% of inner city and 9.1% of outer suburbs commuters use public transport.**
>
> **In keeping with this commentary, in the inner and middle suburbs Melbourne has the highest bicycle use to get to work – 5.5% and 1.9% respectively – compared with 0.3% in the outer suburbs. While use of public transport is not optimal it is clear there is an increasing appetite for it. After upgrades of the SmartBus network (Public Transport Victoria) 'the number of passenger boardings is now at 40 year highs.'[6]**

The RACV canvassed the public about outer suburban concerns in 2012 recorded these responses:

- There should be more frequent and more reliable bus services.
- We need more frequent buses and longer hours of operating.
- There is a need for better planning of transport routes.
- Trains and buses need to be better maintained and they need to be serviced and replaced more often.[181]

Strategic transport planning followed by implementation is crucial for the attainment of environmental sustainability outcomes.

The Victorian Auditor-General recently reported that congestion costs were rising and that congestion was a pressing issue.[183] In the VAGO report on congestion[184] the work of the VCEC (2006)[185] was cited in which it was estimated that the economic cost of congestion in Melbourne ranged from $1.3 billion to $2.6 billion per year, and this figure was likely to double by 2020. The Auditor-General remarked that there 'is a need to explore more fiscally sustainable strategies [to meet this challenge] and it is not evident that agencies are actively exploring strategies'.[182] These comments are reinforced by VAGO's more recent report on transport infrastructure for growth areas (2013).[186]

Car share and bike use

Remarkable as it may seem, Infrastructure Australia calculates potential congestion tax revenue for Sydney at $5 billion per year.[3]

In Melbourne, illustrating the range of issues and trade-offs involved in this issue:

'... the ABS has estimated that the avoidable social cost of congestion for Melbourne's statistical division alone is $4.447 billion. [And by way of contrast] bus patronage is up by 9% and demand for public transport is expected to grow by 70% in the next decade.'[187]

The Department of Climate Change and Energy Efficiency reported in 2011 that:

'Transport emissions accounted for 14 per cent of Australia's total domestic emissions in 2009 at 83 Mt CO_2-e. Baseline transport emissions are projected to average 85 Mt CO_2-e per year in the Kyoto period, 37 per cent above 1990 levels. In 2020, transport emissions are projected to be 97 Mt CO_2-e, 29 per cent higher than in 2000. Road transport accounts for the largest proportion of emissions in this sector, averaging 73 Mt CO_2-e per year over the Kyoto period and 83 Mt CO_2-e in 2020. Indicative modelling suggests baseline transport emissions will be around 104 Mt CO_2-e in 2030.'[206]

RECOMMENDATION 23

It is recommended that the Victorian Government establish an independent transport working group to investigate and recommend best practice transport improvements.

ATTRIBUTES

The working group will represent broad-sectoral interests. The priority actions for the group will include:

- **identifying innovative funding mechanisms,**
- **assisting the government with the implementation and monitoring of demonstration projects,**
- **exploring active transport options,**
- **exploring the possibilities of improving train scheduling by the implementation of moving block in cab technologies, and**
- **evaluating and reporting publically on the electric vehicle trial.**

4.3.1.1 Savings

The environmental and other savings of active transport have been calculated.

'A study commissioned by the Queensland Government in 2011 found that, for a typical off-road path in an inner urban area, economic benefits per kilometre walked or cycled are: decongestion (20.7 cents per kilometre walked or cycled), health (up to 168.0 cents per kilometre), vehicle operating costs (35.0 cents per kilometre), infrastructure savings (6.8 cents per kilometre) and environment (5.9 cents per kilometre).

The aggregate result is that:

- 1,000 pedestrians per day will generate discounted benefits of around $7 million per kilometre over a 30-year appraisal period ($2.12 per kilometre walked, per person)
- 1,000 bicycle riders per day will generate discounted benefits of around $15 million per kilometre over a 30-year appraisal period ($1.43 per kilometre cycled, per person).

'This means that, for each person who cycles 20 minutes to work and back, our economy benefits by $14.30; and each person who walks 20 minutes to work and back benefits our economy by $8.48. The same study found that the average cost of a typical off-road path is around $1.5 million per kilometre, depending on the location and extent of planning and construction work required.'[188]

4.3.2 Environmental impacts of transport

In 2011, Stanley, Hensher and Loader reported 'transport is Australia's third largest and second fastest growing source of greenhouse gas emissions' and that 'major behavioural and technological changes would be necessary to deliver significant reductions'.[193]

Positioning for both the economic and environmental benefits and triple-bottom-line outcomes industry leaders such as Linfox with its Eco-Drive Training Program[194] and local governments such as the C40 City of Melbourne with its Transport Strategy[195] are making changes. Internationally, first movers have seen the benefits of acting early and positioning themselves for a wide range of perceived improved outcomes.

Initiatives can be multi-scale and multi-sectoral. For example, a small regulatory change in Chicago is driving change with the institution of a city ordinance to punish vehicle idling beyond 3/60 minutes.[196]

4.3.2.1 Impacts of private vehicle use

Notwithstanding improved vehicle emissions standards, personal motor vehicle use, particularly in circumstances of congestion, adversely impacts air quality, produces greenhouse gas emissions and is inefficient.[197]

The Australian Bureau of Statistics (ABS) tells us that we are a 'car nation'.[198]

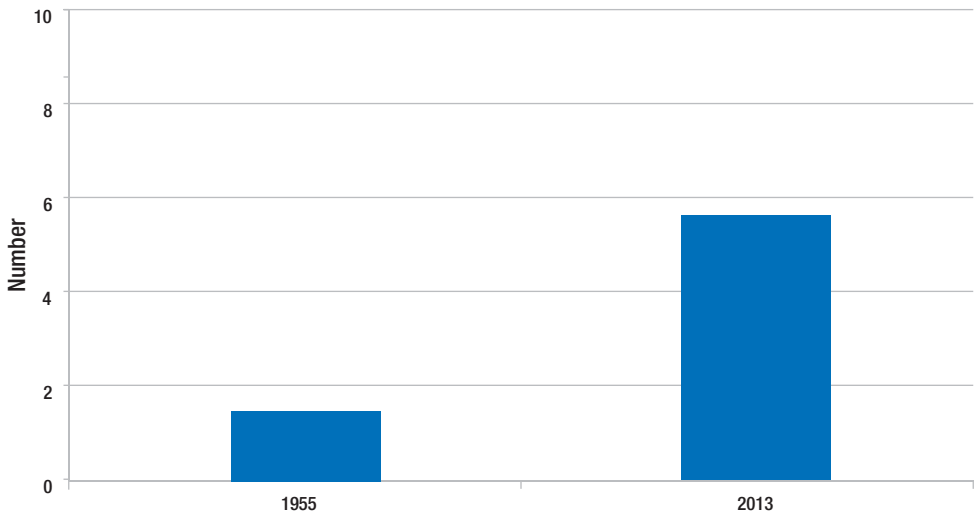


Figure B.4.3.2: Number of passenger vehicles per 1,000 people Australia-wide

Notes:

1955 Motor Vehicle Census data are at 31 December, Population data are at 30 June 1954. 2013 Motor Vehicle Census data are at 31 January and Estimated Resident Population data for 2013 are at 31 December 2012 and are based on 2011 Census of Population and Housing (Australian Demographic Statistics 3101.0 Dec 2012).

Source: ABS 2013 Motor Vehicle Census, Australia, 2013.

Figure B.4.3.3: Passenger vehicles and population

	Number of passenger vehicles			Passenger vehicles per 1,000 population[a]	
	2006 no.	2013 no.	Average annual increase %	2006 no.	2013 no.
New South Wales	3,395,905	3 877 515	1.9	499	528
Victoria	2,997,856	3,446,548	2.0	586	607
Queensland	2,138,364	2,556,581	2.6	526	554
South Australia	915,059	1,016,590	1.5	585	612
Western Australia	1,205,266	1,476,743	2.9	588	597
Tasmania[b]	271,365	305,913	1.7	554	597
Northern Territory	73,302	91,071	3.1	350	384
Australian Capital Territory[c]	191,763	229,060	2.6	576	603
Australia	11,188 880	13,000,021	2.2	542	568

Notes:

(a) Estimated Resident Population for 2006 is as at 31 March 2006, Estimated Resident Population data for 2013 are at 31 December 2012 and are based on 2011 Census of Population and Housing (Australian Demographic Statistics 3101.0 Dec 2012).

(b) Excludes vehicles with registration less than one month before the census date.

(c) Vehicles for which registration expired prior to 31 March were removed by processing systems used before Motor Vehicle Census 2008. Approximately 2% of ACT registrations have been omitted. The error has little impact on ACT annual fleet growth rates.

Source: ABS 2013 Motor Vehicle Census, Australia, 2013.

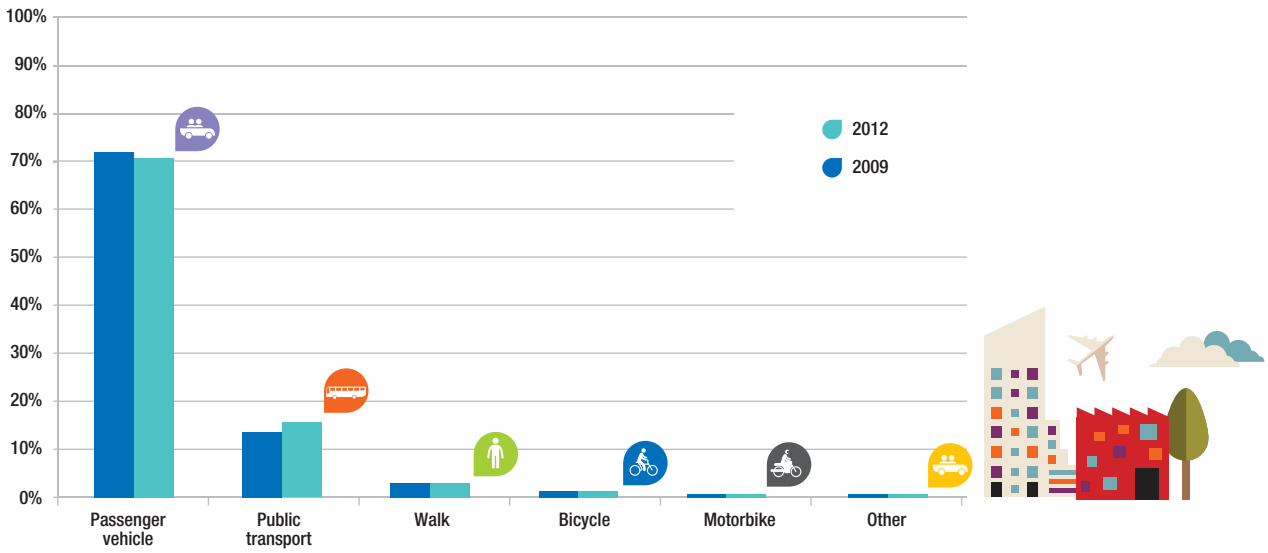


Figure B.4.3.4: Main form of transport used to get to work or full-time study, 2009 and 2012

Source: ABS Waste Management, Transport and Motor Vehicle Usage Use Survey.

The youth/older person split in car travel is very illuminating. In 2012, people aged 55–64 years were the most likely to drive to work or full-time study (78%), while young people (aged 18–24 years) were the least likely age group (63%). Young people were the most likely to take public transport (28%) to work or study, compared with older age groups.[198]

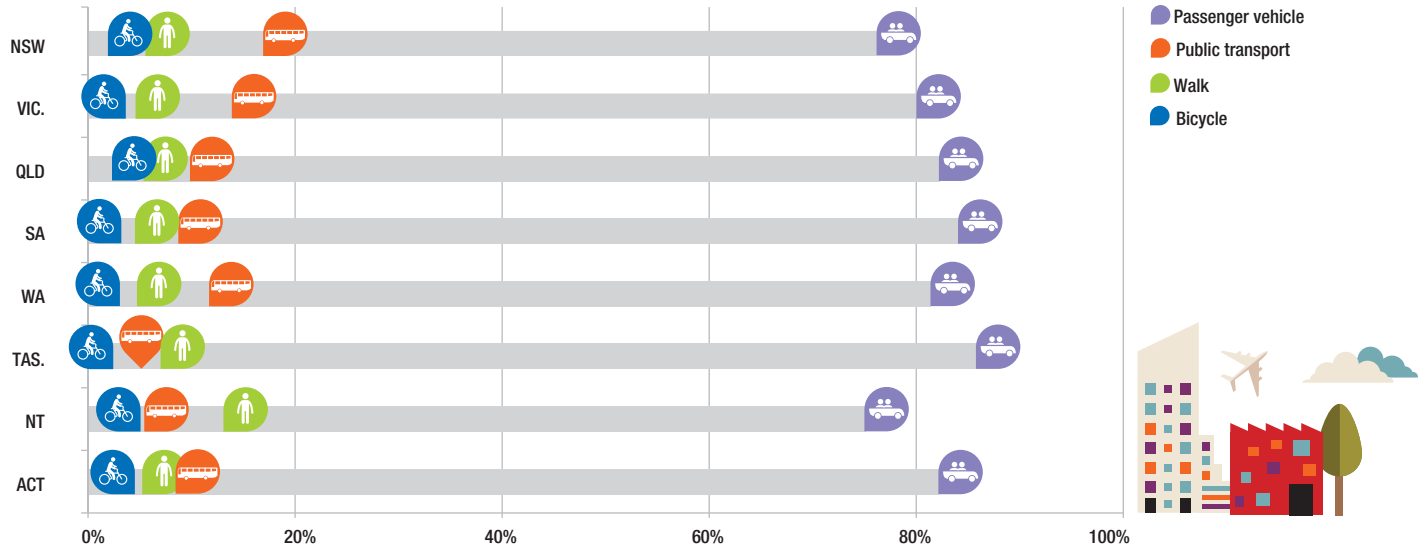


Figure B.4.3.5: All methods[(a)] of travel to work[(b)] by state or territories, 2011

Notes:

(a) More than one form of transport may be specified.

(b) Of those who travelled to work.

Source: ABS 2011 Census of Population and Housing.

In 2011, Sydney had the lowest passenger vehicle use to get to work (70%) and the highest public transport use (25%). Conversely, Adelaide had the highest passenger vehicle travel to work (84%) and the second-lowest proportion of people walking to work (2.9%).

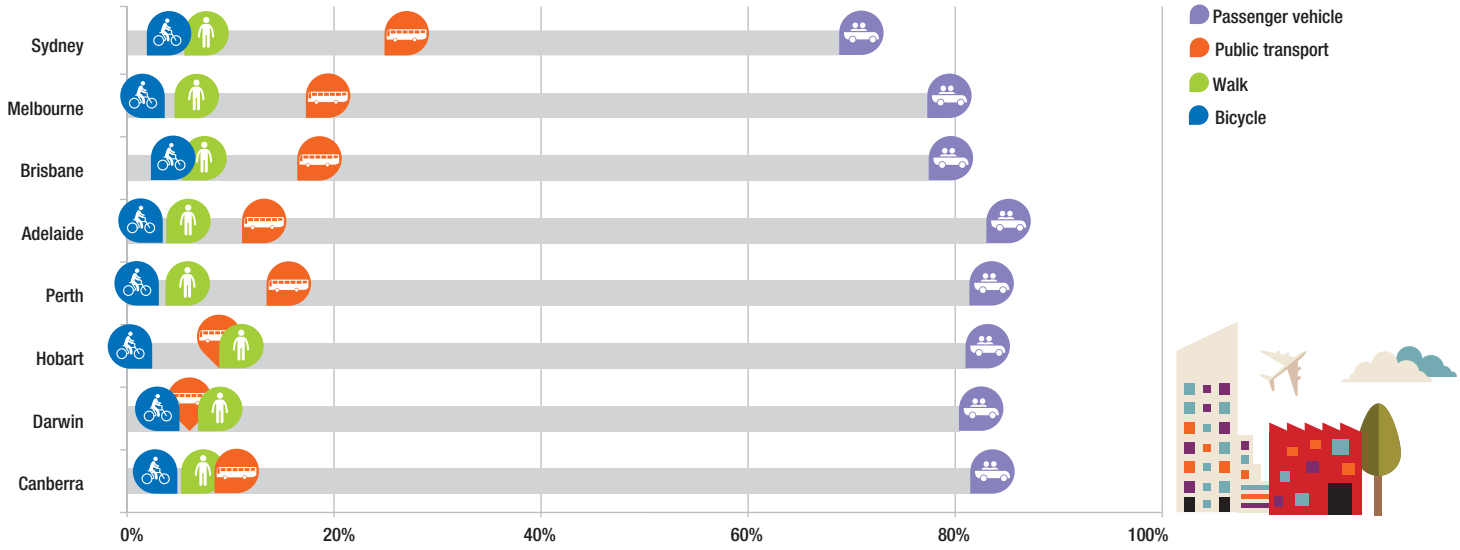


Figure B.4.3.6: All methods[(a)] of travel to work[(b)] by capital city, 2011

Notes:

(a) More than one form of transport may be specified.

(b) Of those who travelled to work.

Source: ABS 2011 Census of Population and Housing.

Having regard to the Victorian and Melbourne ABS data presented above, as a community we have some choices to make about our funding preferences in respect of transit.

4.3.3 Choices for decades to come

The Victorian *State Budget 2013–14, Building for Growth*, reflects the choices a developed industrial nation will be making in the coming years and decades.[199] The choices we make now will be with us for a very long time.

East–West road link and the alternative

At present $294 million has been committed over two years for planning, initial procurement and works on the East–West road link. This link has been under active consideration for years, and as early as 2008 the Eddington Report built on earlier proposals.[200] By way of contrast, $10 million has been allocated for developing the Melbourne Metro train tunnel.

Infrastructure Australia, our pre-eminent Commonwealth infrastructure organisation, lists the Melbourne Metro rail project (IA) as ready to proceed and the East–West road link as requiring project development funding.[201]

The rail tunnel has been described by the Department of Transport Planning and Local Infrastructure as the only way to boost capacity of Melbourne's urban rail network.[202] This capacity boost is considered to be imperative. It is suggested that 95% of Melbourne peak-hour trains will be overcrowded by 2020 if the rail tunnel is not constructed. A total of $520 million has been committed to public transport infrastructure, including contributions to develop the suburban precincts of Ringwood and Syndal, upgrade the Frankston line, and build two new regional stations at regional centres Grovedale (Geelong) and Epsom (Bendigo). Regional rail is increasingly seen as a component of metropolitan Melbourne rail systems.

Again by way of contrast, it is suggested that a lot more could be done to make the train system more efficient, including adopting braking and scheduling changes which are increasingly possible as a function of moving block in-cab signalling.[207]

There is a real need to start building business cases for public transport systems that extend beyond the conventional, traditional methodologies. The KPMG and Department of Transport (UK) High Speed Two (HS2) rail proposal report (*High Speed Two Limited Regional Economic Impacts Report*) illustrates the changes taking place.[208] In that report conventional project appraisal inputs are used as analytical tools but, instead of conventional analysis, 'overall economic productivity and the location of economic activity' have been used to gauge the economic viability of the project. While this is a high-speed rail project in another jurisdiction, and it does not expressly incorporate environmental considerations, it illustrates the potential for change.

In our recent 2011–2012 Strategic Audit, *Co-benefits: The Rise of Environmental Profit and Loss*,[209] we discussed the manner in which the sports good company Puma, using PricewaterhouseCoopers as its consultant, was developing environmental profit and loss to frame its corporate responses to environmental sustainability challenges.[210] Changes in accounting practices and analysis are occurring across private enterprise and they are accelerating.

Over time we have developed a number of strategies to deal with these issues, none of which were conceived in circumstances of the population growth or climate change scenarios that we now confront.

It is, however, recognised that it is possible to plan for transport changes by promoting avoidance by changing our growth patterns, shifting modes and improving technology. Whatever we chose to do, we will have to plan, implement, monitor and then evaluate our actions. Government has the pivotal role in planning for efficient and effective 21st century transport modes. This should be supported by business cases, which relflect best practice.

4.3.4 Emissions reduction strategies: the 'improvement paradigm'

There are a number of actions, some of which are currently being supported by state and federal governments across Australia, that seek to reduce emissions from the private vehicle fleet. These include:

- improving vehicle technology to burn petrol cleaner
- improving fuel efficiency of vehicles
- investigating less polluting sources such as biodiesel and electric vehicles.

In respect of technological advances, Australia has moved to introduce Euro 5 and Euro 6 air pollutant emission standards.[211] It should be noted, however, that while all OECD countries and some significant non-OECD countries such as China and India have fuel economy standards/targets in some form, Australia is alone among developed economies in not having a regulated fuel economy standard/target. A federal government draft regulatory impact statement (RIS) is in preparation but has not been released.[212]

Improvement has been effected across a range of modes, and where this has occurred clearly better outcomes have been reported. Most of the studies that examine this issue point to a mix of measures being the most effective methods of attaining change. The IEA in its recent report *Tale of Renewed Cities* actively promotes recourse to a mix of measures.[213]

While these efforts can reduce the range of travel impacts on the environment, they do not affect changes to existing travel behaviour. Often these efficiencies prove to be systemically ineffectual given the size and scope of issues to be addressed.[203, 204]

On the issue of mixed measures driving both technical and behavioural change, the Victorian Electric Vehicle Trial has resulted in the publication of a report examining the environmental sustainability of electric vehicles and guidance has been published on how vehicle operators can ensure they reduce greenhouse gas emissions when using electric vehicles. Energy used by vehicles in the trial itself was matched by additional Green Power or Renewable Energy Certificates through one of the trial partners.[214]

Given the outcomes of this trial, it is important that the Victorian Government consider measures that provide incentives or simply ensure by other measures that operators of electric vehicles use clean energy to power their vehicles.

4.3.5 Getting 'shift' in transport choices

It is clear that reliance upon a private vehicle can be structural. Whittlesea residents who want to use the train have to get to the station at Wallan, kilometres to the west of the town. In circumstances where new suburbs are created without public transport infrastructure, time lags in obtaining services may be considerable. The recent development at Aurora is still without bus services notwithstanding bus stops were installed.[215]

All 10 of the interface councils that ring Melbourne are ranked in the bottom third of councils with access to public transport, and every one of the 189 census sites without public transport are in the Interface Council Zone.[6]

Commuters' explanations for travel choices are detailed in the ABS data.

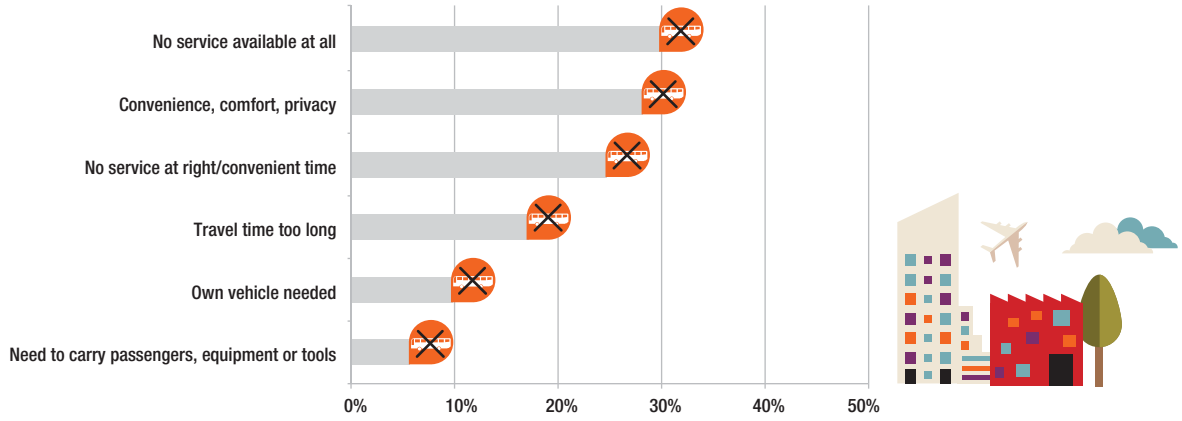


Figure B.4.3.7: Selected reasons[(a)] for not using public transport[(b)] to work or full-time study, 2012

Notes:
(a) A person may report more than one reason for not using public transport.
(b) For people who drove to work or study, as a driver or passenger.

Source: ABS Waste Management, Transport and Motor Vehicle Usage Use Survey.

Even in that seemingly discouraging scenario, there may be some capacity to shift modes of travel. We do know that 55% of all car trips are less than 5 kilometres and 68% of car trips are less than 10 kilometres, and that people are expressing the desire to act more sustainably.[205]

Data shows that there has been strong growth in public transport patronage since 2000 for all modes of public transport. Growth has been strongest in train travel but the use of trams and buses has also increased markedly.[224] A recent surge in the take-up of bus services has also been reported.[217]

'New research shows that the number of passenger trips on Melbourne buses has risen by more than 15 per cent. In the year ended December 2011, an additional 15.3 million bus trips were taken in Melbourne – a total of more than 117 million trips. Public Transport Victoria (PTV) research shows the increase in patronage is a result of new bus routes, route upgrades, population and employment growth in Melbourne's outer suburbs, as well as the strategy and investment focused on routes 401 and 601, SmartBus and Doncaster Area Rapid Transit (DART).'[218]

Shift in transport use will occur if a number of things align. Public awareness of the benefits of some of the other forms of transport will only occur if options are available, attractive and convenient.

4.3.5.1 Improving public transport access, frequency and coverage

Environmental sustainability can be advanced by the application of many modest initiatives, at lower costs, and with fewer environmental trade-offs than typical capacity-building projects. Sir Rod Eddington is recently reported as observing that the 'pursuit of "icon" projects at the expense of smaller projects' is not optimal.[219] Co-benefits in health and economic outcomes frequently attend smaller initiatives.[251]

A majority of services radiate out from the Melbourne CBD, and service frequency is based on peak commuting times. This mode of transport has inured us to service frequency decisions that reflect peak-hour travel in particular directions. Public transport provision, given the changing nature of the outer urban population, its different needs and aspirations, its different travel patterns, has to be deconstructed.

Two particular examples of travel system inefficiencies were provided to the Parliamentary Inquiry into Interface Councils.[6]

A trip in the City of Casey could take 56 minutes by an indirect public transport route or 21 minutes if streamlined. The lack of direct cross-suburb connections for the Mornington Peninsula Shire resulted in a trip taking half a day as the traveller had first to go into Frankston before then taking public transport out of Frankston to the chosen, otherwise relatively proximate, destination.

Beyond the need to plan transport options in a place-based way to deal with local conditions, we also need to shed a century-long commitment to fixed-rail methods of conveying multiple passengers. There are other, cheaper, highly efficient methods that do not require the heavy fixed infrastructure of rail networks, at least in suburban settings.

Stonnington (and other councils) have been making this point for some time. Most recently in its submission to the Metropolitan Planning Strategy inquiry Stonnington provided a list of features that would address transport issues in the middle-outer suburbs. These included a bus service that:

- ran more frequently
- started earlier
- stopped later
- ran on Sundays
- complied with schedules
- provided real time bus information
- followed more direct routes
- ran faster times between locations.

Services had to be made available in growth areas as residents moved into housing developments.

4.3.6 SmartBus services[220]

Public Transport Victoria (PTV) has been rolling out SmartBus routes for some time (collaborating in this work with VicRoads to gain road priorities for bus services), and other Bus Rapid Transit (BRT) possibilities are regarded by many commentators as fit for purpose for both intra-suburban travel and travel from the fringe to the centre.[252] Each expansion of the SmartBus network has been carefully studied and is based upon a sound business case.[253]

Expansion and integration of the bus network throughout Victoria could be a cost-effective way to improve public transport options between outer suburbs and new activity centres, providing quick links to train stations. When planned and operated optimally, bus systems can be more effective people movers than train systems.[221]

The momentum created by the development of the Smart Bus network, operated by PTV, could be a catalyst for BRT across Victoria.

4.3.6.1 Bussing it – Bus Rapid Transit (BRT): nimble but needs to be nice

Bus Rapid Transit (BRT) systems operate on designated and integrated laneways in which buses can perform as high-functioning public transport solutions, but with the accessibility and low cost of traditional bus use. Tickets are prepaid, and service and provision can be hierarchical as to size of bus and level of service, with different sizes of buses and different levels of service. Hubs operate to generate efficiencies and reliability.

Sunshine bus shelter refurbishment

The National Bus Rapid Institute in the US reports:

> **'Bus Rapid Transit (BRT) is an innovative, high-capacity, lower-cost public transit solution that can achieve the performance and benefits of more expensive rail modes. This integrated system uses buses or specialised vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet a variety of local conditions.'**[222]

To put the use of BRT into perspective, well-established rail systems around the world are frequented by those on foot, by bus or by tram. BRT systems now operate all over the world.

Case Study: Mexico City Bus Rapid Transit system

Mexico City has a population of 8.8 million people and it established its BRT in less than three years. Its Metrobus BRT system, launched in 2005, has been so successful in efficiently transporting daily commuters that the city is considering expansions.

The Metrobus has 'contributed to the reduction of commute time from 1.5 hours to 1 hour for the same route and reduced CO_2 emissions by 35,000 tons annually'.[223]

The service covers nearly 20 kilometres of ground with 36 stations and two terminals and has condensed 350 standard operating buses to 97 BRT vehicles.[224]

London, Canada is working on establishing a BRT after commissioning a report from AECOM and putting together the business case which suggests that for every dollar spent $1.80 will be recouped (London Transit).[225]

On the other side of the world in Nigeria the Lagos Metropolitan Area Transport Authority is commencing an e-ticketing system for its BRT.[226]

In Burma the Greater Yangon Strategic Development Plan is instituting a BRT to run every three minutes along the primary route with 'modern comfortable buses'.[227]

Geary, Richmond, USA cannot get its BRT going as quickly as Mexico City. It will be up and running by 2018, but it is intended to carry heavy passenger loads, and the business case stacks up.[228]

Mumbai in is also delivering BRT to its commuters.[229] Demonstrating the power and importance of 'badging' an iBus BRT has been established in Indore, also in India.[230]

Case Study: Curitiba Bus Rapid Transit system

Curitiba is the largest city in Brazil's southern region with a dense population of 1.8 million (4,200 inhabitants per square kilometre).[231] Its BRT system was the first of its kind. Features include: a bus every 90 seconds, exclusive priority lanes, free transfers between routes, pre-board fare collection, information displays and traffic signal priority.[232]

In 2009 Curitiba upgraded one of its bus lines to run a 100% biodiesel articulated bus, further reducing the city's greenhouse emissions. In October 2011, ICLEI produced a report as part of its Ecomobility campaign, reporting that approximately 2.1 million passengers use the BRT's 2,000 vehicles every day.

New York City Bus Rapid Transit

Perth's BRT is said to be working well at Ellenbrook. One of its important attributes was that the system was installed as the community took up residence in the development. It has been described as 'hugely successful'.[254]

The Adelaide O'Bahn, on specially built tracks combining both roadways and tracks, is also successful. The service runs for 12 kilometres, can travel at up to 100 kilometres, carries 7 million passengers a year (18,000 an hour) and it is 50% cheaper than rail. It travels local roads and dedicated busways.[255, 256]

4.3.7 Integrating service provision: interchange hubs

The Melbourne Transport Forum regards interchange hubs as a fundamental element of an effective BRT transit system, as the hub provides the physical node for the interconnectivity of the system.[6] Hubs provide for synchronisation and reliability.

The Bus Association of Victoria argues that BRT is quicker to establish than fixed rail, it is cheaper, and requires relatively little outlay on infrastructure, costing 10% of the outlay necessary for heavy rail. Improved local bus networks organise linkages. Opportunities exist to establish rapid bus services for Mernda, Epping North and Broadmeadows.

In supporting the 'promotion of improved connectivity'[6] the Outer Suburban/Interface Services and Development Committee of the Victorian Parliament articulated the attributes of BRT systems as:

- regularity
- higher capacity
- better performance
- good access, wide operating hours
- scalable – both up and down

The inquiry observed the need for different marketing, branding, defined rights of way, separation of traffic streams, and clearly designated stops at greater spacings than usual bus routes.

Using the ABS data there would appear to be some opportunity to improve the bus-feeder and pedestrian access to train travel. Integration requires a broad commitment to synchronisation across the public and private transport sectors and practical applications on timetabling.

CfES staff Ride2Work Day 2012

Figure B.4.3.8: Transit mode to train stations

Mode	Passengers	Percent
Walk	87,216	61.3
Feeder bus or tram	26,718	18.8
Car driver	20,208	14.2
Car passenger	6,041	4.2
Bicycle	1,282	0.9
Other (mainly taxi)	888	0.6

Source: ABS Train station access mode on Census day, 2006.[233]*

It is worth highlighting the large proportion of people who walk to train stations. This means provision of priority walking networks to train stations should be a significant element of local transport planning around train stations. DTPLI has developed a method for identifying and developing priority networks for pedestrians called the Principal Pedestrian Network. This method is currently being applied by a selection of local governments around Victoria.[257]

Many strategic planning and policy documents in Victoria have discussed the need to integrate transport and land-use decisions and improve connectivity between transport modes.[234–238] There are, however, limited examples of these strategies transformed into action.

It is anticipated that we will see an increase in public transport use of 71% by 2021.[258] Private bus companies, of which there were 16,[259] will have a role to play in meeting this increased demand.

In 2011, PTV reported that additional bus routes for the SmartBus system were 'under consideration'.[260] Presently the SmartBus system, which has been tendered to Transdev Melbourne from August 2013,[261] is working to provide integration and connectivity.[239]

The SmartBus network includes three orbital SmartBus routes and four Doncaster Area Rapid Transit SmartBus routes that run from Manningham to the city.

* See Department of Infrastucture and Transport (Commonwealth), Bureau of Infrastructure, Transport and Regional Economics, 2011, population growth, jobs growth and commuting flows in Melbourne, Report 125, Canberra, found at www.bitre.gov.au/publications/2011/files/report_125.pdf for additional commentary but no new statistics.

'SmartBus has been designed to complement Melbourne's radial train and tram network by providing 'cross-town' connections to train stations, tram lines, schools, universities, hospitals and shopping centres. Services run along major arterial roads, making journey times shorter and journeys more direct for passengers.

SmartBus services run more often and for longer hours than most bus services. On weekdays services run:

- **every 15 minutes between 6.30 am and 9.00 pm**
- **on average every 30 minutes between 5.00 am and 6.30 am**
- **on average every 30 minutes between 9.00 pm and midnight**
- **On weekends and public holidays:**
  - **on average every 30 minutes between 6.00am and midnight on Saturdays and public holidays**
  - **on average every 30 minutes between 7.00am and 9.00pm on Sundays, Good Friday and Christmas Day.'**[239]

Case Study: Integration – Toronto

The Greater Toronto Area ensures the provision of supportive uses and infrastructure through its Mobility Hub policy. These are defined as public transport stations surrounded by walkable communities and offering a range of services and transport options.[240]

Importantly, the policy acknowledges that one size does not fit all circumstances.

Integration of emerging transport systems such as car share and bike share form a part of the solution to our transport problems and these should also be considered to reduce reliance on private vehicles,[241] expand the catchment areas of public transport stations and also free up public transport spaces.[242] This would require strategic planning and the strategic use of land adjacent to train stations.

More work is needed on communicating the ease, availability and benefits of using linked travel modes. More needs to be done to brand and promote the transport system as a linked, accessible and useful system. The bus network could be more overtly incorporated in travel mode information than is presently the case. A Bus Tracker information service would form part of any changes.[262] Research has suggested that a range of other e-technologies is also important for making the transport system more efficient.[263]

RECOMMENDATION 24

It is recommended that the Victorian Government expand implementation of the SmartBus system throughout Victoria to improve public transport access.

ATTRIBUTES

Expansion of the system will require:

- **high-speed trunk services on key routes**
- **strong local transport systems**
- **flexible, efficient, regular, safe, clean and reliable local transport systems.**

Mayors on Bikes Ride to Work Day 2010

4.3.8 Improving transport options

Recognising geographical, social and other limitations, walking and cycling are the most sustainable forms of transport, producing effectively zero emissions.

There are barriers to these modes. Some are easily surmountable and others are not. Homogenous and spread-out land uses restrict walking and cycling adoption due to distance, and can take years to correct. Concerns over safety and feasibility in well-connected places can be overcome with incremental infrastructure and urban form improvements and education programs.

Active transport serves an increasingly critical function for certain travel patterns freeing up public transport and reducing the need for parking provision. Active transport uptake can be achieved by:

Committing to a steady stream of funding – funding the bike and the bike path

A potential barrier to active transport in Victoria is intermittent or limited funding.

Funding for the VicRoads Bicycle Program continued into the 2012–13 state budget[244] and additional funding has been committed in the 2013–14 budget, A total of $30 million is being provided to increase cycling uptake.[264] However, only 42 of the 79 Victorian councils met or exceeded the recommended local bicycle expenditure threshold of $5 per capita in 2011.[245]

Bicycle commuting (to work) has grown by 5 per cent per year from 2001 to 2011.[246] The Cycling into the Future: 2013–23 Victoria's Cycling Strategy, identifying strategic directions for improving cycling data, safety, accessibility, breadth, education and coordination was recently launched.[265]

The Darebin Creek Trail bridge and bike path link has also recently received a funding boost that will promote increased bicycle commuting.[266]

Incorporating the consideration of active transport infrastructure in all road projects and new developments developing 'complete streets'

Some best-practice examples in retrofitting streets for active transport emerge from across the United States. Federal, state and local governments are actively developing and enacting Complete Streets policies and legislation. The Living Street work being done in the UK is instructive[267] as is the work done on the New York City Plaza.[268]

Complete Streets ensure that transport agencies incorporate space for pedestrians, cyclists and public transport users into roadway design and reconstruction.[243]

Tram stop on Collins Street

The *Transport Integration Act 2008* [269] in Victoria and VicRoads' Smart Roads policy[270] provide a foundation for Complete Streets legislation and policy. The *Transport Integration Act 2008* is an overarching framework that guides transport and land-use decision making in Victoria. The Act requires all agencies to partner in delivering a sustainable and integrated land-use system. It also seeks triple-bottom-line decision making. However, the weight given to each objective (environment, society, economy) is determined by the transport body proposing the change. Smart Roads is VicRoads' method for comprehensively assigning road space to competing users and 'connecting communities'. The policy factors in all road users, considers fluctuating time of day requirements, accounts for differences in activity type and intensity, and manages roads as a network rather than individually.

The work that Yarra Trams and VicRoads are doing on the Route 86 tramline provides an illustration of how change can be effected.[271] The works are awaiting a determination of merit in the 2013 Melbourne Design Awards. Sustainability attributes include permeable paving, tree planting, recycling of construction materials and water-sensitive urban design.[272] Active transport is encouraged and safety is a major consideration. The community was actively involved in the work to develop the streetscape.[273]

Strengthening behaviour change and education programs

Habitual recourse to inefficient transport modes can be shifted by other mechanisms, including:

- public information campaigns
- branding that makes the very prospect of using public transport attractive
- simple efforts to ensure the service is used as well as recognised
- improving safety, security and end-of-trip facilities for walkers and bicycle riders
- improving priority for active travel participants
- policy direction
- costing mechanisms, including congestion changing
- incentive programs.

Case Study: Examples

In Portland, USA travel demand management, public awareness, education and free central district public transport have changed the transit mode model.[280] In Singapore, a stronger approach including the adoption of congestion charging and enforced restrictions on car use has been adopted.[281]

Importantly, both of these cities have influential metropolitan governance systems that marry transport provision and land-use decisions and whose policies that extend beyond the city limits to the suburban commuting areas.

Cambridge Municipal Code (USA) reduces vehicle trips and traffic congestion in the city by requiring parking and transportation demand management (PTDM) plans for commercial projects that propose parking. The ordinance calls for a single-occupancy vehicle mode-share commitment of 10% below the 1990 Census data for the project location.

PTDM plans must include a comprehensive set of transport demand measures, and annual monitoring and reporting to the city is mandatory. According to the city, the ordinance has contributed to a 24% reduction in vehicle miles travelled and contributed to a reduction in 38 million vehicle miles in 2011 and 62% of the monitored projects in 2011 met their mode-split commitments for 2011.

The city offers technical assistance for non-compliant projects to identify and promote additional measures that reduce travel. This mutually reinforcing process has avoided the use of the enforcement provisions contained within the PTDM ordinance.[282]

4.3.9 Pricing the car

The Victorian Auditor-General's Office (VAGO) makes the point that there is scope to leverage SmartRoads for better transport outcomes, including in relation to congestion, and that this should be done.[182] VAGO's congestion recommendations are endorsed.

VAGO recommendations

The Victorian Auditor-General's Office (VAGO) has recommended that:

- the Department of Transport reconsiders its initial proposal for the Network and Service Strategy as a stand-alone dedicated transport plan.
- the Department of Transport and Department of Planning and Community Development establish arrangements that assure comprehensive public consultation on transport issues, preferably in a stand-alone transport plan, but otherwise in the context of the Metropolitan Planning Strategy.
- the Department of Transport, in collaboration with other transport agencies, develops a congestion management plan within the context of broader transport and land-use strategies which sets out statewide objectives, priorities, targets and agency responsibilities.
- Public Transport Victoria develops explicit mode shift strategies and targets that are demonstrably aligned with defined statewide congestion management priorities.
- the Department of Transport, in consultation with stakeholders, reviews its governance arrangements and establishes mechanisms for systematic monitoring and reporting by agencies on the progress and outcomes of statewide congestion management initiatives.
- the Department of Transport, in consultation with transport agencies, develops and systematically implements a portfolio-wide decision making framework for congestion related infrastructure expansion projects that:
  - includes clear standards and procedures for assessing both the congestion benefits and disbenefits of proposed initiatives, including induced demand, relative to defined statewide congestion management priorities.
  - assures the nature and scope of proposals is adequately informed by sufficient consideration of statewide demand management options and initiatives.
- the Department of Transport, in consultation with other stakeholders, develops and regularly updates a statewide travel demand management strategy that:
  - includes initiatives and targets for moderating the use of private vehicles and the associated demand for road travel across the network during congested periods is informed by a review of the likely cost-effectiveness and feasibility of road pricing options and regimes.
  - includes targeted initiatives offering practical, sustainable transport alternatives to car use during peak periods, particularly for trips originating in car-dependent areas
  - is informed by a review of the lessons learned from previous statewide demand management initiatives, and leverages the opportunities identified by the Department of Transport in 2011
  - identifies clear agency responsibilities and accountabilities for contributing to road congestion and related travel demand management initiatives, and for updating the strategy.

- VicRoads:
  - improves the frequency and targeting of its traffic signal reviews by leveraging available congestion data from SCATS (Sydney Coordinated Adaptive Traffic System)
  - develops a strategy, including time frames, for implementing Network Operating Plans and activating SmartRoads priorities across the metropolitan road network
  - develops a strategy, in consultation with local councils, to better leverage the potential of clearways for managing congestion along the arterial road network
  - systematically reviews the efficiency and effectiveness of its operational management of the road system
  - develops measures and targets for network efficiency and congestion management initiatives in consultation with stakeholders.[274]

The cost of car use is subsidised at a high rate in Victoria. Only one-sixth of the total costs of driving are upfront costs. The remainder are external costs. These external costs – called externalities – are largely assumed by the community, in the form of accidents, diminished environmental quality, delay and time loss, road maintenance costs and free and subsidised car parking.[276]

Governments have attempted to shift some of these costs onto road users. A congestion levy is imposed on car park owners in and around Melbourne CBD.[277] However, research shows that the levy does not meet its objective of relieving congestion by increasing long-stay parking costs, because the full costs are often deferred.[278] Recent work of the Committee of Melbourne again raises the utility of levies.[275]

Rather than pricing car parking, pricing road use can both reflect the burden that private vehicle use places on the environment and society and provide an upfront inducement not to drive.

RECOMMENDATION 25

It is recommended that the Victorian Government investigate road-transport pricing and payment measures.

ATTRIBUTES

The independent transport working group could be engaged to consider the following:

- **a peak direction, peak time congestion charge cordon around inner Melbourne**
- **expanding distance-based tolling to all major highways**
- **tolling for heavy vehicles based on peak/off-peak periods.**

WHAT IS CONGESTION CHARGING?

In traffic management, congestion charging, or congestion pricing, is the practice of charging motorists a fee in order to enter areas where congestion is a problem during certain times of the day.

CONGESTION PRICING TYPICALLY AIMS FOR THREE GOALS:

1. **THE REDUCTION OF CONGESTION** in busy urban areas by encouraging motorists to reconsider their travel habits.
2. **RAISING MONEY** for the maintenance and improvement of transport infrastructure.
3. **REDUCING THE AMOUNT OF LOCAL AIR POLLUTION** caused by high volumes of traffic and thus promoting public health.

SUCH PRICING SCHEMES ARE CURRENTLY IN PLACE IN A HANDFUL OF MAJOR CITIES:

LONDON - CONGESTION CHARGE

> Began in **FEB 2003** as a £5 charge for entering central London, Increasing to £8 in 2005, £10 in 2011.

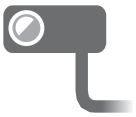
£5 → £8 → £10

Previously vehicles emitting less than 100g/km of CO_2 have been exempt.

TfL have proposed reducing the exemption threshold to 75mg/km

The charge remains in effect between 7am and 6pm Monday to Friday.

London's network of Automatic Number Plate Recognition (ANPR) cameras check a car's registration against a central database to establish whether the driver has paid the charge.



SINGAPORE - AREA LICENCE SYSTEM / ELECTRONIC ROAD PRICING

> The world's first congestion charging scheme was instituted in **JUN 1973** as the Area Licence System.

Charged S$3 per day for motorists entering the 'Restricted Zone'.

Was replaced in 1998 by Electronic Road Pricing, the world's first digital congestion charging system.

In-vehicle Units (IUs) are installed in all cars which are charged when drivers pass into the restricted zone.

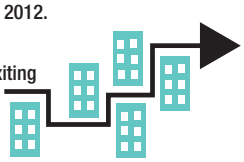
Charges vary depending on the size of the vehicle and the time of day.

STOCKHOLM - CONGESTION TAX

> Was instituted on a trial basis between **3RD JAN AND 31ST JUL 2006**.

Initially, cars running on alternative fuel sources were exempt from paying the charge, but this was abolished in 2012.

The charge is levied both on entering and exiting the city per day, up to a maximum of E6.



Fees charged vary depending on the time of day, with 7:30-8:30am being the most expensive time of day.

MILAN - ECOPASS / AREA C

> Began as a one-year trial in **JAN 2008** and was then extended until the end of 2009, then again until the end of 2011.

Ecopass allowed free travel for vehicles meeting low-emissions standards.

Charged either E2, E5 or E10, depending on the size and type of vehicle.

In 2012, Ecopass was replace with 'Area C' which abolished exemptions only for all traditionally fuelled vehicles.

The entrance also completely bans entrance for petrol vehicles not meeting at least Euro Emission Standard 1.

The charge is in effect 7:30am to 7:30pm Monday, Tuesday, Wednesday and Friday, and 7:30am to 6:00pm on Thursdays.

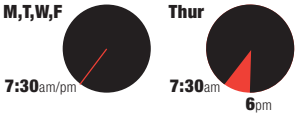


Figure B.4.3.9: Congestion Charging[218]

Stockholm's congestion charge represents global best practice with regard to impact on private vehicle use. Traffic volumes have been consistently reduced since 2006, despite a relative decrease in the price of the charge. Support for the congestion charge grew from 36% in the first year (2006) to 70% in 2011.

How the congestion charge operates

Launched in 2003 in London, the original cost was set at £5 per day. This was increased to £8 per day in 2003 and £10 per day in 2011.

Payment can be made on the day of travel or subsequently, incurring a small surcharge. The penalty for non-payment is £130. People who can prove that they live within the congestion zone receive a 90% discount, while those with a disability receive a 100% discount on the charge.[279] The congestion charge runs from Monday to Friday during peak hours.

In February 2013 incentives were factored in for electric car use. The Ultra-Low Emission Discount (ULED) offers a 100% discount to electric and ULED cars and vans.[280]

Criticisms

Some commentators have argued that the congestion tax was a tax on the poor, because the charge incurred was a flat rate and did not account for type of car and the user. The flat rate is also charged to key workers, nurses, teachers and professionals who must work within the CBD but whose salaries do not allow them to live within the zone.

Small businesses remain concerned that the charge has affected business due to traffic being deterred and seeking business outside the taxable area.[281]

While the congestion tax appears to have been successful at reducing traffic, critics have argued that:

- it was very costly to introduce
- revenues from fines were much lower than expected
- there were serious technical problems with the number plate recognition software
- it is unfair on those low paid that have to drive into London to work, such as key workers, such as nurses, ambulance drivers, and the police
- the charge is regressive in its impact, which means the poor pay proportionately more of their income on the charge than the rich
- many businesses have suffered as people stop shopping in London.[282]

Outcomes

It has been reported that a small number of embassies refuse to pay the charge under the Vienna Convention, which exempts staff from paying local taxes. This estimated revenue owed from these embassies is £50 million.[281]

Transport for London estimated that the impact on traffic flow was a reduction of 50,000 cars per day.[283] The London School of Hygiene and Tropical Medicine produced a report outlining a modest impact on air pollution and life expectancy since the introduction of the congestion charge.[284]

According to TfL's *Travel in London, Report 5*:

- Bus usage reached a 50-year high in 2011, with 30 per cent more services and 20 per cent less waiting compared to 2000–01
- Bike trips increased 79 per cent from 2001 to 2011, after having stagnated between 1993 and 2001.[283]

Emerging research from cities around the world suggest some benefits from seasonal and temporal road pricing, which incorporates the likelihood of ecosystem services cleansing the air and diluting emissions.[285]

Social and economic co-benefits of congestion charging include:

- significant reductions in congestion
- dedicated revenue for sustainable transport improvements (a deficiency of the current levy)
- environmental and economic savings through the ability to forgo road expansion and new road projects
- improved travel times and efficiency of public transport
- improved public health and fitness as a direct result of increases in public and active transport use.

Wind powered tram

4.3.10 Public transport payments: alignment of all service provision

According to a survey by the National Transport Commission in 2011, Victorians were unhappier about their public transport fare payment system than residents of any other state or territory.[286]

Improvements to and alignment of public transport payment and pricing can establish cohesion between modes of transport. This sort of alignment can:

- increase cost recovery for public transport operators
- increase public transport use and
- improve travel times by reducing stoppage time at stops and stations.

E-ticketing has been problematic in Victoria but it is plainly the way the public transport system ticketing systems are moving.[287] Further, e-ticketing is an essential component of a successful rapid bus transit system.

Periodically the issue of providing free public transport is raised as a mechanism for increasing public transport use. Staggering a free service for very early morning travellers has increased take-up. Tallinn, the capital of Estonia has commenced a free public transport service in the city this year (2013), and it will be one to watch.[289]

4.4 Climate Change and the Built Environment

Proposition

Much of our social and economic activity depends on infrastructure that was built for a climate that is now subject to significant change. All of our cities and all our rural infrastructure networks are challenged by climate change eventualities. Current construction must respond to present and future needs, and present and future climate conditions.

Context

Flexibility and robustness manifest themselves in a variety of ways depending on the setting. There is no one-size-fits-all approach to ensuring our complex built environment, in all its diversity, is resilient to impending changes. The realities of climate change have ensured there is no more status quo. There is no longer an option of not changing. Now we must, as a community, consider how we might change. The discussion in Section 4.4 provides some ideas of what we might consider to ensure our quality of life – its social, cultural, economic and environmental facets – is protected as the world around us changes. For a further discussion of the susceptibility of our built environment see Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play.*[290]

4.4.1 Extremes and consequences

Weather extremes are a part of life in Victoria. Such events have always happened and they always will. Climate change is projected to increase the intensity of such events.

In Melbourne on 6 March 2010, roofs collapsed, houses were flooded, trains failed to run, and 100,000 houses in the city lost power. The insurance bill was calculated to be over $1 billion – essentially the same as the Black Saturday bushfires. All this was caused by 26 mm of rain and hail falling in less than an hour.[291]

An event of this intensity is considered a one-in-10-year storm. Put another way, it has a 10% chance of occurring every year. Yet, a similar storm occurred in Melbourne in February 2011 and resulted in insurance claims of $384 million.

4.4.1.1 The economic strain

The effects of more frequent extreme weather events have been recognised by the financial industry, particularly the insurance sector. The sector recognises that mechanisms must be developed to manage and compensate for the consequences of these events. Insurance has a key method for businesses and individuals to manage financial risk.

Economic losses amounted to some US$ 380 billion in 2011, making it the most expensive natural disaster year to date, multiples more than the previous record (US$ 220 billion) set in 2005. At US$105 billion, insured losses also were at new high. The loss figures were dominated by the 2011 earthquakes – in addition to Japan, above all the devastating event in New Zealand. However, the year also included the floods in Australia, Thailand, France and Italy and the tornado outbreak in the USA.

The re-insurer, Munich Re, in reporting these figures states that weather-related risks in the USA and Canada are constantly changing as a result of anthropogenic climate change and natural climate cycles like La Niña.[292] Munich Re was considering the potential impact of climate change on business as early as the 1970s.

4.4.2 Infrastructure: a driver of development, not an afterthought

Our level of knowledge is improving about the impacts of climate change is constantly improving even in the context of uncertainties. Cities will be at the forefront of adjusting to these challenges. Strategic adaptive management that enables targeted and responsive changes to the built environment is a powerful tool for promoting resilience.

These impacts can be depicted in the following ways.

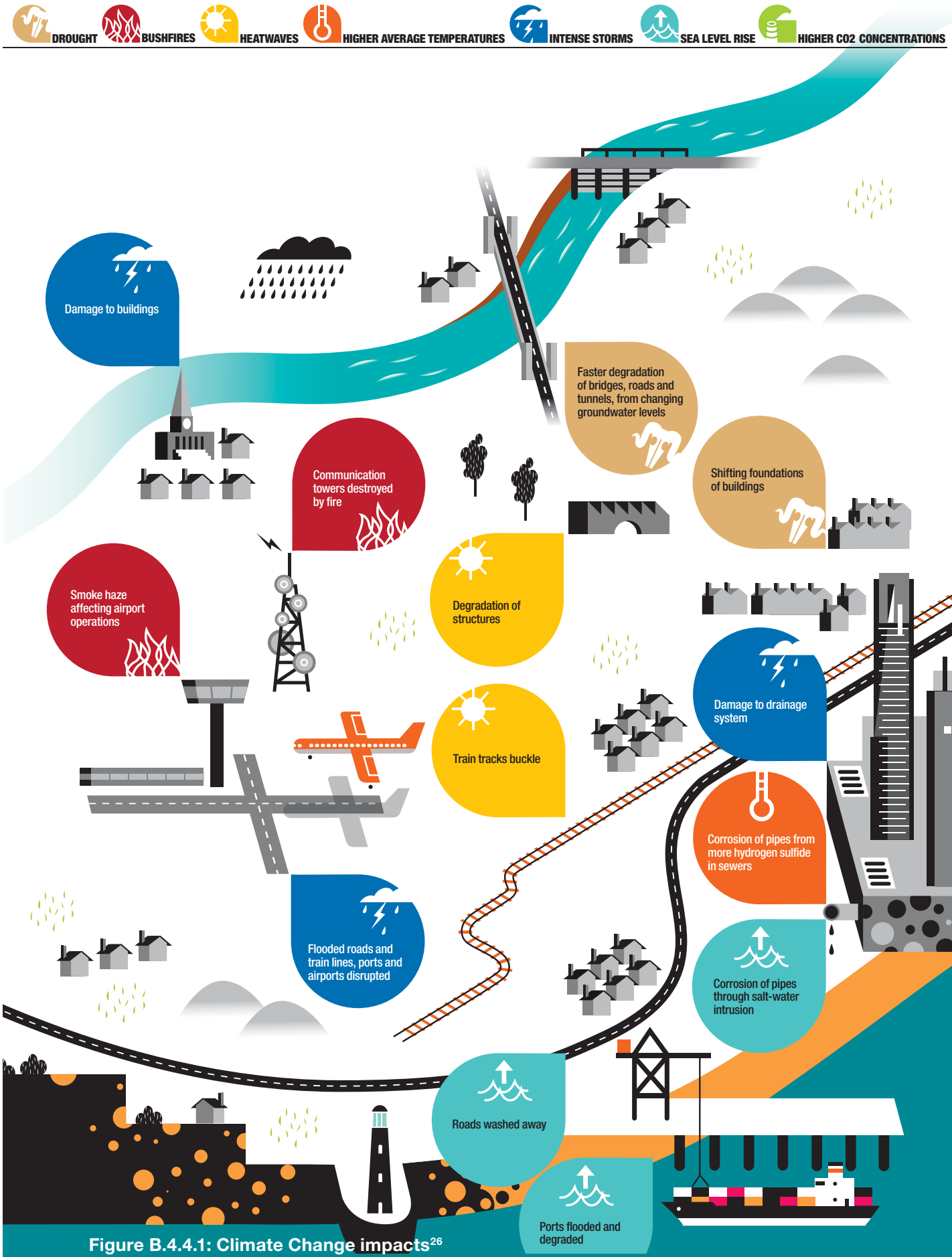
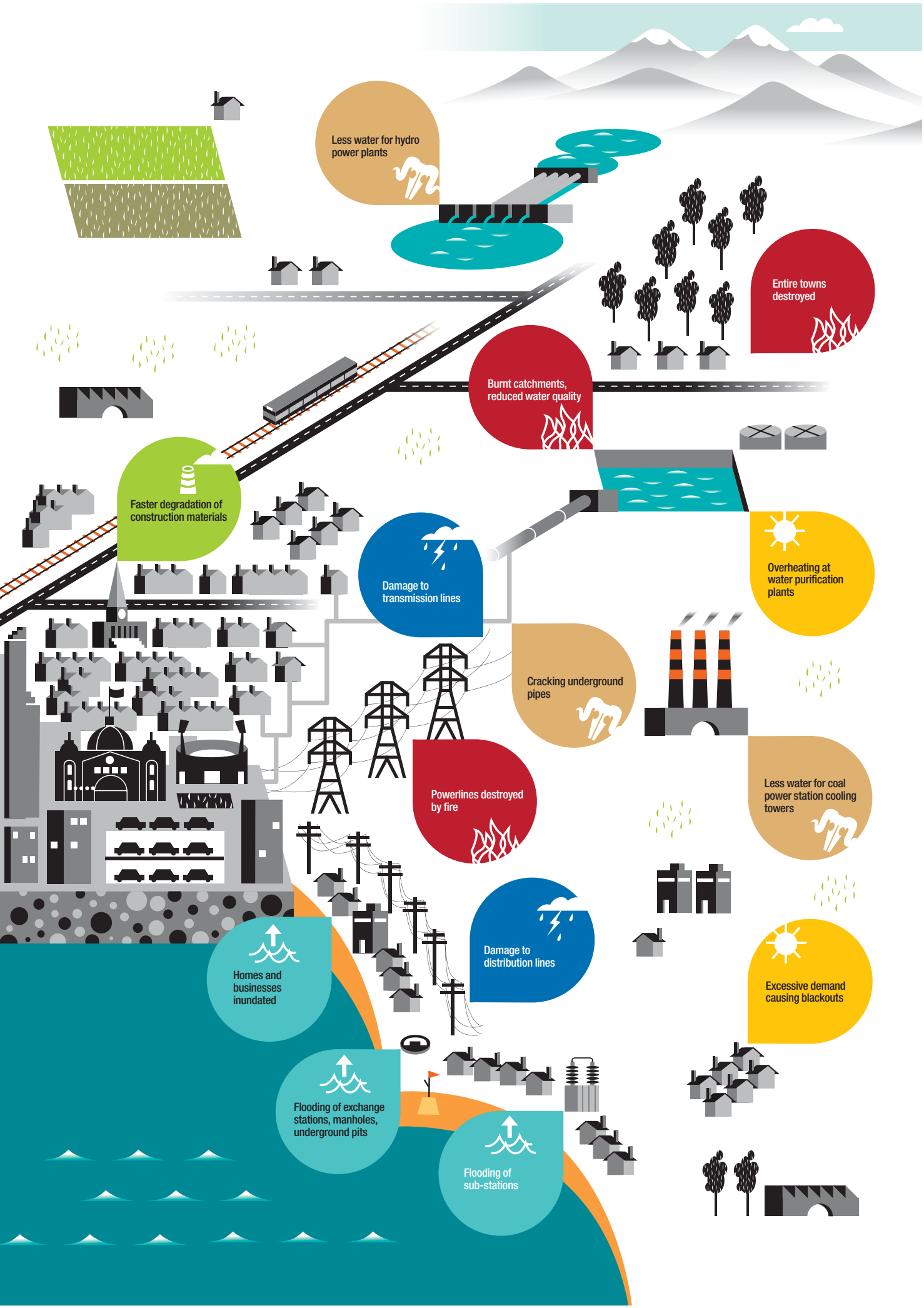


Figure B.4.4.1: Climate Change impacts[26]

Beyond these direct impacts there are cascading impacts, as each climate change scenario has the potential for multiple impacts – sea-level rise, heatwaves, intense storms –and this necessitates an 'all-hazards' planning ethos.[304]


Less water for hydro power plants
Entire towns destroyed
Burnt catchments, reduced water quality
Faster degradation of construction materials
Damage to transmission lines
Overheating at water purification plants
Cracking underground pipes
Powerlines destroyed by fire
Less water for coal power station cooling towers
Damage to distribution lines
Excessive demand causing blackouts
Homes and businesses inundated
Flooding of exchange stations, manholes, underground pits
Flooding of sub-stations

The potential costs are imposing. In 2009 during the heatwave, one-third of all metropolitan train services were cancelled and the total financial losses were $800 million.[306] Our built environment will have to be resilient and responsive to climate change impacts. We will have to adjust and adapt and we will have to both plan for all hazards to maximise our capacity to respond and design our built environment to reduce the impacts.

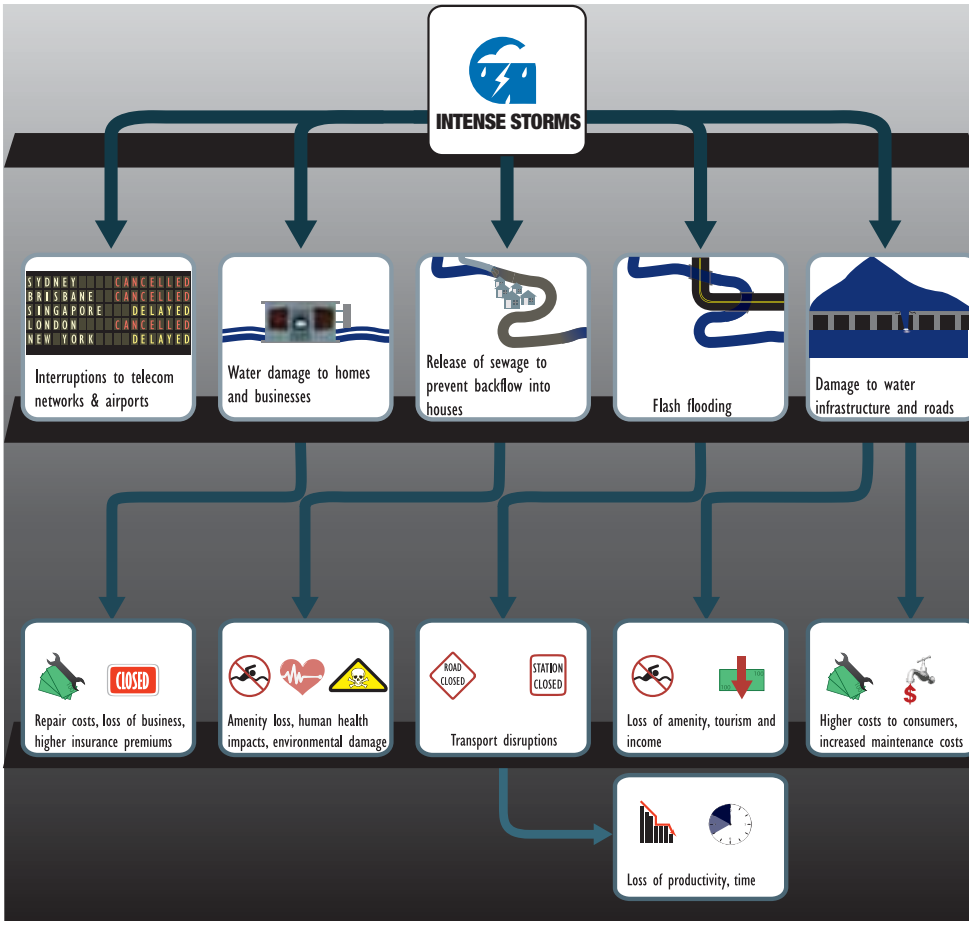
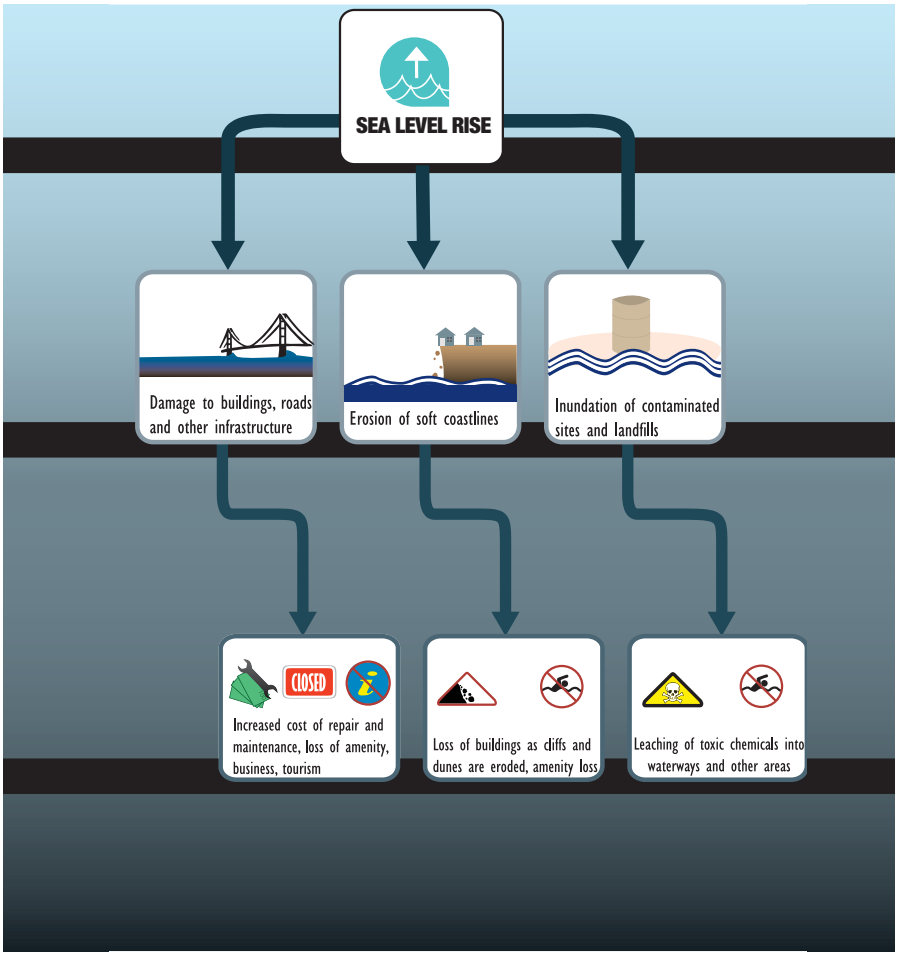
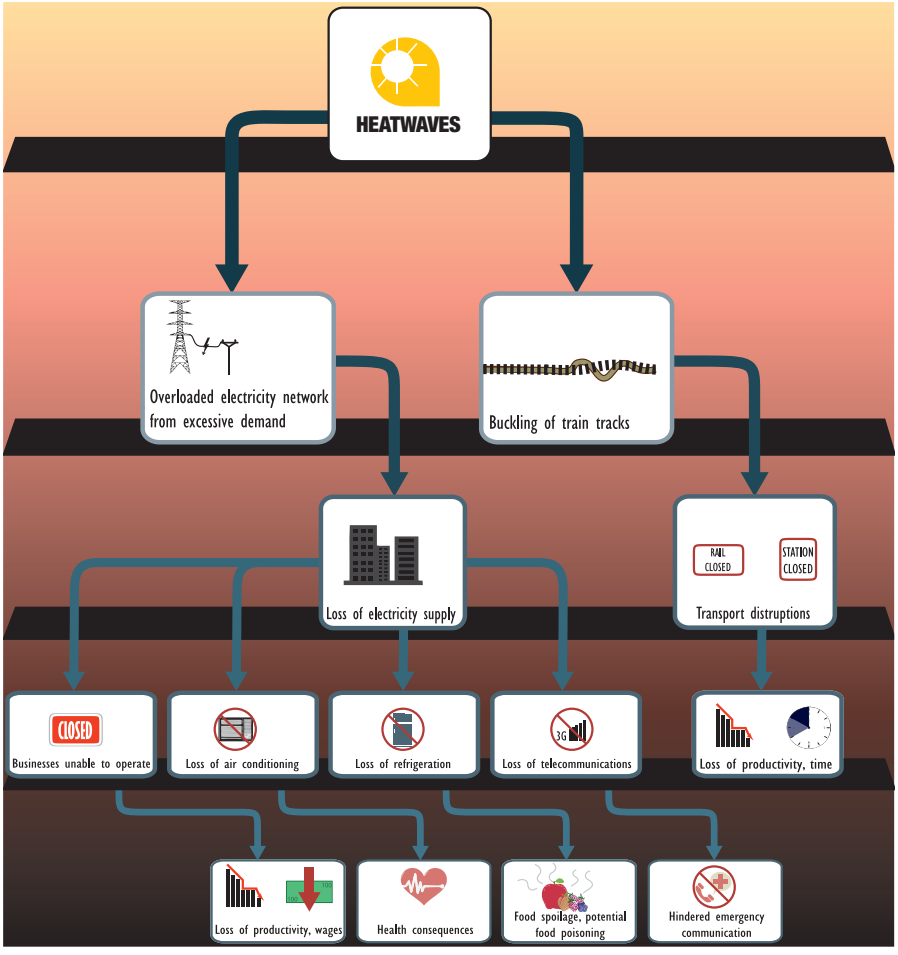


Figure B.4.4.2: Cascading Impacts


SEA LEVEL RISE
Damage to buildings, roads and other infrastructure
Erosion of soft coastlines
Inundation of contaminated sites and landfills
CLOSED
Increased cost of repair and maintenance, loss of amenity, business, tourism
Loss of buildings as cliffs and dunes are eroded, amenity loss
Leaching of toxic chemicals into waterways and other areas


HEATWAVES
Overloaded electricity network from excessive demand
Buckling of train tracks
Loss of electricity supply
RAIL CLOSED
STATION CLOSED
Transport distruptions
CLOSED
Businesses unable to operate
Loss of air conditioning
Loss of refrigeration
3G
Loss of telecommunications
Loss of productivity, time
Loss of productivity, wages
Health consequences
Food spoilage, potential food poisoning
Hindered emergency communication

4.4.3 Victoria's Climate Change Adaptation Plan

The Victorian Government has published its Climate Change Adaptation Plan 2013 in accordance with the requirements of the *Climate Change Act 2010*.

The Adaptation Plan outlines the need to:

- manage risks to public assets and services
- manage risks to natural assets and natural resource based industries
- build disaster resilience and integrated emergency management
- improve access to research
- support private sector adaptation
- strengthen partnerships with local government and communities.

Existing adaptation responses are detailed, as are roles, responsibilities, strategies and management efforts.

Victoria has joined with all other governments in the COAG Select Council on Climate Change and adopted a *Statement of Common Understanding on the Roles and Responsibilities for Climate Change Adaptation in Australia* (November 2012).[307] The priorities outlined in this statement are:

- water resources
- coasts
- infrastructure
- natural ecosystems
- agriculture
- emergency management
- vulnerable communities

In the Victorian context the Adaptation Plan observes that:

> **'... loss or damage to Victoria's transport, water supply, health, human services and education infrastructure ... is a major risk.'**[308]

Rebuilding, replacement and disruptions all have the capacity to impact the economy and the community. While certain of our critical infrastructure is privately owned and will be privately insured, this is not the case for all infrastructure.

In particular, Victoria is exposed in relation to health and education facilities, public housing, water infrastructure, government buildings and transport. The Victorian Managed Insurance Authority (VMIA) conducted a roundtable for the public sector in 2012 to discuss the implications for physical facilities, supply chains, information technology services and communication networks.[288] The VCCCAR is also providing policy makers with advice about scenario planning and flexible decision making. An example of this engagement is a VCCCAR convened 'Think Tank' in February 2013 dealing with government risk management.

4.4.4 All-hazards planning

Reflecting concerns about the implications of hazards, work has been done to engender resilience and insulate critical infrastructure services from loss. This work is intimately connected with concerns about loss of infrastructure from emergencies that are not necessarily associated with climate change; hence the focus on 'all-hazards' planning.

We began with the Evans review of Part 6 of the *Terrorism (Community Protection) Act 2003,*[293] and have now produced a Green Paper *Towards a More Disaster Resilient and Safer Victoria* (2011) and the White Paper *Victorian Emergency Management Reform.* This work has led to the Roadmap for Critical Infrastructure Resilience, which will in turn produce the Strategy for Critical Infrastructure Resilience, which is under development

What we derive from all this work is, in the words of Lieutenant General Evans AO, DSM, the clear understanding that the current arrangements need to be improved and transformed into a 'legislative and policy framework that captures the strategic intent of an "all hazards and all agencies" approach'.[294]

The outcome of this collection of reports will include the establishment of a State Crisis and Resilience Council (late 2013), an inspector-general for emergency management (with a co-regulatory role), and in the Department of Transport, Planning and Local Government a range of Sector Resilience Plans. This outcome is consistent with international trends and the work done in both the regional Critical Infrastructure Protection and Resilience Network and, at the Commonwealth level, the Trusted Information Sharing Network for Critical Infrastructure Resilience (TISN for CIR).

Even as we plan in this way for all-hazards responses, it also makes sense to undertake maintenance and proactive, anticipatory planning, dealing with the things we can do now. While we know that the future climate will be different to what it is today, to what extent and how climate change will impact Victoria is uncertain. Despite significant scientific research and analysis, this uncertainty is the new norm as future atmospheric greenhouse gas concentrations are inherently difficult to forecast.[295]

Questions such as 'When, and how much, will the sea level rise?'; 'Could temperature increases impact the life of this infrastructure project?'; or 'How frequently will storm surges occur?' must be factored into future planning and development decisions.[327] This climate uncertainty creates an additional challenge to the already complicated task of predicting the infrastructure needs of Victoria's future population and economy 20, 60 or 100 years into the future.

4.4.5 A multitude of stakeholders

The decisions about how Victoria's built environment is designed, constructed, managed and improved are influenced by a wide variety of stakeholders, reflecting an even broader range of interests.

The state and federal governments play a critical role in guiding and governing the built environment through legislation, policy frameworks and funding models.

Although state and federal action may influence behaviour, it is important to note that the multitude of owners, operators and users of the built environment presents an added challenge to adaptation and resilience planning. This is particularly evident with buildings, due to the high level of private ownership[298] and changing tenancy.

4.4.5.1 Strategy types

In Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play*, we provide a discussion of the variety of strategy types for improving climate resilience:

- no regrets
- flexible
- safety-margin
- soft and reducing decision making horizons.

A climate-resilient approach to infrastructure provision would consider all strategies and incorporate multiple strategies in a phased and continuously monitored delivery approach. What is not recommended from a decision making perspective is choosing and designing infrastructure that is optimised to perform well under a single, specified future climate scenario.[295] All-hazards planning is the optimal methodology to address the issues.

Figure B.4.4.3: Risks to Victoria's built environment

Climate change has the potential to impact Victoria's built environment in a variety of ways.[298]

		Primary built environment impacts				Flow-on impacts
	Climate change impacts	Environmental damage	System damaged/ shutdown	System overburdened	Reduced system performance	Impact to residents
Water	Extreme weather Increased daily rainfall Ground movement	*	*	*		Price increases Service disruptions Health concerns
Energy	Extreme weather Sea-level rise Ground movement		*	*	*	Price increases Service disruptions Blackouts
Telecom	Extreme weather Bushfires		*			Price increases Service disruptions
Transport	Extreme weather Sea-level rise Increased temperature Heatwaves Ground movement	*	*		*	Service disruptions Safety concerns
Buildings	Extreme weather Sea-level rise Increased temperature Heatwaves Ground movement		*		*	Service disruptions Safety concerns

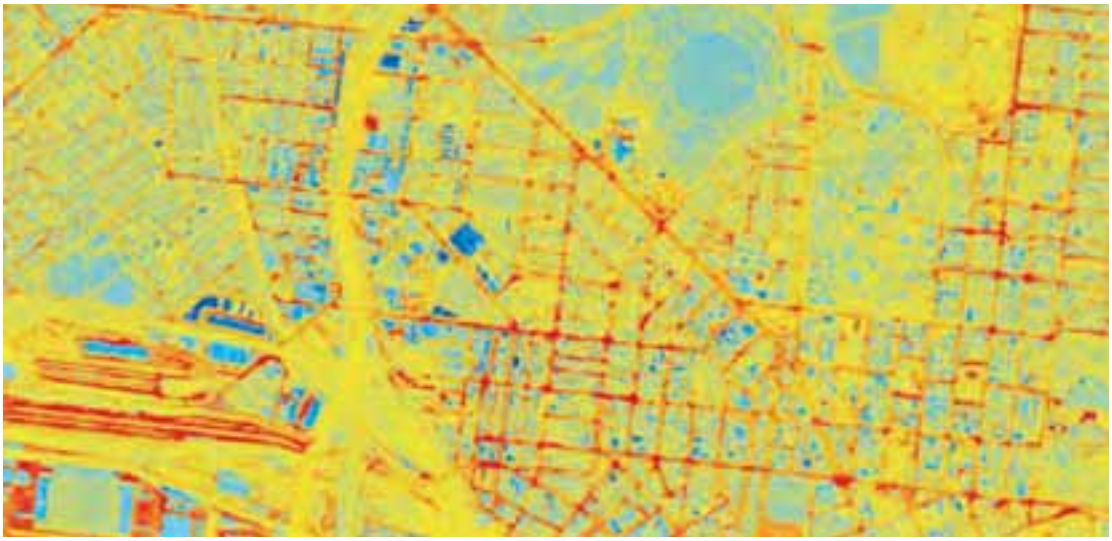


Figure B.4.4.4: Thermal imaging of Melbourne at night shows the impact of public infrastructure on urban temperatures

4.4.6 Planning for climate resilience

The impacts of climate change mean that there is an increasingly urgent need to re-evaluate the way infrastructure is analysed, prioritised and provided in Victoria. The traditional approach of making decisions primarily from an economic perspective prioritises projects based on their short-term efficiency. However, this efficiency can only be realised if the pressures remain largely unchanged throughout the years between concept, delivery and use of the infrastructure.

We know from current studies of climate change that this assumption no longer holds true. The question then becomes, how do we plan for the future of our human settlements while ensuring this uncertainty is accounted for? The answer, at this stage, appears to be a swift change in the way infrastructure is defined, analysed and provided.

As emphasised in a recent World Bank working paper, there is a need to transition away from cost-benefit analysis of infrastructure projects that identify 'optimal' solutions for a specific future scenario and develop a system that recognises the need for flexibility and 'robustness' in infrastructure planning.[229] We must therefore develop robust solutions to enhance the resilience of our infrastructure and built environment.

The development of these interventions must also move beyond the use of historic data to determine our needs and responses, as argued in Chapter 4 of Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play*.

4.4.6.1 Different decision making

Proactive decision making and planning can also enable better environmental and socioeconomic results. An example of this would be requiring new water infrastructure to incorporate triple-piping (the purple pipe) to accommodate non-drinking water delivery to buildings.

Case Study: Purple Pipes in Googong

Developers of the new township of Googong, south of Queanbeyan in southern New South Wales, have unveiled a $90 million plan to recycle water. The new town will recycle about half of its waste water, including sewerage, contributing to an overall water saving of 60 per cent. The system will enable the township's 16,000 residents to use less water than 7,000 residents would in an average Australian community. While the recycled water will be at a drinkable standard, it will be pumped back into homes through a separate main to be used for secondary purposes, such as washing cars and flushing toilets.[297]

The purple pipes will contain recycled water to be pumped back into homes

Source: Robert Herrick, ABC News.

The planning system and infrastructure

Once the decision making process is improved, the planning system also needs to be adapted to ensure that analysis and prioritisation results in more resilient infrastructure and urban design.

Planning coordinated at the regional level and better aligned with built and natural systems can enable consistent climate resilience approaches across Victoria.

New infrastructure provided by developers for the further development of urban areas and new development in greenfields must be climate resilient. This is especially true in areas that are already vulnerable to climate change, such as coastal and river-adjacent areas susceptible to flooding, and grassland suburbs (e.g. Melbourne's west) susceptible to urban heat island impacts.

RECOMMENDATION 26

It is recommended that the Victorian Government establish an independent, statutory authority to analyse Victoria's priority infrastructure needs and make recommendations.

ATTRIBUTES

The primary objectives include:

- **projects that are prioritised on the basis of environmental, social and economic benefits**
- **an audit and review of completed infrastructure projects**
- **promoting the use of green infrastructure**
- **the use of incentives to deliver environmental, social and economic benefits.**

4.4.7 Green infrastructure solutions

Emerging examples from within Victoria and around the world are demonstrating the ability to do more with less, reuse and retrofit existing systems, utilise ecosystem services in design, take advantage of development clusters and achieve co-benefits for people and nature. These projects can be referred to as 'green infrastructure'.

The key benefits of green infrastructure systems over traditional 'grey infrastructure' approaches is their ability to regenerate, enhance (as opposed to just limit the damage to natural and environmental systems), and cope well with changing pressures and demands.[301] A related benefit is the ability to implement green infrastructure projects at a variety of scales – a local project in one jurisdiction can link to an adjacent project, or spur a region-wide or statewide effort.

The adoption of green infrastructure, such as street trees, green roofs, green walls, permeable pavements and other landscaping elements can help to decrease local temperatures and reduce the need for cooling. This, in turn, can lessen the burden on the energy grid, mitigate the need for new and costly energy capacity and help protect communities as temperatures increase.[300] The added benefit of increased energy performance and potential cost savings for buildings makes these types of improvements 'no regrets' strategies.

The following is a brief summary of benefits and savings that green infrastructure projects can provide.

Figure B.4.4.5: Green infrastructure solutions

4.4.7.1 Achieving co-benefits for environment and society

Green infrastructure can lead to significant cost savings for governments, developers and residents, as well as assisting to mitigate future climate change by storing carbon in new vegetation and soils. If implemented thoughtfully, green infrastructure can reduce heating and cooling costs, water use and water treatment costs. Additionally, it can reduce the need for very costly grey infrastructure systems to accommodate population increases in urban areas.

Green infrastructure projects typically include the provision of natural systems in urban areas. This can increase the exposure of residents to biodiversity, vegetation, and water; creating an opportunity for people to obtain an appreciation for the services these natural systems provide as well as their aesthetic value.

The success of local initiatives such as the City of Melbourne's Urban Forestry Strategy and City West Water's Greening the West are testament to their utility and the ability of local communities and organisations to deliver such projects.

City of Melbourne Urban Forest Strategy

RECOMMENDATION 27

It is recommended that the Victorian Government establish a Statewide Urban Forestry Strategy.

ATTRIBUTES

The Department of Environment and Primary Industries should be the responsible department and the Victorian Adaptation and Sustainability Partnership could be considered as the delivery mechanism.

4.4.8 Integrating infrastructure

Internationally, cities, states and nations are considering how to maximise the function of their infrastructure by taking a strategic and integrated approach to infrastructure provision.

One example of how this is being achieved is by the creation of independent 'infrastructure boards' with the purpose of analysing infrastructure needs, prioritising projects in a comprehensive manner and identifying and monitoring appropriate financing and delivery approaches. These boards can improve the way infrastructure is delivered and ensure that a coordinated approach to the development of transport, drainage and energy infrastructure is taken.

If such a board were to be created in Victoria, it would be essential that sustainability and green design be built into the enabling legislation to ensure that the maximum environmental, economic and social benefit is realised through infrastructure projects. In addition, infrastructure provision in Victoria needs to return to its former legacy as a driver of development, rather than an afterthought. For this to occur, coordination with any proposed regional planning authorities should be mandatory.

Case Study: VicRoads

Roadway design is standardised across Australia through Austroads. However, VicRoads has developed supplements to address specific areas and issues in Victoria.

Prominence can be given to green infrastructure practices in Victoria through developing a supplement that requires the use of certain practices to reduce stormwater run-off and urban heat island impacts in new and restorative road projects.

At a minimum, the adoption of techniques that divert a certain percentage of stormwater from entering the sewer system through incorporating landscaping and permeable pavement into new roads and the use of high-albedo (heat absorption reducing) pavements to reduce heat retention and local temperature increases should be a mandatory consideration during the design process.

A more prescriptive process would require certain levels of stormwater diversion and heat reflectivity for roads in problem areas across Victoria. It is acknowledged that VicRoads only has jurisdiction over a portion of Victoria's public roads, however, this policy could serve as justification to amend the State Planning Policy Framework to require the use of green infrastructure in the design and construction of roads maintained by local councils as well.

4.4.9 Protecting Victoria from the long-term impacts of sea-level rise

While the strategies and approaches outlined here have benefits and can generally be more affordable than other intervention types, they have limitations as well. For example sea-level rise above a certain threshold may be beyond the coping levels of green infrastructure, or other engineering solutions.

Some controls and policies do already exist, including the Victorian Coastal Strategy (VCS) 2008, which sets the policy and strategic direction for responding to coastal hazard risks in the context of climate change.[300] It states that planning for climate change should incorporate sea-level rise of 0.8 metres by 2100. The combined effects of tides, storm surges, coastal processes and local conditions also require consideration. The strategy is incorporated into the Victoria Planning Provisions.

However, the VCS is targeted at one impact of climate change, and in isolation does not represent a coordinated approach. As noted by the Climate Institute – gaps, inconsistency and conflicts across and within jurisdictions exist within climate change regulation and planning across Australia.[296]

Early strategic planning and regular review of policies and targets as circumstances evolve or change can help reduce the long-term impacts of climate change, and help local communities to increase their adaptive capacity.

Port Fairy Beach

Although likely to be publicly and politically unpalatable, decisions such as planned retreat of coastal and bushfire prone communities, or moratoria on building permits, the reality is that these actions will need to be considered. These approaches can save lives, investments and possessions in the long term. They can also delay or eliminate the need for permanent and costly infrastructure investments by the State Government, and they are the decisions we need to be making now.

Continued development in at-risk areas places many Victorian households at risk from coastal and river flooding due to the combination of long-term sustained sea-level rise and storm surges from increases in extreme weather.

It is critical that Victoria adhere to the planning strategies stated in the Victorian Coastal Strategy 2008 and relevant sections of the Victorian Planning Provisions. In addition to a planning benchmark, specific triggers based on modelling, which mandate certain development regulations in coastal areas are desirable. For instance, if projected sea-level rise for a coastal area reaches 0.2 metres, specific flood protection building regulations must be applied to new and redevelopment (e.g. an 'x' centimetre rise in floor height for new buildings and renovations). If projected sea-level rise reaches 0.8 metres, a moratorium on all development must occur and if sea-level rise reaches 1.1 metres, retreat and relocation must begin to take place.

Strategic Adaptive Management (SAM) can be employed as a method for engaging government (including local government), science communities and residents in the climate change discussion. This would allow for mutually agreed thresholds for sea-level rise action and clearly defined responses for each threshold. Importantly, SAM also acknowledges uncertainty by establishing a process for continued engagement and enables a dynamic response to climate change.

Local geography, development and topography will also influence impacts of sea-level rise across Victoria, so flexibility to allow for variance by each council should be incorporated. The evolution of the Victorian Coastal Strategy into an effective long-term adaptation solution, will necessitate the continued review of thresholds and regulatory responses, taking into account the most up-to-date scientific knowledge.

Release of Draft Victorian Coastal Strategy 2013 for consultation

The Victorian Coastal Council preparing the next iteration of the Victorian Coastal Strategy. The first stage in preparing the next VCS was the release on 11 September of a draft for public consultation. The draft strategy outlines a proposed approach for planning and managing Victoria's coast and marine environment.

The release of the draft is an opportunity for all Victorians to comment on how our coast is managed. The Victorian Coastal Council would like to know if its draft strategy reflects the community's aspirations for the Victorian coast and if it provides effective guidance for decision making.

Public submissions are due on 4 December 2013*

* www.vcc.vic.gov.au/news/release-of-draft-victorian-coastal-strategy-2013-for-consultation

Case Study: WA State Planning Policy 2.6

In July 2013 the State Coastal Planning Policy, which provides for the long-term sustainability of WA's coast, was released.

There are pressures on the coastal zone for land use and development for a variety of purposes including a mix of recreational, residential, industrial and commercial uses. The policy provides a balanced approach to these often competing needs and desires in a way that takes into account the values of the coastal zone. The policy ensures that current and future generations of Western Australians can benefit from opportunities presented by the values and resources of the Western Australian coast.[302]

The coastal policy recommends notices be placed on title for properties likely to be affected by sea-level rise, sets out four adaptation measures and more than doubles the expected rise over the next 100 years. The policy must be given 'due regard' in preparing local planning schemes and is required to be considered when deciding coastal planning approval applications. The planning minister can require a local government to amend a local planning scheme to make it consistent with the policy.[303]

Rise could erode sandy coast

As recommended by the WA Planning Commission in 2010, the policy raises the allowance for sea-level rise by 2100 from 0.38 metres to 0.9 metres. The policy states: 'The allowance for erosion caused by future sea-level rise should include consideration of the potential reduction in wave attenuation by reef and the resulting impacts on shoreline stability.'

Disclosure on title

On consideration of approval for subdivision and/or development current and/or future lot owners should be made aware of the coastal hazard risk by providing the following notification on the certificate on title: 'VULNERABLE COASTAL AREA – This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years.'

The policy lists in order of preference four adaptation measures when an 'unacceptable' level of risk is identified to a community or a proposed development:

- Avoid the presence of new development within an area identified to be affected by coastal hazards;
- Planned or managed retreat or the relocation or removal of assets within an area identified as likely to be subject to intolerable risk of damage from coastal hazards over the planning timeframe;
- Accommodation of the risks through design and/or management strategies that render them acceptable; and
- Carry out coastal protection works if it can be justified in cases where there is a need to preserve areas, access or property 'that is not expendable'.

The policy says new coastal protection works and significant upgrades of existing works are only permitted 'after all other options for avoiding and adapting to coastal hazards have been fully explored, as part of a comprehensive coastal hazard risk management process'.

Onus on the proponent

The policy also includes a reference to the precautionary principle, stating that 'lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation'.

'The onus is on any proponent to show that development does not pose any likelihood of serious or irreversible harm to the environment,' If the proponent can't demonstrate that such harm doesn't exist, the onus is on them to show that the harm can be managed.[304]

4.5 Review and Reduce Non-Regulated, Distributed Emissions

Proposition

Mechanisms to improve air quality in Victoria have been largely successful. Impacts from major industries are generally well managed, and exhaust emissions from motor vehicles are expected to reduce over the next two decades, despite growing populations. However, these measures mean that a range of non-regulated emissions from distributed sources, such as wood heaters and off-road engines, will be responsible for a greater proportion of pollution impacts than in the past.

Context

Particles and ozone will be the pollutants of greatest concern arising from both distributed sources and major natural events (bushfires and dust storms). Additionally, climate change is expected to further increase pressures on air quality.

Although emissions from non-regulated sources are not currently well represented in national inventories, state inventories include reasonable estimates, and further research in this area is underway. This proposal discusses potential methods for limiting the impacts of non-regulated sources in the future.

4.5.1 The policy framework for air particle emissions

Victoria

In Victoria, the Environment Protection Authority (EPA) has responsibility for administering the *Environment Protection Act 1970*, which includes requirements for air quality.

- There are three critical statutory polices, developed by the EPA, that oversee air quality management:
- the State Environment Protection Policy (Ambient Air Quality), which sets ambient air quality targets
- the State Environment Protection Policy (Air Quality Management), which establishes the framework for managing emissions into the air environment in Victoria from all sources of air pollutants
- the Environment Protection (Vehicle Emissions) Regulations 2003, which specify standards and test methods for motor vehicle air and noise emissions.

The Vehicle Emissions regulations are due to expire January 2014. A regulatory impact statement and draft revised regulations were released for public consultation in August 2013.

Commonwealth

- The Commonwealth Government administers a number of important pieces of legislation, including:
- the *Motor Vehicle Standards Act 1989* and the *Australian Design Rules*, which set standards for vehicle design, including exhaust emission limits

the *Fuel Quality Standards Act 2000*, which controls the chemical content of all vehicle fuels sold in Australia (for example, the amount of lead or sulphur).

The Council of Australian Governments (COAG) is currently developing a National Plan for Clean Air, due in late 2014. This will involve a number of stages of work, with the first stage focused on particles (PM_{10} and $PM_{2.5}$). Particles have been chosen as the initial focus because exposure rates are high and significant health benefits can be realised by reducing particle emissions, making actions more likely to be cost-effective.

4.5.2 Why non-regulated emissions are a critical gap in our air quality management

4.5.2.1 Sources and impacts of major air pollutants

There are several common pollutants that have serious, detrimental impacts on human health and ecosystem function in Victoria (Figure B.4.4.6). High levels of air pollution in Melbourne are associated with increases in daily mortality[310] and hospital admissions[311] (see Part A, for further discussion of health impacts).

Figure B.4.4.6: The effects and sources of common atmospheric pollutants[312, 313]

Pollutant	Toxic effects on human and ecosystem health	Sources
Particles (particles smaller than 10 microns: PM_{10} and smaller than 2.5 microns: $PM_{2.5}$)	Respiratory tract infection and irritation Increased mortality from cardiovascular disease Increased infant mortality	Burning fuels (wood, diesel, coal) Industry Bushfires and planned burning activities Wind-blown dust from land erosion and vehicle movement on unpaved roads Mining activities Agricultural activities
Ozone (O_3)	Eye and throat irritation Exacerbation of respiratory disease Reduced plant growth	Ozone is not emitted directly but forms as a product of reactions between other pollutants (e.g. NO_2, CO and volatile organic compounds such as xylene)
Nitrogen dioxide (NO_2)	Harmful for children, the elderly and people with asthma May pollute water and soils	Burning fuels (natural gas, diesel, coal, petrol)
Carbon monoxide (CO)	Toxic to humans, can cause coma and death	Petrol exhaust Wood smoke Bushfires and planned burning activities
Sulphur dioxide (SO_2)	Throat irritation Exacerbation of respiratory disease May cause acidification of water and soils	Coal-fired power stations Metal smelting
'Air toxics' (e.g. benzene, benzo(a)pyrene, formaldehyde, toluene, xylene)	Eye irritation Lung cancer Asthma	Motor vehicles Industry

4.5.2.2 Air pollution inventories and management

Nationally, the major sources of air pollutants are recorded in the National Pollution Inventory (NPI).[314] The NPI is a publicly accessible database that provides free information to the community, government and industry on the emissions and transfers of substances to our environment.

The NPI shows the approximate locations of emission sources, and emission rates for each substance, although it does not specify the exact location of industrial stacks or their height above ground. The NPI database provides direct emissions from large point sources as reported by industrial emitters; it also provides limited information on diffuse emissions (e.g. from motor vehicles), although these data are not always up to date. State-based emissions inventories, such as the one prepared by EPA, include NPI information plus further details about the exact location, timing and chemical profile of pollution emissions, as well as more detailed information on diffuse emissions.

In Victoria, the major sources of air pollutants are subject to regulations administered by the EPA. Current standards and frameworks are set out in the state environmental protection polices (see above). New industry proposals for emissions to air are subject to rigorous review (which may involve background monitoring, emission estimation, impact modelling and review of best practice) and considerations of practical emissions control. For major industrial sources, the EPA controls offsite impacts by requiring relevant industries to operate under a licence which sets emissions limits.

Significant improvements have been made to Victoria's air quality since the 1970s, through application of state and commonwealth legislation. Pollutants related to vehicle exhaust are continuing to improve, despite the pressures of a growing population, due to improvements in vehicle design and fuel standards.

4.5.3 Addressing future emissions

While air pollution has been successfully managed over recent decades, the patterns of air pollution are changing, and new issues are emerging. The EPA has been working in partnership with CSIRO to identify how air quality impacts might change in the future.[315]

The key points of its Future Air report were:

1. Emissions from motor vehicles will decrease as tighter national regulations are introduced.
2. The impacts of large industrial sources of pollution are being managed effectively through legislation, and this situation is expected to continue in the future.
3. The main influence of climate change will be to increase ozone pollution, largely through more frequent days of hot, still conditions in summer.
4. The pollutants of greatest importance in the coming decades will be ozone and particles.
5. It is expected that, as population and density increase, business operations and residential activity will form an increasingly larger proportion of pollutant sources.

The increasing importance of non-regulated, distributed emissions

Point 4 (above) highlights the future significance of particles and ozone as pollutants – both of which have well-documented health impacts. Because ozone is not directly emitted, but forms as a product of reactions between other pollutants, any measures to limit levels will need to address sources of ozone-forming compounds (such as NO_2 and volatile organic compounds (VOCs), which are emitted from a wide range of human activity as well as from natural sources.

Point 5 (above) raises the issue of an emerging suite of emissions sources that are not currently directly regulated and potentially not well represented by estimates in the NPI. These are primarily emissions of particles and ozone-forming compounds produced by domestic sources or small businesses. These sources are small individually but numerous – and as historically large emissions (heavy industry, traffic) decline or remain steady these sources can play an increasingly substantial role in reducing air quality. Because these sources are often located close to where people live, growing urban populations will have greater exposure leading to greater health impacts.

Examples of such non-regulated, diffuse sources are:

- wood heaters
- small engines (generators, lawnmowers, etc.)
- surface finishing (spray painters, etc.)
- commercial and domestic fuel use for heating, hot water and cooking.
- other activities that generate particles (e.g. construction, demolition, soil transport)

As well as these sources, bushfires, planned burns and dust storms can also result in very high levels of particulate air pollution. The frequency of these events in coming decades may be influenced by climate change. Understanding these trends will require advanced modelling as well as rigorous monitoring over long time scales.

4.5.4 The National Plan for Clean Air

The importance of air quality is recognised at a federal level and in 2011 COAG identified air pollution as a 'Priority Issue of National Significance'. As a result, the COAG Standing Council on Environment and Water has been tasked with developing a National Plan on Clean Air[316] by the end of 2014, with the first stage focusing on particle emissions.

The purpose of a national plan is to:

- coordinate Commonwealth, state and territory actions
- integrate air quality standard setting with actions to reduce pollution and exposure to pollution
- modernise standards and respond to the latest science
- prioritise measures that achieve a net benefit to the community, and
- respond to emerging trends.

In its first stage, the national plan will involve development of an exposure reduction framework for particles, and will consider potential cost-effective actions for particle reduction measures. This includes assessing options such as emission standards for specified products sold across jurisdictions for some currently non-regulated, diffuse sources. These are:

- wood heaters
- non-road spark ignition engines (e.g. garden equipment – see boxed text)
- non-road diesel engines (e.g. generators and outboard motors).

While the particle emission reduction projects are at varying stages of development, similar assessment processes are being applied for all three projects and all have included the drafting of regulation impact statements (RIS).[317]

The above devices have been identified by COAG as the emissions sources of greatest concern. There has not, as yet, been a comprehensive review of emissions from non-regulated, distributed sources on air quality and human health in Australia.

Unregulated emissions from garden equipment

The United States regulates exhaust emissions from all non-road engines, including petrol and diesel lawnmowers. There are no Australian regulations that limit air emissions from non-road engines, although the use of tools such as lawnmowers, leaf blowers and generators is likely to increase in future in line with population growth.

RECOMMENDATION 28

It is recommended that the Victorian Government fund multi-sectoral research into the potential impacts of emissions from emerging sources and review the current status and projected change of the emissions.

ATTRIBUTES

The proposed research would:

- **include quantification of concentrations, population exposure and health risk**
- **include the study of direct and indirect climate change impacts**
- **include quantification of air pollutant exposure and consequent health effects**
- **include social and activity surveys and local monitoring studies to verify predicted impacts**
- **identify emerging issues not covered by the National Plan for Clean Air.**

RECOMMENDATION 29

It is recommended that the Victoria Government address emissions standards to reduce exposure to particles and ozone.

ATTRIBUTES

Standards for exposure to particles and ozone (via the EPA) would be addressed by:

- **tighter PM_{10} standards for wood, wood fuel standards (e.g. moisture content is regulated in Western Australia[318])**
- **improved regulations for emission of ozone forming compounds from surface coatings and non-road engines**
- **ozone being brought into alignment with the development of the National Plan for Clean Air.**

The introduction of new regulatory measures would be supported by:

- **education and incentives specifically for small business which might be impacted by any regulatory changes**
- **clear guidelines for communication and clarification of enforcement responsibilities between relevant agencies (such as EPA and local councils).**

GOAL **FIVE** UNDERSTANDING THE ENVIRONMENT

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GOAL FIVE UNDERSTANDING THE ENVIRONMENT

5.1 Monitoring and Data Collection

Proposition

Many of the recommendations in the 2008 State of the Environment Report in the Land and Biodiversity chapter related to the need for better monitoring (see for example LB1.7, LB2.8, LB3.3, LB3.6 and LB4.3).

Furthermore, Part A of this document illustrates that there is significant opportunities for improvement in monitoring. In some instances the methodologies for monitoring and reporting have changed, creating problems in comparing indicators over time.

It is imperative we review the state of environmental monitoring in Victoria and identify key gaps and priorities for funding.

It is also important that there be some formal recognition of the role of citizen science and the invaluable work the community does.

Mechanisms need to be established for guiding future monitoring and it is important that this is done on the basis of management targets (for example, the benchmark targets for the Index of Stream Condition, due to be established in 2018). These targets need to be established at state level by the government. Furthermore, we require formalisation of the following:

- agreed standards and protocols
- centralised accreditation for reporting, consistent with existing national and international programs.

Context

In a seminal article in 2007, multiple authors asked: – 'Who needs environmental monitoring?'[1]

The answer was: '... monitoring should be considered a **fundamental** component of environmental policy' (emphasis added).

This view has been reiterated by policy advisers, biophysical and social scientists, and community commentators over many years.

Monitoring is fundamental to understanding environmental health and the state of ecosystems and therefore it is pivotal in understanding the benefits of ecosystem services. It is also crucial in determining the impact of human activities on the environment.[2 – 23]

5.1.1 The importance of monitoring

Planning forwards[24] is fundamental to environmental management – however, looking backwards informs that process. Strong standards and protocols – and adequate resource allocation – for data collection provides the evidence base for review of our intervention and management of Victoria's natural capital.

Appropriate environmental monitoring is an essential component of adaptive management. In this process, management actions are cyclically evaluated and adjusted based on progress towards clearly defined targets. This approach, which is being increasingly adopted by natural resource managers (for example, by Parks Victoria[25] and nationally for wetland habitats),[26] requires indicators that are appropriately chosen and properly monitored to demonstrate progress – or otherwise – towards desired environmental outcomes.

Monitoring and the collection of data enables environmental practitioners to:

- address barriers to change and good management
- undertake knowledge gap analysis
- support technology transfer and scientific and technological cooperation
- develop and review targets
- update biodiversity strategies, action plans and indicators.

Internationally, at the *2012 Conference of Parties* (COP 11) to the *Convention on Biological Diversity* (which Australia has ratified) delegates reiterated the imperative of monitoring.[27]

5.1.2 Indictor formalisation and continuity

To ensure the importance of ongoing monitoring is elevated and that data collection is supported appropriately, the standards and protocols for monitoring need to be formalised to the extent that this is possible.

Continuity of indicator selection and funding of ongoing monitoring is fundamentally important. Data sets are of limited use if they lack continuity. Discontinuity in respect of monitoring and the production of data sets represents a waste of often limited resources. For this reason alone we need to be organised in our selection of indictors and consistent in our scrutiny of them.

Having made those observations, it is important to observe that a great deal of environmental monitoring work is being undertaken. High-quality environmental data is essential to monitor long-term changes in ecosystem function and quantify the effects of management decisions and environmental degradation on the provision of essential ecosystem services.[28]

We require monitoring which:

- is historical and long-term
- operates across wide scales
- is locally specific, addressing variability
- provides an understanding of tipping points and the consequence of crossing them
- reflects upon the effectiveness and impacts of the environmental management which is actually being undertaken
- is guided by long-term goals for environmental outcomes.

5.1.3 Increased support for environmental monitoring programs is necessary

Effective environmental management needs to be supported by adequate monitoring of the state of ecosystems that can demonstrate progress towards clearly defined environmental objectives and targets that guide and inform adaptive management decisions. Numerous independent assessments have concluded that such monitoring has not been achieved in Victoria. It is critical that baseline monitoring is improved and a stable, long-term source of funding to support this monitoring is ensured.

Commensurate to this, it will be critical to review and consolidate current and historical environmental knowledge. This would include an analysis of crucial areas that have been under-represented in monitoring (e.g. biodiversity). Where practical, this would be entered into modern databases to allow inclusion in future analyses.

5.1.4 Monitoring and reporting in Australia

A range of large-scale data collection is undertaken in Australia. Nationally the Australian Bureau of Statistics (ABS) and the Bureau of Meteorology (BoM) report on environmental data. The ABS is constantly updating its data sets and publishing information online for the public.[29] Biophysical data and satellite imagery is provided by Geoscience Australia (GA).[30]

5.1.4.1 ABS monitoring

Nationally, the ABS collects data on a number of environmental themes:

- Climate and natural resources
- Energy
- Environmental management
- Greenhouse gas emissions
- Land use and management
- Sustainability
- Waste.

The most recent ABS publication on environmental trends (released in 2010) reported on:

- population and urban issues
- human activities (including trends on energy and waste)
- atmosphere
- water (including trends on consumption, conservation and management)
- marine and coastal waters
- landscape (including trends on land, forests and biodiversity).[31]

As well as biophysical data, in 2012, the ABS reported on Australian's environmental attitudes, noting a drop in concern about the environment – whereas eight out of 10 people were not confident about environmental condition in the previous survey, the 2012 survey suggested only six out of 10 people were so concerned.[32]

See below for a discussion of the ABS's experimental land account for Victoria.

5.1.4.2 Bureau of Meteorology (BoM)

The BoM provides public access to a range of data products and services including:

- Weather forecasts, including information designed for use by farmers
- Climate and weather observation data
- Marine data (e.g. tides, currents and sea temperature)
- Ultraviolet levels

The BoM is also a lead agency in the Nation Plan for Environmental Information, which brings together data from multiple sources (see further discussion in 5.2).

5.1.4.3 Geoscience Australia (GA)

GA is principally concerned with large-scale earth observation and satellite imagery.

Publically available environmental data sets include:

- earth observation and satellite imagery (including aerial photography)
- groundwater
- environmental hazards – sentinel bushfire mapping application, Australian earthquakes database
- marine and coastal – Australian Marine Spatial Information System (AMSIS) and Australian Maritime Boundaries (AMB).

The national *State of the Environment Report, 2011*[33] used the data from the above agencies extensively to report on environmental trends. The most recent NSW,[34] ACT[35] and South Australia[36] state of the environment reports also rely upon this data, as does Victoria.

5.1.5 Monitoring and reporting in Victoria

In addition to the national monitoring initiatives there are a number of state-based programs.

In Victoria, monitoring of natural resources status and function is primarily undertaken by DEPI, which operates a range of programs. Important, collaborative and stand-alone contributions are made by the EPA, Melbourne Water and CMAs.

Part A provides a comprehensive analysis of environmental data in Victoria and its analysis. The following information is only provided as an overview to contextualise the accompanying recommendations.

Statewide Natural Resource Management (NRM) Monitoring and Reporting Program[37]

DEPI has committed to a more formal and uniform system of NRM monitoring, reporting and investment.

CMAs, Regional Coastal Boards[38, 39, 40] and Parks Victoria[41] are the key organisations to implement improvement and create effective protocols and standards to generate clearer and more consistent statewide monitoring and reporting on the management and condition of our natural environment.

This project is using a range of tools, including aerial photography – available online[42] – and remote sensing information.

Victorian Forest Monitoring Program[43]

Public forests and parks are also subject to monitoring by DEPI. Collectively these programs are described as the Victorian Forest Monitoring Program (VFMP).

VFMP is Australia's most comprehensive statewide public forest monitoring system. The data and information generated through VFMP can be used to improve land management policy and decision making. The data can also support state and national reporting of sustainable forest management through the Victorian State of the Forests Report. Data can also be accessed online. This data could be among the data sets reflected in the proposed Environmental Data Portal.

River health[44]

A range of river health monitoring and surface-water monitoring programs provide baseline river health data. This work includes the River Health Report Card[45] and the Index of Stream Condition.[46] However, this information is updated at relatively long intervals (Index of Stream Condition has been released in 1999, 2004 and 2013; River Health Report Card was published in 2009).

The government has made a commitment to streamline the index development process by using remote sensing and aerial photography and improve on the coverage of the last index, which only sampled a number of actual sites along the 26,000 km of stream frontages across the state.

Groundwater

Thirty-four Groundwater Management Areas and 19 Water Supply Protection Areas are monitored across the state quarterly via the State Observation Bore Network.[47] This Observation Network is being refurbished.[48] This work may go some way to assisting us to answer the question raised by VAGO in 2010 when it reported that DEPI 'did not know whether the use of groundwater in Victoria was sustainable'.[49]

The first regional groundwater report ever compiled – *South West Victoria Groundwater Atlas*[50] – attests to the:

- dearth of collated information about this issue
- extent of the available uncollated information
- range of parties holding information
- need for monitoring and reporting to enable understanding of this utterly essential ecosystem service and environmental resource.

It was remarked in the atlas:

> **'... groundwater is a valuable resource but its great potential is hidden.**
>
> **It is complex, often described in unfamiliar technical language and hard to visualise. This atlas provides information in words and graphics that readers can understand – to help them develop their knowledge of this vital water resource. The atlas describes the groundwater resources in South West Victoria: how much there is, where it is, how deep and thick it is, what it could be used for and how it is used now.'**

Water resources

The *Monthly Water Report*[51] is published online providing an updated summary of the current state of Victoria's water resources.

The *Victorian Water Accounts*[52] provides an annual overview of water availability and use across Victoria in terms of bulk supply, including a detailed water account for each of Victoria's 29 river basins.

5.1.5.6 Victorian Catchment Condition Report

The Victorian Catchment Management Council (VCMC) compiles data collected by DEPI and the catchment management authorities (CMAs) in the Victorian Catchment Condition and Management Report, published every five years.[53] This monitoring also attempts to identify the effects of management interventions.

The 2012 report includes recommendations that:

- robust processes be established to determine the condition of Victoria's land and water resources and the effectiveness of land-protection measures
- this crucial function be assigned to an independent and appropriately resourced entity, with the task of reporting annually on progress towards the implementation of these processes, and every six years on overall condition
- a state *Integrated Catchment Management Plan* be developed to define, explicitly, the quality of the land and water resources that will maintain and enhance long-term land productivity while also conserving the environment.

The Commissioner for Environmental Sustainability endorses the recommendations of the Victorian Catchment Management Council in its Catchment Condition and Management Report of 2012 and calls for the Victorian Government to adopt them in their entirety.

Environment Protection Authority, Victoria

EPA Victoria measures a range of environment indicators as defined in State Environment Protection Policies (SEPPs).[54] This may include where pollution affects (i) human health and wellbeing, (ii) ecosystem health or (iii) other beneficial uses of the environment.[55]

The EPA's powers, duties and functions outlined in the *Environment Protection Act 1970* reflect the extent of the organisation's work (see section 13 (e), (i) and (l)).

The EPA routinely makes data available on its website on air and water quality.[56]

Monitoring Victoria's air quality

As at 2013, EPA Victoria monitors air quality at 15 sites across Victoria, with:

- 13 in metropolitan Melbourne (11 long-term and 2 short-term)
- 1 in Geelong
- 1 in the Latrobe Valley.

The EPA also receives data from industry operated stations such as Alcoa's site at Point Henry.

The EPA prepares an *Ambient Air Quality Annual Report*[57] based on this monitoring that assesses compliance with the air quality policy outlined in the state Environment Protection Policy (Ambient Air Quality). Additional air quality reports are made available on the EPA's website.[58]

Monitoring Port Phillip Bay[59] and water and beach quality.

The Beach Report program provides information on water quality at 36 beaches in Port Phillip Bay in summer.

A Cleaner Yarra River and Port Phillip Bay – A plan of Action.[60]

Yarra Watch[61] is a project funded and managed by Melbourne Water which is implemented in partnership with the EPA and DEPI. The EPA is the custodian of the data.

RECOMMENDATION 30

It is recommended that the Victorian Government audit the scope, quality and accessibility of environmental monitoring in Victoria.

ATTRIBUTES

This work could be undertaken by an existing monitoring agency such as VAGO.

The role of this audit would be to define standards and terms that can be used by multiple agencies to produce datasets that can be meaningfully compared.

It can also provide guidance to government on a range of issues including:

- **accreditation of monitoring methods**
- **allocation of funding**
- **developing programs for public access to data**
- **setting management targets**
- **enforcement processes.**

5.1.6 Problems with monitoring: gaps

In recent years there have been a number of investigations by the Victorian Auditor-General's Office (VAGO) into the effectiveness of state environmental management agencies. These have covered topics such as the administration of the *Flora and Fauna Guarantee Act 1988*,[62] groundwater management,[49] (also see above in groundwater discussion) soil health[63] and marine protected areas.[64]

Typically, these audits have concluded that even when robust management frameworks exist they have been undermined by inadequate data collection. Assessing the success, or otherwise, of management interventions becomes difficult, if not impossible, in these circumstances. This results in a lack of accountability – a fundamental governance issue.

Predominant reasons for gaps in monitoring are that:

- the indicator has never been monitored
- monitoring was undertaken but has ceased
- limited research has been conducted.

5.1.6.1 The indicator has never been monitored

There are numerous indicators of both biophysical trends and environmental impacts on people that are not – and have never been – monitored. The reasons for this vary. In some cases, the indicator in question is not broadly relevant. Often, however, the failure to monitor an important indicator hinges on the absence of a consistent method of data collection. This is particularly so in the case of social indicators, such as adaptive capacity.

5.1.6.2 Monitoring was undertaken but has ceased

There is a set of indicators where data can be obtained but the data will not reflect changes in recent times. The relevance of biodiversity and ecosystem structure and function indicators are adversely effected by this sort of hiatus. The benefits of long-term continuous monitoring have been clearly demonstrated in the case of the Leadbeater's possum (see Case Study).

However, collecting information on biodiversity indicators is often labour-intensive and time consuming – discontinuing monitoring programs diminishes and adversely affects our ability to recognise long-term changes in the environment.

The cessation of indicator monitoring in biodiversity is also deeply frustrating to the public involved in such monitoring and frequently keenly interested in the outcomes and tracking changes over time. We had this reported to us across Victoria at the Winton Wetlands and by members of Project Platypus in western Victoria.[65] In particular, people commented on the frustration associated with 'episodic funding' and the 'disappointment which attended the commencement and then cessation of pilot programs'.[66]

Kangaroos

Case Study: The Case for Ongoing Monitoring of the Leadbeater's Possum

In the mid-late 1990s, several records of the possum denning in Snow Gum indicated that Lake Mountain might support a significant population of this endangered species. In 2003, 30 nest boxes were installed to survey the distribution and abundance of Leadbeater's possum across the breadth of the Lake Mountain plateau. The results were particularly encouraging, with 28 of the 30 nest boxes colonised by the species. It confirmed that the Lake Mountain plateau supported a substantial population containing 200–300 individuals, one of the largest documented strongholds of the species.

The Lake Mountain plateau was burnt severely on Black Saturday (7 February 2009), with 95% of the sub-alpine woodland burnt at high severity. Surveys were expanded in an attempt to locate sites where Leadbeater's possums had survived the fires. The results were devastating.

Just two possum families, together containing just five individuals, survived on the plateau in one partially burnt gully system. Supplementary feeding trials were initiated by Parks Victoria, the Friends of Leadbeater's possum and Healesville Sanctuary during winter 2009 to assist the survival of these possums in fire-damaged habitat. The supplementary feeding program was maintained during the winters of 2010 and 2011. Early in 2012, following the disappearance of several of the surviving possums, the decision was made to bring the last three possums on the plateau into captivity at Healesville Sanctuary to ensure their welfare. The results from Lake Mountain highlight how vulnerable the Leadbeater's possum is to fire and habitat loss, and the major impact that catastrophic events can have on populations of threatened species.

In April 2013, four years after the devastating impacts of the 2009 Black Saturday fire, two Leadbeater's possum families, each containing two individuals, have returned to the plateau. It is anticipated that it will take at least 15–20 years for the recovery of foraging conditions for the possum at Lake Mountain, a necessary precursor for Leadbeater's possum population recovery to occur.

5.1.6.3 Limited research has been conducted

In these circumstances data or case studies may be available for individual sites but no systematic statewide monitoring is available to identify long-term trends. This is not necessarily problematic, as some indicators that have a high relevance to communities at a local scale will not be useful at the statewide level. However, limiting indicator consideration to specific carefully circumscribed sites is potentially problematic as it produces a narrow reporting scope.

This also includes indicators that combine data from multiple sources to provide high-level summaries of our environmental performance. The ecological footprint of Victoria, commissioned by the EPA and presented in the State of Environment 2008 provides a good example of this.

Such indices, produced for particular research projects or individual reports, provide valuable snapshots of the current state of particular impacts or assets. If they are not systematically repeated, however, they have limited use in demonstrating progress towards long-term environmental goals and guiding management decisions and policy formation.

5.1.6.4 Critical authoritative commentary about monitoring shortcomings

The implications of these gaps are the subject of commentary in the 2012 Victorian Catchment Management Council *Catchment Condition and Management Report*.[53] The council observed that its assessment was 'incomplete' due to a lack of clarity about targets and measurement processes (lack of consistency, fragmentation) for the natural environment.

This absence has contributed to a situation where data regarding the Victorian catchments of 2011–12 cannot usefully be contrasted with the 2007 data. This in turn limits the ability of the VCMC to identify changes in the state of the catchments over time and constricts the council's capacity to provide guidance for management strategies.

5.1.7 Frameworks for environmental monitoring and accounting

The need for an integrated approach to environmental monitoring has been recognised nationally and internationally. This has led to the development of strategies that seek to provide framework for multiple forms of environmental information and allow managing agencies to compile accounts of changing states.

There are attributes consistent across the strategies, each:

- works across a range of sectors
- involves the development of cross-jurisdictional partnerships
- seeks to provide consistent and comparable metrics for ecosystem condition.

5.1.7.1 System of Economic and Environmental Accounting: United Nations Environment Program[67]

As suggested above, if and when monitoring frameworks are maintained over decades they will provide invaluable long-term information on management intervention and changes in ecosystem function and ecological processes.

However, to be truly effective, monitoring programs need to be properly integrated to provide data that is comparable over both time and space. Because of the diverse range of collection agencies, it is critical that special attention is paid to standardising methods and metrics.

The pressing need for an aligned and integrated monitoring framework for collecting environmental data has been recognised as critical in improving our environmental outcomes. At a national level, steps have been taken to establish common standards beyond jurisdictional boundaries.

The *System of Economic and Environmental Accounting* (SEEA) is an international experiment that is being trialled in Australia by the ABS and BoM. SEEA has developed a set of metrics that can be used:

- to monitor natural resource assets in Australia
- to compare areas within the country and against overseas territories.

Initially, this system concentrates on monitoring the economic value of tradable assets such as timber and water, but the next stage of the project will expand the system to include the economic and non-economic value of ecosystem services.

SEEA has been used by the ABS as the basis for producing experimental accounts that report on:

- energy
- waste
- water
- land (see 5.1.7.2 for further discussion).

It is not proposed that the ABS manage any monitoring directly. This work provides a common framework for agencies. The ambition is for this system to form the basis for an internationally agreed set of environmental accounting metrics. This work is being supported by the Wentworth Group of Concerned Scientists, CMAs in Australia, and by the TEEB internationally.[68]

Consistent standards and metrics will arguably promote the credible and authoritative combination of data sets and provide for comparative study with comparatively less effort than is currently the case. This would greatly enhance the accessibility of information across geographies, sectors and with the general public and interested stakeholders (see 5.2 Public Access to Data).

For example, Waste Accounts in 2012 detailed an increase in the national population of 22% between 1997 and 2012, an increase in waste from all sources (including, for instance, construction and residential facilities) of 145%, and observed that nearly 50% of all waste from households was organic.[69]

This data is of enormous importance – continuity in collecting provides us with indications of worsening problems and the standardisation of the indicators used means the data is reliable and that conclusions can be formed as a result.

Environmental monitoring that achieves coverage across the state will involve multiple collectors, collators and custodians even when managed by central environmental agencies such as DEPI.

Consistent and coherent standards, a mutual language and normative measurement mechanisms supported by robust quality assurance by all monitoring agencies will be necessary. Only by achieving some level of mutuality will data sets be comparable in a straightforward and transparent manner across organisational cultures and other scales and settings. A super structure such as that provided by SEEA will assist this process immeasurably.

5.1.7.2 Experimental Land Accounts (ABS and DEPI)[70]

Scope exists for innovative partnerships to develop new monitoring regimes and reporting partnerships. One recent study from the ABS and the Department of Environment and Primary Industries (DEPI) involved generating new and experimental land accounts to assist in the valuation of ecosystem services.

The first of these experimental land accounts for Victoria – assessing the value of land for 10 NRM regions – was released in 2012. Key findings included:

- The total rateable value of land in Victoria covering approximately 23 million hectares as at June 2012 was $1,047 billion. While the area of land is shared relatively evenly between the 10 CMAs in Victoria – Port Phillip and Westernport CMA dominate land value contributing a total of $874 billion (83%).
- Land classified as 'residential' represents $878 billion or 83% of Victoria's total rateable value but only 5% of the state's total land mass.
- More than half of all land in Victoria is classified 'primary production' (56%).
- The CMA with the highest value of land used for primary production is Port Phillip and Westernport ($17 billion) despite representing the second smallest area of land used for primary production in the state.
- The total rateable value of land used for livestock grazing on irrigated pasture in Victoria is $626 million.

Land, the soil from which produces the food we eat, and the water systems that impact it, is of considerable financial value. Understanding this assists in a whole range of other standard accounting exercises. Internationally, *The Economics of Ecosystems and Biodiversity* (TEEB), is exploring the value of ecosystem services for a range of reasons and in a number of settings and across sectors.[71]

5.1.7.3 Regional Environmental Accounts trial led by the Wentworth Group of Concerned Scientists[72]

The Wentworth Group of Concerned Scientists has developed a framework that could apply SEEA at a regional level, thereby informing national environmental accounts; initially in *Accounting for Nature* (2008) and subsequently refined in *Accounting Metrics for Building Regionally Based National Environmental Accounts* (2009).[73, 74]

This work aims to create a 'common currency' for determining the value of environmental assets while maintaining monitoring that is specific to, and relevant at, the regional scale. This is a means of standardising measurement of environmental assets, both in terms of rate of change and benchmark states. This model will allow:

- the state of comparable assets to be compared across Australia
- the rate of change to be compared between asset classes
- regional reporting to be combined to form a consistent national account.

This system has been trialled nationally across 10 CMAs. Victoria is represented by Corangamite[75] and North Central[76] CMAs.

In a paper to the UN Statistics Division in 2012, Professor Peter Cosier observed of these trials that they have two tests:

'1. Is it possible to construct asset condition accounts using a common unit of measure?

2. Is it feasible to do so?

The Australian trials are built on five design principles:

1. **Environmental accounts should enable people to understand and track the status and direction of changes to their environmental assets.**
2. **Indicators may vary from region to region according to agreed standards.**
3. **Existing data sets should be used wherever possible.**
4. **Measurements of condition are based on specified reference condition benchmarks against which change in indicators can be measured and compared.**
5. **Measurements to be generated at a regional scale should be capable of aggregation to the national scale.'**[77]

Final outcomes of this trial will be reported by the Wentworth Group in late 2013. When this occurs, Victoria will be well placed to capitalise on the potential to improve examination of environmental outcomes in a formal and systematic way as the state has played an important role in developing and trialling the model.

5.1.7.4 National Plan for Environmental Information (NPEI)[78]

The NPEI is a framework, established in 2010, and led jointly led the Bureau of Meteorology and Department of Sustainability, Environment, Water, Population and Communities. The ultimate aim of the project is to create a network to support the collection, access, and reuse of environmental information. The infrastructure will be designed to enable environmental information to be widely provided and shared by working alongside existing data management systems.

This framework will be closely linked to SEEA and there is an opportunity for Victorian agencies to make major contributions to its development. These contributions will build on initial work carried out with the Regional Environmental Accounts trial (see above) and experimental land accounts (see below) that have been produced in Victoria.

Other accounting systems (and the agencies that administrate them) that will inform the creation of an integrated national environmental accounting framework include:

Water Account Australia (ABS)[79]

This is based on the SEEA framework and reports physical and monetary uses of water. These describe who uses water, how much, and for what purpose.

National Water Account (BoM)[80]

This is complementary to the Water Account Australia and aims to report on the total national water resource. It reports on the volume of water assets and liabilities (e.g. water allocations and rainfall) and actual water flows (e.g. the delivery of water against water allocation and rainfall).

National Greenhouse gas inventory (DCCEE)[81]

Australian greenhouse gas emissions are compiled to meet reporting commitments under the United Nations Framework Convention on Climate Change.

5.1.7.5 National Data Grid[82]

Separate to establishing management outcomes and environmental indicators, monitoring needs to be supported by data frameworks that allow the flexible analyses of data from numerous agencies.

To this end, the National Data Grid, developed by the CRC for Spatial Information, is currently being developed to provide a common technical infrastructure which is based on a set of standard grids and projections that allows spatial data from multiple sources to be combined, analysed in decision making systems and also used for modelling.

Once established, this platform will be able to support spatial analyses by land management professionals – even if they have limited technical knowledge.

Spatial decision making will arguably be capable of being built into decision making processes as a result of this technology being adopted.

5.1.7.6 Monitoring, Evaluation, Reporting and Improvement (MERI) Framework

The Commonwealth, in recognition of the importance of high-quality monitoring in natural resource management has produced the Monitoring, Evaluation, Reporting and Improvement (MERI) Framework.[83] The purpose of the MERI framework is to provide a generic framework for monitoring, evaluating, reporting on and improving Australia's management of 'key' natural assets.[84]

The MERI framework is being applied by the Commonwealth Environmental Water Holder (CEHW)[85] to the Murray–Darling Basin (MDB). It is highly relevant to Victoria.

The application of MERI in this context has the long-term goal of protecting and restoring the environmental assets of the MDB.

As well as establishing the monitoring required to ensure operational compliance, MERI will establish monitoring to report on immediate and long-term ecosystem responses to management. This is a very important development in river system management at the national scale.

Targeted monitoring to inform intervention and decision making will be prioritised to address the need to understand short-term outcomes and demonstrate the effectiveness of water deliveries. In turn, this will inform annual planning and guide and enhance long-term intensive monitoring.

MERI will assess basin-wide, long-term changes in baseline conditions in response to environmental monitoring. This will be achieved through:

- low-intensity, broad-scale monitoring of key ecological indicators at randomly selected sites that will be used to validate more intensive monitoring
- monitoring of larger-scale responses from environmental watering including wide-ranging, longitudinal and lateral biodiversity-connectivity studies and the wide-ranging vegetative-response monitoring of mobile species such as birds.

RECOMMENDATION 31

It is recommended that the Victorian Government establish a systematic, environmental data collection plan.

ATTRIBUTES

Elements of a data collection plan would include:

- **clearly defined outcomes and targets**
- **a range of core indicators that are:**
  - **examined consistently**
  - **accompanied by a public explanation if discontinued**
  - **regularly reported against indicator type, and any failure, or delay in reporting, to be publicly explained**
- **a range of data sources at multiple spatial scales**
- **consistent protocols**
- **maintained and shared standards**
- **quality assurance procedures**
- **a register of monitoring programs past and present.**

Hindmarsh Landcare, 2010

5.1.8 Broad-scale monitoring systems

Monitoring programs need to be achievable within resource constraints. This means they also require methods that deliver, within the available funding, information that is scientifically valid while still covering the greatest possible area. One method of achieving this is to create a broad network of coarse-scale, low-cost monitoring that is refined and validated at selected locations by higher-quality instrumentation (for a detailed description see BLANkET Case Study).

Gaps in spatial temporal resolution in data sets can also be improved by adopting autonomous instrumentation and incorporating remote sensed imagery and data assimilation models into the monitoring toolbox. The Integrated Marine Observing System provides a good example of how information from multiple sources can be integrated (see Case Study).

Case Study: Broad-Scale Monitoring Systems

The Base Line Air Network of EPA Tasmania (BLANkET)

This is a network of 19 small air quality stations reporting near real-time indicative particle concentration data (i.e. from smoke or dust) to the EPA division's public web pages. The stations will also collect and report meteorological data (air temperature, wind speed, etc.).

This network uses low-cost, low-maintenance instruments to provide indicative air quality data. This is regularly cross-checked against reference instruments. This allows a wider coverage with many more instruments able to be deployed.[86]

Integrated Marine Observing System (IMOS)

IMOS is designed to be a fully integrated national array of observing equipment to monitor the open oceans and coastal marine environment around Australia, covering physical, chemical and biological variables. All IMOS data is freely and openly available through the IMOS Ocean portal for the benefit of Australian marine and climate science as a whole.

IMOS observations are guided by societal needs for improved ocean information, and focused through science planning undertaken collaboratively across the Australian marine and climate science community.

The system has been operational since 2006 and is in a mature phase. It promotes standardised infrastructure that is strategically placed in Australia's coastal and offshore waters. Deakin University and CSIRO are currently in discussion for the development of a Bass Strait node for the next iteration of IMOS. To date, all other states have engaged with, and benefited from, this initiative.

The United States is running a program called BISON (Biodiversity Serving Our Nation) coordinated by the US Geological Survey, which also seeks to cover multiple focal points.[66, 87]

5.1.9 The role of citizen science[88, 89]

There is a critical role for citizen science in monitoring, information dissemination and gathering, and knowledge creation. While formal, organised and institutionally embedded monitoring is fundamental, valuable supplementary and foundational information can be gathered using citizen science programs.[90]

There are many great examples of citizen science that were brought to our attention during public consultation across the state. One example is the Yarra Riverkeeper Association.[91] The association also works on monitoring the Yarra's health, advocating for its care and providing input into relevant inquiries.

The association was established in 2004 and is a not-for-profit community organisation affiliated with international organisations that also care for waterways. This association's activities are a great example of citizen involvement in environmental issues.

Waterway monitoring has also provided a good model for community data collection in the Waterwatch program (see above and Case Study below). More broadly, waterway management is also a matter of concern for landholders when they consider the value of stream frontages. Organisations such as Landcare have plainly encouraged better practice and community monitoring of waterways.[92, 93, 94]

We have shown the real benefits of highly localised community monitoring in Foundation Paper One, *Climate Change Victoria: The Science, Our People and Our State of Play*, where we cited the work of the *Friends of Beware Reef*.[95, 96]

The work done by the public in bird audits both here – for example, the Bird Atlas Data collected by volunteers and coordinated by BirdLife Australia program Birdata[97] – and internationally[98] is indicative of the capacity of the public to provide meaningful, continuous, cost-effective and efficient local assistance in this work.

We have reported the work of the community at Kings Billabong, south of Mildura, where George Kerridge, a retired scientist, and a band of active and committed local people have been studying bird populations for years. Just before the Millennium Drought broke, this group:

> **'... recorded 136 species and 6,577 individual birds within 40 km of Mildura [and after the drought broke in December 2010] 173 species and 19,293 individual birds [concluding that] adding water [to the system] does make a difference ...'[65, 99]**

It was the efforts of local people that resulted in the establishment of bird tourism along stock routes in NSW, giving effect to environmental and economic co-benefits by promoting local economies and conservation at the same time.[100, 101, 102]

Members of the public – sometimes guided by professionals, sometimes receiving formal training, but often simply engaging in participant observation – monitor environments and consistently collect large amounts of environmental data over wide geographical ranges.

In one research study of community forestry monitoring collaborations it was concluded that:

> **'... collaborative monitoring can lead to shared ecological understanding among diverse participants, build trust internally and credibility externally, foster social learning and community-building, and advance adaptive management.'[103]**

Sealake charrette VCCAR and CfES

Although concerns have been expressed about the quality of data gathered in this way, and there are issues of custodianship, much will depend on how we define success,[104] and the electronic age increases the possibilities of collaborations and partnerships.[105] Citizen science can provide valuable long-term data on environmental issues if programs are designed to be well-integrated into broader monitoring and have the resources to ensure good quality control.

We have given substantial consideration to the formal place for Aboriginal people's concerns about monitoring and their role in this work – native title connections reinforce their long-held cultural connections to waterways.

MLDRIN provides some insights into how this work is done and coordinated through Indigenous organisations, both formal and informal.[106] This work requires formal acknowledgement as an illustration of cultural commitment to – and deriving benefits from – monitoring which reflects community needs. A recent example of this in Parks Victoria's release of Ngootyoong Gunditj Ngootyoong Mara South West: Draft Management Plan, August 2013.[107]

WaterWatch and EstuaryWatch (see notes above about these two programs)

The Waterwatch and EstuaryWatch community monitoring programs are key components to the Victorian approach for monitoring waterway health. These programs are part of the broader monitoring framework and provide credible data to assist in waterway management.

WaterWatch and EstuaryWatch act as trusted conduits of information to waterway frontage landholders. In these programs it has been shown that community involvement in resource monitoring has multiple benefits:

- enhancing community knowledge regarding waterway health and related issues
- increasing the spatial coverage and sampling frequency of formal data collection as the data is generally collected outside the Victorian Water Quality Monitoring Network (VWQMN)[108, 109]
- providing an 'early warning system' for impacts as a direct function of frequent surveillance and local knowledge of local waterways.

5.2 Public Access to Data

Proposition

The Victorian public has an active interest in data that:

- reflect current issues
- government collects and uses in the formation of public policy
- is used to inform decision making generally.

Metropolitan and regional views were canvassed by the DBI in 2007 and again in 2011.[110] The survey concluded that Victorians' public interest in accessing scientific information had increased from 50% to 60%, and that seven out of 10 people said they made a science information search at least once a week.

Information on environmental issues forms a key part of this interest. If communities are to be able to make informed decisions about their future, they need to have access to up-to-date research, high-quality data products and the means to analyse that data according to local interests.

Educators seek information to fulfil the requirements of various school and post-school education curriculums. Community members wishing to plan for personal environmental outcomes desire this data to assist them in making choices about housing and other infrastructure proposals – particularly in bushfire and flood-prone areas. Those interested in biodiversity, pollution, health, and water issues wish to explore the current state of knowledge.

Context

The advances of the information age will make us increasingly subject to 'data deluge'. Although this will create its own difficulties regarding quality control and equity, it also promotes 'unprecedented data access [that] will enable world class research ... focussed towards addressing the key policy issues [of the future].'[111]

Internationally, instruments such as the 2001 Aarhus Convention[112] and the 2011 Draft Chisinau Declaration[113] stipulate the international commitment to provision of information to the public and the public's right to both access and involvement in decision making processes.

Institutions as diverse as the World Bank, Canadian International Development Agency, and USAID support the widely available and comprehensible provision of data sets. Further, as learning is a two-way process – both bottom up and top down.

5.2.1 Environmental data in the information age

It is apparent that access to information is necessary to ensure meaningful contributions to change our management of environmental issues.[114]

Science as an Open Enterprise, a 2012 report from the Royal Society,[115] provides case studies of good practice and the range of possibilities in broadening the public's access to data and information. The Royal Society suggests:

- better communication with the public and the media is a role for scientists
- common standards are necessary for usability
- publication in useable form should be mandatory
- more experts are needed to manage the growth of data
- new software tools will be necessary.

While scientists and academic institutions have a role in this, it is increasingly apparent that governments do as well. Governments are responsible for publication in useable form and for the continued funding for public accessibility to useable data sets.

5.2.2 Access to current research

The first step in allowing the public to make informed decisions about the future of their communities is to facilitate access to the most up-to-date research and reporting. Some scientific reports will not be appropriate for informing the broad public – due to their dense and technical nature. However, it is critical that the community are the judge of this as open-access publishing models are developed to make environmental and other scientific data collections and analysis easily available to the public and not financially prohibitive.

For example, the UK Government has recently promoted public access by ensuring that all scientific articles that are based on publically funded research are available without subscription costs (see Case Study: Free Public Access to Academic Journals in the UK).[116]

Case Study: Free Public Access to Academic Journals in the UK[117]

The UK Government has introduced a scheme to make publicly funded scientific research immediately available for anyone to read for free by 2014.[116] The UK has adopted the 'gold' model of open access. This model allows journal publishers to charge 'article processing charges' to authors for papers that will be made freely available once published. This approach places the burden of cost on research funding, and early estimates predict that approximately 1% of the £4.6 billion annual research budget will have to be used to pay for open access.

The transition to open access is currently being guided by the UK Open Access Implementation Group, which is comprised of funding bodies, higher education umbrella groups and some publishers who support open access.

This group aims to:

- increase the proportion of UK research output that is available as open access
- ensure that adequate funding is available to support gold-model open access
- and limit the cost of processing charges set by publishers (currently around £2,000 per article).

5.2.3 Data products

Numerous high-quality environmental data sets are already available as downloads. It is significant that most data sets that provide information at a large spatial scale report on biophysical attributes such as land-cover types or weather and climate. Information on biodiversity and ecosystem health is often more nuanced and it is also very labour-intensive to collect. These data sets are less complete over time and it is a much more complex undertaking to make this data meaningful and accurate.

Large-scale earth observation data can be obtained directly from the Geoscience Australia website, even though analysis requires technical expertise and specialist software making the material more useful to researchers than the general public.[118]

By way of contrast – and as an example of public accessibility best practice – the Bureau of Meteorology (BoM) has made high-quality weather and climate data available for free that can be visualised online through its own web interface.[119] Anyone in the community can conduct in-depth interrogation of data to inform local interests.

5.2.4 Government repositories of environmental data in Victoria

In Victoria there has long been a recognition that information provision is fundamental to good governance in organisations. Victoria has embarked upon an effort to be effective in managing data for government, researchers, the general public and business.

It is critical to ensure that data is managed in effective and efficient ways. This will necessitate the establishment of portals and it will require a level of maturity about standardising data sets – an issue which we have struggled with in environmental management, both statewide and nationally, for decades.

This work needs to be informed by a recognition that funding for public data accessibility requires continuity, for when programs such as this are not maintained the initial investment is wasted. The Victorian Water Resources Data Warehouse is an example of a project that started well, but data has not been updated. This, coupled with inconsistent funding and an ageing data infrastructure, have limited its usability, although a planned ‘refresh’ of the site may address some of these issues.

The EPA[120] provides information through its Beach Report, partnership arrangements in Yarra Watch, air quality reports, and specific interest studies – such as the 2007 Noise Survey. These initiatives are also underpinned and guided by monitoring of public awareness of environmental information.

Melbourne Water provides guides for the public on the 8,400 km of waterways in Port Phillip Bay and Western Port. The 'Know Your River' series is an example of accessible and relevant information provision. Melbourne Water also provides data on water storage, a weekly water report, water levels and restrictions. An interactive Water Supply map is also found on the website together with water education materials.[121]

Engagement with, and access to, water information is also advanced by the Office of Living Victoria's efforts to both involve the public in its decision making processes by calling for public comment on proposed policy matters.

Information on biodiversity issues is sought as actively as information about pollution and water, and efforts are being made to address this interest despite the difficulties inherent in making this often highly complex material both physically accessible and meaningful to the broader public.

5.2.4.1 Victorian Resources Online (VRO)

Despite challenges in collating and presenting biodiversity data, some of the environmental information that is held by DEPI is made available to the public through the coordinated portal VRO.[122] This portal brings together a range of resources such as:

- maps
- digital files
- searchable directories
- management plans
- links to relevant external information including BoM weather and climate data.

Information is grouped by themes and at the catchment scale (enabling regional information compilation). This resource includes the *Biodiversity Interactive Map* (see below), which allows the public to view existing biodiversity information at a fine scale.

Alpine high country

5.2.4.2 DEPI Biodiversity Interactive Map 3.2

The primary focus of the *Biodiversity Interactive Map* is to provide information on Victoria's biodiversity by displaying the latest natural resources data including:

- threatened flora and fauna distribution
- native vegetation extent and quality
- significant wetlands
- critical marine habitat
- landscape disturbances.

Two levels of access are available – General Users and Authenticated Users.

General Users can view publicly available information, including:

- threatened flora and fauna
- vegetation classes
- wetland categories
- marine habitat
- fire history
- timber harvesting
- cadastral boundaries.

They can also access data sets held by:

- CMAs
- Parks Victoria
- Victorian Environmental Assessment Council
- Victorian Government administrative regions.

Authenticated Users have access to data such as:

- restricted flora and fauna
- biosites
- land for wildlife
- historic places
- Catchment Activity Management System (CAMS)
- pest plant and animal infestation sites
- Indigenous cultural heritage places
- the latest as well as historic satellite imagery and aerial photography.

At this time the interactivity function does not extend to comparisons of data sets. For example, it is not possible to overlay biodiversity data with data sets maintained by other agencies, such as climate.

Case Study: Biodiversity Data Centre

One example of the provision of public access to environmental data sets is found in Europe. The European Environment Agency established a Biodiversity Data Centre which provides access to data and information on species, habitat types and sites of interest in Europe and to related products for biodiversity indicators and assessments.

Priority is given to policy-relevant data and information for European and national institutions, professionals, researchers and the public.[123]

RECOMMENDATION 32

It is recommended that the Victorian Government develop and maintain a public-access Environmental Data Portal.

ATTRIBUTES

The portal would be a single point access for environmental information, such as:

- **all state-funded research**
- **common technical standards consistent with national and international practice**
- **the library of publications from government reporting agencies – VEAC, VCMC, VCC and the Commissioner for Environmental Sustainability**
- **all government publications and submissions to policy reviews**
- **links to all relevant authorities and agencies (including parliamentary committees)**
- **all Flora and Fauna Guarantee Act 1988 action statements and the current DEPI Advisory Species List, and**
- **reports on prosecutions conducted pursuant to the powers of the various departments.**

It is advisable that a Users' Guide to the portal is developed to make it accessible to all Victorians regardless of their level of disciplinary engagement with the issues they are examining.

5.2.4.3 DataVic Portal – Victorian Department of Treasury and Finance

In Victoria, the Department of Treasury and Finance (DTF) has led a process to develop better public access to data sets, encouraging the use and reuse by the community and business of data made available through practical tools. This is being achieved through the DataVic portal and guided by the DataVic Access Policy (see below).

The proposed Environmental Data Portal could be aligned – and possibly supported – by the existing DataVic portal, although the two portals are for different purposes and have clear distinctions. For instance, DataVic does not publish reports but makes data available in machine readable (raw) form for further innovation and development.

The DataVic portal provides access to a number of categories of data. Environmental data is one category. While there is a lack of specificity with current data sets, there are in excess of 900 raw data sets attached to the portal which inform each of the categories.

Examples of the environmental data sets available through DataVic include:

- 2001–02 to 2007–08 Local Government Waste and Recycling Service Survey (Sustainability Victoria)
- 2009 Green Light Report (environmental attitudes survey)
- ByteBack Dropoff Points (free computer recycling service – trial only)
- CFA locations
- Detox Your Home disposal points
- Melbourne water use by postcode
- recreational fishing spots
- ResourceSmart retailers (300 retailers' environmental performance and running costs)
- Solar Report (% cost and GHG emissions)
- Streamflow water gauging
- urban water restrictions
- Victorian Energy Efficiency Target (register of participants)
- Victorian Energy Efficiency Target (register of VEET certificates)
- current water storage levels
- spatial data on flood extent.

See www.data.vic.gov.au for a comprehensive list of data available.

Each of these data sets makes provision for public commentary, which will not be posted on the website, providing anonymity for members of the public.

Other data portal categories which have environmental content include Transport and Communication.

Transport currently includes data sets on arterial-road traffic volumes, bicycle volumes, car-pooling data, the government executive fleet, and Parks Victoria's initial strategy for the Metropolitan Trail Network.

DataVic encourages the public to provide views on what other categories should be included for the purposes of data retrieval and display.

On the basis of this brief outline some conclusions can be drawn. The DataVic portal:

- carries the authority of a central agency of government
- is guided by a policy statement which is open to public scrutiny
- represents a commitment to better information transparency
- reflects a commitment to improved science communication
- seeks to engage the public not just with present content but with proposed content which is of importance to the public
- is a good start to the vast task of digitising data for public digestion.

5.2.5 Intellectual property and limits to data access

The DataVic web portal is supported by the DataVic Access Policy Standards and Guidelines.

The explicit purpose of the policy is:

- to enable public access to government data to support research and education, promote innovation, support improvements in productivity and stimulate growth in the Victorian economy
- to enhance sharing of, and access to information-rich resources to support evidence-based decision making in the public sector.

This policy has to be read in conjunction with the Victorian Government Intellectual Property Policy (March 2013), which accepts that the state's intellectual property is a public asset and access rights should be granted 'in a manner that maximises its impact, value, accessibility and benefit consistent with the public interest', ensuring 'the fewest possible restrictions' within legal constraints and avoiding infringing the rights of others.

The policy undertakes that only data that is owned or sufficiently licensed to the Victorian Government will be released. Strictures on release of data through the portal are explained in this way:

> **Not all government data will be suitable for release. Access to data may need to be restricted for reasons of privacy, public safety, security and law enforcement, public health, pre-existing contractual arrangements and compliance with the law.**

In respect of environmental data sets this policy is consistent with international initiatives.

It is clear that a freely available Victorian Environmental Data Portal replete with environmental data would assist in the public contribution to investigation of improved local environmental outcomes and policy options.

The data provided through this proposed portal will be freely available unless there is an express statutory function to commercialise or unless there is explicit Ministerial authorisation.

Further restrictions may also be imposed as a function of a number of legal constraints.

These may include:

- privacy concerns
- public health issues
- public safety
- security and law enforcement issues
- the existence of pre-existing contractual arrangements, including commercial-in-confidence arrangements put in place by government and other parties pertaining to data-collection arrangements.

5.2.6 How will we interrogate data products?

According to the *2011 Strategic Roadmap for Australian Research Infrastructure*:[124]

> **It is recognised that improving the integration of data relating to Australia's terrestrial systems is a big task. The degree of difficulty derives firstly from the complexities of the systems being studied and secondly from the range of researchers, organisations and jurisdictions involved in environmental research and management. Linkages should continue to be strengthened. For instance, collaborative development of integrated observing and information systems for the coastal zone will be important. eResearch infrastructure provides enabling platforms for data-intensive capabilities.**

In spite of continuing issues with consistency and coverage of environmental monitoring, developments in remote sensing, digitisation of data sets, and increasing access to the web and social media have created the potential for locally specific environmental data to be used by the communities.

RECOMMENDATION 33

It is recommended that the Victorian Government establish an interactive, scenario-based state environmental data tool.

ATTRIBUTES

Information for the tool would be generated through the environmental data collection framework.

The tool outputs will be based on needs identified in engagement with regional communities - such as the condition of locally-valued ecosystems.

The tool will:

- **allow access by the public to interrogate state-wide datasets at a local scale for a selected set of scenarios**
- **be aligned with the work and organisational structures which are evolving at the national level, including AURIN, TERN, and the National Data Grid.**

Narrawong Primary School students walking through sand dunes

5.2.7 Existing tools: Victorian Government

Large, high-quality datasets are being assembled, and services that allow these data products to be examined and compared in new ways provide increasingly powerful tools for managers and policy makers. Examples of these efforts can be found in the Victorian Biodiversity Atlas[125] and the Federal Government's Atlas of Living Australia.[126]

The State Government department that manages our ecosystems and natural resources (DEPI) has developed several tools that aid environmental managers in strategic decision making and represent a wealth of environmental data.

A more detailed discussion of these tools can be found in Foundation Paper Two, *Land and Biodiversity Victoria: The Science, Our Private Landholders, Incentives and Connectivity.*[127]

Examples of these tools include NaturePrint, Ensym, Soil Management Information System, Victorian Land Use Information System and the Victorian Biodiversity Atlas.

NaturePrint[128]

NaturePrint provides simple-to-use outputs for biodiversity decision making. The information is publicly accessible via a web portal. Information on biodiversity values, ecosystem functioning and threatening processes, species distribution (based on modelling) for over 500 native mammals, birds, frogs, and reptiles is collated for public access.

Native vegetation is included as groups of co-located species. This information is used for strategic land management decisions by DEPI (see Part B: 1.2 Native Vegetation Management).

EnSym (Environmental Systems Modelling)[129]

EnSym uses scientific models to illustrate the impact that revegetation, weed control and riparian management actions have on the landscape. Users can visualise, test and interpret results of changes in climate, land use and land management practices through a single user-friendly interface.

Soil Management Information System[130]

Public users of this program are able to generate soil maps based on geographic areas. The public can also interrogate and extract data.

Victorian Land Use Information System (VLUIS)[131]

VLUIS is a dynamic information tool that describes what and where land tenure, land use and land cover is present. It does so at a fine scale. Accredited users and stakeholders can access this information – for example, planning and policy groups and those who model, report and monitor.

The Victorian Biodiversity Atlas (currently under development)[125]

The VBA, when completed, will be a web-based information system designed to manage information about native and naturalised species occurring in Victoria. The system will include species attributes, including origin, conservation status, vital attributes and life-form. It will also give access to records of species distribution and abundance, including systematic survey data, herbarium and museum records, and general observations.

5.2.8 Existing tools: National tools and portals

ANDS – Australian National Data Service

ANDS recognises that ongoing research is producing increasingly large volumes of data and it is necessary to find ways to store this data and make it available as widely as possible.

AURIN – Australian Urban Research Infrastructure Network

AURIN is a science initiative with a commitment to sharing and integrating systems of knowledge and data.

This work is demonstrating that partnerships between governments and researchers to provide information to research communities and the broader public are increasingly possible once the legal, contractual and intellectual property issues are managed.

AURIN has been working for three years to resolve highly complex information-sharing issues that have confounded integrated and collaborative research efforts.

It is increasingly recognised that integrated approaches are required to answer complex questions. This is detailed in the *2011 Strategic Roadmap for Australian Research Infrastructure: National Collaborative Research Infrastructure Strategy*[124] with its 19 priority research areas ranging from population and health to sustainable energy and terrestrial systems. The strategy also includes associated enabling areas of interest such as e-Research Infrastructure. One of the singular issues that underscores the whole agenda is a commitment to an environmentally sustainable Australia.

In committing to this work, AURIN is working across a number of programs. From Victoria's point of view, the pivotal one is that involves the North West Metro Area studying walkability, employment, housing and health issues.[111]

The partners in this work include the Victorian departments of Human Services, Health, Environment and Primary Industries, Transport, Planning and Local Infrastructure, and Justice, and the Valuer-General.

TERN – Terrestrial Ecosystems Research Network

TERN is changing the way we understand access to data, interdisciplinary partnerships and engaging the public with research reports and projects in ways which would have been inconceivable a decade ago.

The TERN Data Discovery portal is the outcome of ecosystem scientists sharing and storing their research and data.

The network also brings together the following projects as equal contributors:

- Ecoinformatics
- MultiScale Pilot Network
- AusCover
- OzFlux
- Soil and Landscape Grid of Australia
- Australian Coastal Ecosystems Facility
- Ecosystem Modelling and Scaling Infrastructure.

According to Professor Colin Prentice, Macquarie University eMAST Director, the ambition of the network is to produce 'truly practical tools' and have strong links with the Australian National Data Services (ANDS), the National Computational Infrastructure (NCI) and CSIRO.

Knowledge-sharing is a fundamental component of this work.

Australian Ocean Data Network (AODN) Portal

AODN uses data primarily provided by the Integrated Marine Observation System (see Part B: 5.1 Monitoring and Data Collection), and provides another example of the role of networks in providing insights about environmental issues to the broad public, and of engagement across jurisdictions and sectors.

5.2.9 Constraints of the current suite of tools

Despite continuing efforts to improve access to raw environmental data and analysis tools, public criticisms include:

- questions as to scale and a lack of local specificity
- a failure to ground truth data
- concerns about what data is actually collated and who makes the decisions about what data to collect and collate – including data about threatened species and threatened vegetation communities
- how zonings are selected
- how 'estimates' are determined and how they are revised, if they are revised
- complacency about climate change's cascading impacts and feedback loops and concerns about tipping points being ignored
- the actual/real extent of access to information for the broadest possible public – that is, information without limitations.[65]

Apollo Bay Community Gardens

5.2.10 Towards public analysis of environmental data

As government and other agencies continue to develop high-quality data products for specific purposes, there is scope for the government to act as a coordinating agency to expand the use of existing data by working with stakeholder groups to identify data needs. Different communities have different priorities and assets they wish to protect.

Combined or used separately these data-reproduction tools bring together large amounts of high-quality data. Relatively sophisticated investigation of the current state of environmental assets can be achieved by their use.

Not only do these reproduction tools provide raw information they can also be used:

- to determine potential outcomes of management regimes
- to determine the costs and benefits of implementing particular policies, and
- by local decision makers (such as local government and CMAs) who are working in partnership with the State Government.

Work that has already been carried out to identify priority ecosystem services (see Part B: 1.1 Managing the Landscape for Ecosystem Services) and core environmental indicators (see Part B: 5.1 Monitoring and Data Collection). can be extended by working with local governments to map local assets. This would entail a period of concerted effort to engage with regional councils.

In each case, when local priorities have been identified, the datasets available can be used as the basis for investigating the outcomes of policies and management actions at the local scale. For example: town planning, natural resource management or climate change adaptation.

It is critical that government continues to develop and improve tools that will allow environmental data to be used to evaluate management interventions, prioritise resource use and assess the costs and benefits of future actions.

It is also possible that environmental data products could be combined with geographical data from external sources using methods similar to those employed in AURIN (see above) to form the basis of a state environmental data service.

Ultimately, a state environmental data service could provide access to numerous environmental datasets that are collected and maintained by expert custodians.

The public tools for overlaying and interrogating datasets would:

- be straightforward to use
- allow varying levels of access according to user need
- be made available with sufficient information resources for outputs to genuinely inform the public
- include agreements with data providers to ensure security of data ownership and quality assurance.

5.3 Ecosystem Services: Public Awareness and Engagement

Proposition

Part B: 1.1 Managing the Landscape for Ecosystem Services includes Recommendation 1 for the Victorian Government to develop a Ecological Processes Management (EPM) Plan. A key prerequisite of this proposed EPM Plan will be to conduct broad-based community consultation to identify relative values and priorities for use of ecosystem services and constituents of wellbeing – avoiding absolute valuation and monetisation where not appropriate.

Below we discuss the plethora of great work which is undertaken by community groups and government agencies to engage the broader community in environmental practice. Many of the examples and principles referenced below were discussed in detail in our publication *Many Publics: Participation, Inventiveness and Change*.

This work and the strong networks formed across Victoria by community groups, landowners, businesses, educators, government agencies, Indigenous communities and culturally diverse Victorians creates a powerful foundation to expand upon and conduct the broad-based community consultation required to understand community values and priorities for use of ecosystem services and input them into the proposed EPM Plan.

Context

The Commissioner for *Environmental Sustainability Act 2003* (section 8) provides for the audit of 'public education' programs across Victoria.

In 2012, the Office produced a wide-ranging report on public awareness and engagement in multiple environmental protection issues called *Many Publics: Participation, Inventiveness and Change*.[65] This report reflected our rounds of consultation with the community across the state.

Since publishing that report the Office has continued to actively engage with the community about environmental issues. A great deal of this engagement has been localised and it is clear that there is a deeply organic movement to protect the environment which crosses sectors, generations and cultures.

5.3.1 Promotion of ecosystem services

Lessons for us and observations to be made about the success of community engagement in environmental issues include:

- projects with the greatest likelihood of success are not traditional top-down 'education' programs
- there is no universal model but continuity of support and consistency in messaging is extremely important
- the information flow is not only one way
- highly localised efforts receive better support[132]
- the level of government funding is not always an indicator of success
- co-benefits are important
- people are not waiting for direction from authoritative knowledge brokers
- recruitment of participants is influenced by many factors and can be affected by leadership, pertinence of campaigns and trust alliances
- people value being included in decision making in meaningful and respectful ways
- the involvement of the community in decision making improves outcomes for a range of reasons and is highly useful to institutional decision makers.

The experience of community engagement that led to the publication of *Many Publics* demonstrated that a diverse range of people are seeking better environmental, economic and social outcomes and they bring with them multiple methodologies. We have concluded that the community, across ages, cultures and sectors, is actively committed to exploring the issues which underpin ecosystem health and ecosystem services.

The unifying thread in all these efforts and in all our conversations was a commitment to improved environmental practice and 'change'. We heard this message, for example, from dairy farmers in Gippsland, rural women in the Wimmera, friends of creeks and rivers in metropolitan Melbourne, Aboriginal people, homes where English was a second language, health workers, energy-efficiency campaigners, school children and senior Victorians.

Naturally, this message about the need for change was echoed by biophysical scientists, social scientists and agency staff involved in environmental issues and those involved in non-government organisations across the state.

Having made that observation, however, research demonstrates that much more needs to be done to protect and restore ecosystem services and processes, particularly as we confront the challenges of climate change and population growth.

The following discusses how we might increase the level of knowledge and commitment, even as we recognise the significant work already underway.

Beechworth Banksia Community Walk

5.3.2 Policy formulation based on community values of ecosystem services

5.3.2.1 Indicators and surveys about public awareness

One of the difficulties in driving public policy in support of decision making-models directed at ecosystem services outcomes, has been generating an evidence base to formulate inclusive policy instruments that reflect community concerns and awareness.

Recommendation 1 includes a prerequisite to undertake this work. How do we determine useful 'indicators' to reflect community values on ecosystem services? Having done so, how do we deal with an apparent lack of nuance in determining the links between ecosystem services, environmental awareness, policy development and action? Whatever indicators we select they may be too narrow, too wide or amorphous. What local lessons can be drawn from the work of community groups and landowners? Can we only forge policy at the local level and are these indicators only then specific to that scale and region?

Our valuing of ecosystem services extends beyond the services in reserve held in our natural assets. For example, our valuing of ecosystem services emerges in our attitudes towards:

- consumer purchasing preferences
- residential water storage and electricity generation (water tanks and solar panels)
- interest in environmental certification
- commitment to recycling and 'upcycling'.[133, 134]

An indicator about the uptake of solar panels in Victoria may tell us a great deal about environmental awareness and concern, but it may also tell us about people's specific economic interests and their interest in co-benefits, which may be either environmental or economic, depending on preference hierarchy and personal circumstances.

Beyond developing indicators to illustrate levels of interest in environmental issues, we are often persuaded to rely upon survey data. The vast scholarship on surveys – techniques, methods, participant selection – suggest this mechanism may not be the most useful indicia of interest or commitment because of disparate motivations, 'value-flux' and a difficulty in separating or understanding the interconnectedness of environmental, social and economic issues.

Some valuable surveys on environmental awareness are undertaken in Victoria[135] and elsewhere in Australia.[136]

EPA Victoria's 5 year plan social research program[165] monitors performance in key outcome targets for stakeholders identified in the 5 year plan 2011-2016. The General Public survey results indicate that providing information that has direct relevance to valued activities and assets by Victorians leads to more awareness and beneficial flow on effects than providing information about condition alone. For example, Victorians aware of living near environmental assets (waterways, beaches), or potential sources of harms (landfills, ports, airports), were more likely to perceive EPA as an evidence-based decision maker and authority on condition.

Similarly, Victorians aware of the Beach Report, Yarra Watch and Air Quality Report services, providing information aimed at helping Victorians make informed decisions for their use of waterways and beaches, or decisions about activities during poor air quality days, were also more likely to rate EPA's performance in this area higher. General awareness of non-specific EPA information is associated with slightly lower scores, but still positive perceptions, while people with no exposure to information were also lower but still positive.

Surveys of public opinion across Australia demonstrate that environmental issues rank below housing affordability, health care, local crime and education.[137]

However, ranking issues presents a highly simplified picture of the actual position of the environment in our quality-of-life concerns and does not incorporate the 'anonymous' role that ecosystem services plays in many people's lives – in fact, these surveys may well highlight the need for a concerted campaign to demonstrate these connections.

There is, for instance, no 'health' without a healthy environment. There is no sustainable housing without recourse to a continuing source of building material provided by the environment – the ecosystem service of timber. The work of *The Economics of Ecosystems and Biodiversity* (TEEB) makes these interconnections indelibly.[138]

Scrutiny of community values and understanding of ecosystem services would generate a more measured, nuanced and grounded discussion, picking up on the systemic connections of environment and economics and, it is argued, it would promote better environmental outcomes.[139]

The US Nature Conservancy undertakes surveys and studies into the US community's valuing of ecosystem services. This work is recognised as international best practice and is often undertaken in collaboration with regional or state universities.[140] It provides a benchmark and useful guidance for the Victorian Government's undertaking of similar foundation work for Recommendation 1.

5.3.2.2 Local matters matter

If we ask a different question, 'What Matters to Australians?', we find that we are primarily concerned about issues that relate to us and our local community.[137]

Accepting the pivotal importance of localism, and recognising that environmental learning occurs when married to improving personal outcomes – including the attainment of co-benefits[141, 142, 143] – it seems that we have the capacity to improve the way we both distil and instil environmental information.

Many people, many communities, numerous sectors and all tiers of government have legitimate and often keen interest in attaining better environmental outcomes. There are presently hundreds of programs, initiatives, formal and informal groups operating to protect and enhance environmental quality in Victoria. Many groups are composed exclusively of volunteers, while some are supported by paid coordinators and facilitators. Some of these groups have been active for generations.

Among them, Friends of the Merri Creek have spent countless weekends across generations – in partnership with local government, local businesses and schools and with representation from many cultures and age-groups – enhancing ecosystem services. They have built a biodiversity corridor, provided habitat for fauna, and improved the area for recreational activities.[127]

Landcare has been operating for 25 years. The Friends of the Helmeted Honeyeater have been active for even longer. The Lake Bolac Eel Festival committee maintained its commitment to an annual festival, celebrating the local environment, even as the Millennium Drought left the lake dry.

There are also many newer groups – concerned about issues like energy, urban water and climate change and its impacts – like the Heyfield Flags Group and the Wangaratta and Portland Sustainability Groups.

Whole towns have committed to improved environmental outcomes – Newstead with the launch of its Community Plan in the Mount Alexander Shire is an example of this. The Newstead Community Plan is a typical example of the blending of environmental, social and economic issues and interests. Bike paths promote health and also have environmental benefits. The tree survey provides a benchmark, establishes need and provides a buttress against climate change impacts. The fire plan is concerned with human safety and also with protection of biodiversity. Hundreds of local people, across generations, have committed thousands of hours to developing this plan to deal with highly local issues.

Social media is playing an increasingly important role in this movement.

5.3.2.3 Crisis driven: fire, drought and flood (2009–2013)

Some of this localised environmental work has been in direct response to particular crises. Much crisis response starts with local social and economic concerns, but it illustrates the embedded nature of environmental considerations and the power and importance of partnerships with others – with NGOs and government.

> The work done in the aftermath of the 2009 bushfires presents us with a good example of a carefully designed program informing the Victorian community about bushfire recovery (and preparation) and focused on local engagement, maintaining continuities, ingraining public consultation and promoting lasting active and interactive learning.[144]

This work is built on Moser and Dilling's impressive collection of essays, which helps us to understand the importance of encouraging public outreach and action learning as the risks and consequences of climate change impact.

Farming communities and individuals, responding to the Millennium Drought, worked to improve their farming practices (see the Case Study on the Victorian no-till farmers in *Many Publics*)[65] and triple-bottom-line co-benefits flowed.

For instance, DEPI research has demonstrated that sheltered pastures lost 12 mm less water than open pastures in the spring growing season. In one study, shelter belts demonstrably reduced the cold stress and live weight-reduction in cattle by as much as 31%. The straw-necked Ibis, attracted to insect-rich pastures, consumes up to 25,000 insects per day; while sugar gliders can eat up to 3.5 kilograms of insects per year. The gross value of pasture output is at its highest level when the proportion of tree area on a farm is 34%.[127]

In some cases soils improved, communities and farming practices developed resilience, and for the long term, climate change adaptation was normalised, mainstreamed and maladaptation avoided. This sort of environmental work has occurred even as the surrounding prevailing ethic may have been to deplete natural capital.[65] It is predicated on sharing relevant knowledge, learning by doing, and the availability of sectoral professional development.

In the aftermath of the 2010–11 floods, localised public engagement was actively sought and underpinned the work of the flood inquiry.[145] The inquiry was itself a catalyst for meaningful discussion at the local level with a view to informing the 'centre'. For example, the MAV, representing local government across the state, consulted widely and promoted both community environmental programs and engineering solutions on the basis of that consultation.[146]

Crises – and the community consultation and public enquiries that ensue – provide the engine room for promoting environmental awareness about the role of ecosystem services in local communities, provided methodologies are relevant and accessible.

5.3.2.4 Co-benefits

Economic or health concerns may present as the initial driver for change, and then positive environmental outcomes may emerge as 'co-benefits' of action.

Regional people in the little town of Merino were invited to join an energy-efficiency program through a local primary-care partnership (the Pass-The-Parcel program).[147] Participants enjoyed immediate economic benefits but also reduced their greenhouse gas emissions. Similar programs with multiple outcomes have been repeated in Brunswick and Coburg.[148]

Processes which were not top-down 'environmental education' programs improve environmental awareness of ecosystem services and produce environment outcomes. Environmental awareness grows by osmosis and learning by doing, not necessarily by didactic strictures. Purposeful interventions by individuals and organisations with expertise and access to community networks is, however, an essential part of the process (see below for a discussion of the importance of trusted organisations) as is evaluation.[149]

Evaluation of community environmental programs provides government with critical information to not only ensure the ongoing viability of community groups but also how to promote the values and understanding of ecosystem services. Key government action would include:

- persistently support and reinvigorate programs that have worked
- consistently assist in meaningful evaluation of the environmental work that is already underway
- promote community leaders
- celebrate successes and value best-practice groups
- routinely fund local initiatives
- maintain continuity of programs and funding streams.

The corollary of this is the need to ensure that the institutional and regulatory environment are clear and that government supports open access to data and monitoring (including citizen science).

5.3.3 Community engagement across the spectrum – trusted organisations building collaborations

Trusted organisations will always play an important role in supporting better outcomes, and in guiding and consolidating efforts. These may include people-centred organisations like Landcare, or institutions like museums and zoos, which have long understood the need to provide accessible information in engaging ways.[150] Museum Victoria featured in our Strategic Audit 2011 for its award-winning recycling of its exhibition space building materials and drawing the public into the discussion of this.[151] Zoos Victoria is probably the best example of a public communicator of environmental messages in the state.

In places where there is interest, but often conflict, it can be harder to engage and build environmental awareness, even for trusted organisations. The EPA, with its focus on pollution, environmental quality and the sanctioning of breaches, has very recently made a number of recommendations indicating the value of an engaged community and promoting the involvement of the public in developing environmental protection policies.[152]

5.3.3.1 EPA review of state environment planning policies

For the government to lead a process to promote, understand and prioritise community values in relation to ecosystem services, much can be learnt from government institutions and agencies such as Museum Victoria, Zoos Victoria and the EPA.

EPA led a consultation process where Environment Victoria, the Environment Defender's Office, environment group representatives and community stakeholders attended a roundtable discussion to discuss ways to enhance engagement and involve the community when state environment planning policies (SEPPs) are made, amended, or referenced.

Proposals included:

- asking children to educate decision makers on what they enjoy doing in the environment
- implementing a citizens' jury to give the community equal say in decision making[65]
- including scientists and industry representation in decision making.

Overarching considerations included a commitment to increasing public accessibility to statutory polices and updates, the condensation and consolidation of content, and avoiding repetition and jargon – a persistent issue in environmental information contexts. A 'user's guide' was suggested as one mechanism for achieving better outcomes for a 'lay' audience and a hierarchy of importance was also suggested as a means of clarifying commitments.

The Commissioner for Environmental Sustainability endorses the recommendations in the EPA's Review of the State Environment Planning Policies.

In particular, Recommendations 13–15, which are concerned with wider community engagement, streamlining policies and the use of clear, simple language respectively.

Charlton Volunteer Centre, flood recovery

Case Study: ResourceSmart AuSSI Vic

The *ResourceSmart AuSSI Vic Initiative* is a government supported framework for schools-based sustainability education.

Its precursors, developed by the *Gould League* and *CERES* (Brunswick), started the Victorian commitment to this work. There are now nine consortia of service providers across Victoria including *CERES* delivering ResourceSmart AuSSI Vic. ResourceSmart AuSSI Vic is managed by Sustainability Victoria in partnership with the Department of Education and Early Childhood Development.

The framework provides a holistic approach to sustainability by integrating educational, environmental, social and economic outcomes for participating school communities.

The Initiative is funded through the Victorian *Sustainability Fund* a perpetual fund provided by the landfill levy.

Over the next few years the existing framework will unfold in the following ways. It will:

- engage with 400 new Victorian primary and secondary schools, bringing the number of participating schools to about 50% of the state's schools
- maintain the current participation of over 700 Victorian primary and secondary schools
- continue to reward and recognise schools' achievements though the ResourceSmart AuSSI Vic 5 Star Sustainability Certification (5 Star) process and the annual ResourceSmart School Awards event
- conduct a pilot environmental sustainability education program with the early childhood sector
- provide incentives by grants of up to $10,000 to schools to undertake energy efficiency activities for the 400 new schools which are being encouraged to join the Initiative.

Localism is a key component of this initiative. It has adopted a place-based delivery model, in that local providers and networks support schools within a designated geographic region.

A great deal of volunteerism underpins the success of the program – from teachers and school communities.

Outcomes

There is a demonstrated minimisation of waste, savings are made in energy and water use and associated accounts, and greenhouse gas emissions are reduced. Benchmarks are set and used as indicators of progress. Management of school facilities and resources is often improved. External relationships are improved and also become more productive.

Sustainability is integrated into school planning and strategic process. Resource-use management is improved, sustainability practices are embedded into the school operations, and teaching, learning and community engagement is actively encouraged.

Leadership is cultivated in the community and in the school itself and students develop environmental awareness and gain skills in environmental management which will position them for environmental leadership roles in the future. The Initiative supports implementation of the Victorian Essential Learning Standards (VELS) and the Australian Curriculum (AUS VELS).

The 5Star Sustainability Certification is awarded when a school demonstrates continuous improvement against benchmarks set in the areas of planning, biodiversity, energy, waste and water.

5.3.3.2 Provision of materials and guides – tool kits and multi media

Tool kits, guides and brief fact sheets are extremely valuable as components of a suite of teaching or professional development aids in generating environmental awareness about the value of ecosystem services.

There is a long history of development of guides of this kind, across sectors and geographies. Tool kits no longer simply deal with isolated or discrete issues. They can be ambitious and use the range of electronic and social media available to expand their potential influence.

Case Study: Examples of the Range of Toolkits

The Australian *Natural Resources Information Management Toolkit*[153] addresses issues like capacity building, monitoring and evaluation. Its target audience is diverse – from technical managers to regional groups – and it provides guidance on general principles and detailed practices. Similarly, the Florabank species navigator[154] provides online species seed propagation and collection advice.

Internationally, the scientific community see the benefits of promoting understanding of ecosystem services through factsheets and toolkits. The Union of Concerned Scientists and the Ecological Society of America have joined forces to develop toolkits[155] for communicating ecosystem services. The resources include easy-to-understand fact sheets with descriptions of things individuals can do to help protect specific ecosystem services.

A *Water Purification Tool Kit* identifies the benefits of pure water and the risks associated with a lack of care for the waterways of New York City.[156] The Tool Kit provides information about a range of individual and other actions which will reduce adverse impacts on water quality including:

- at a farm-scale, avoiding the over-use of fertilisers and pesticides
- in housing developments, resisting the temptation to pour toxic chemicals down drains
- as a community, engaging in active conservation measures, such as getting involved in efforts to clean up waterways
- at all tiers of government, providing real and relevant support for the protection of natural areas and supporting planning regulations that limit the impact of development on ecosystem services.

Illustrating the importance of the water conservation and ecosystem services message, the *Australian Water Education Toolkit* supplies dozens of guides about water resource use and conservation.[157]

Greening Australia has been explicitly advancing the use of toolkits in promoting an understanding of ecosystem services. This work includes the *Make an Impact Toolkit*, which was developed in partnership with Alcoa Australia to assist Alcoa employees to reduce their energy and water use.[158]

Conventional information packages should only be the beginning of the use we make of the electronic aids we now have available to us. Webinars, YouTube, mimeos and the ever-expanding range of electronic aids need to be imported into the options deployed. This requires specific research and application. Teachers and agency staff could be exploring these possibilities and adopting a leadership role in facilitating a shift into the electronic age in education for environmental awareness and ecosystem services.

5.3.3.3 Exploring cultural complexity in raising awareness of ecosystem services

New e-tech ways of generating interest, building a constituency, encouraging people to be active, emphasise the importance of cross-disciplinary integration to engender change in environmental decision making.

Changing our understanding of the mediums in which we can effect improvements is only one of the cultural changes we should be exploring.

We have a wealth of cultural influences in the community of Victoria. It is clear that communities which are 'outsiders' to mainstream environmental discussions may provide us with insights and other, different, pathways. In promoting environmental best practice and understanding the values inherent in ecosystem services, it is important to remain open to the multiple ways of achieving this understanding.

Our Office has been engaged with the great work undertaken in cross-cultural environmental education and awareness by Moreland Energy Foundation Ltd (MEFL) and Environment Victoria in the northern suburbs of Melbourne with the Arabic, Alawi and Asian communities in energy-use abatement and greenhouse gas reduction programs.

We also know that in Nhill the community garden is shared with the active Karen community – who have a long-standing interest in sustainable food.

Aboriginal people, the first Australian nations, have also provided invaluable insights about climate change and cultural connectivity to a wide range of scientists – both biological and social – through the Yorta Yorta Climate Change Group (along the Murray River) and as a function of the Budj Bjim Gunditjmara Lake Condah reflood program.

Climate Communities grants of $50,000 (managed by the Victorian Government) are made available to interested communities. Ongoing reporting and evaluation in the form of videos, photo diaries and stories identifying significant change provide novel methods of evaluating programs.

'There is a lot to learn and there is a lot to share, in organisational cultures and elsewhere.'

Case Study: Melbourne Water organisational change

A new way forward

Melbourne Water is implementing a number of strategic initiatives with the aim of improving organisational efficiency, capability and business outcomes. These involve completely *new ways of approaching business* and will therefore require a *new way of thinking* to implement them.

The projects are enterprise-wide and require extensive cross-organisational collaboration for them to be taken up as the new thinking and way of working. This type of change cannot be forced from the top down. It requires a *cultural shift* and a *new change leadership* approach.

Sustaining Change was engaged by Melbourne Water to assist because we specialise in how organisations and systems think, grow and establish themselves. At Sustaining Change we understand that each organisation has a unique configuration of business, strategic and people levers, required to interact to improve internal capability and external sustainable competitiveness.

To help Melbourne Water implement their new strategies Sustaining Change conducted a series of facilitated, iterative interventions. This was to create dialogue and engagement between different parts of the business on topics that were different from the usual task-based, project management ones. This non-linear approach created space for a wider range of issues to surface than are normally found. It allowed sharing of data about:

- the deeper meaning of work for individuals
- attitudes to their roles.

It also allowed us to identify:

- levels of capability
- leadership and team working skills
- understanding and operation of organisational processes by employees
- employee ideas about solutions to problems.

This data also resulted in shared understanding of the meaning that employees attribute to their work environment, and how they attribute that meaning. This enabled us to work with them to develop solutions that address problems as they see them. It helped create shared visions of what the organisation would look like after the strategic initiatives were implemented; and it helped clear bottlenecks, reduced conflict and created shared processes and activities.

This has also flowed on to improvements in their planning, scheduling and other project management processes. In addition it has resulted in broader and more persuasive communications with stakeholders. These process-based interventions and thinking tools also create capability in the staff who participated in them, so that they in turn can run a similar approach to unblocking hurdles in their own areas of responsibility.

Melbourne Water working differently

We have also assisted Melbourne Water to look at their new initiatives and strategies through both the internal and external lens of how people manage, react to and implement change. This has identified of synergistic linkages between the implementation of new strategies, the operation of them, and the customer experience. This ensures that they all align rather than compete or cancel each other out. This enables Melbourne Water to avoid developing business processes that may be efficient but which are difficult for customers to use; or developing improved customer interfaces that result in more costly business processes for the organisation or which the organisation does not have the capability to support.

Once we understand how people attribute meaning to their environment and what that meaning is, we then know how to influence and lead them, how to resolve problems and design solutions, and what changes need to be deployed for a strategy to be implemented, and achieve the intended results for its business.

Working with our approach has resulted in Melbourne Water being able to better identify its gaps, define solutions, plan its activities and begin to embed its new strategies to achieve the organisational efficiencies and outcomes it seeks.

5.3.3.4 Business opportunities

In reflecting on and raising environmental awareness, it is important to discuss the role played by business.

A range of businesses in Victoria have been working on attaining better environmental outcomes and generating environmental awareness in their organisational structures. There is a significant movement to improve corporate social awareness at the structural level. Shareholders are driving better outcomes. The public is interested in change and business is not immune from these drivers of change. Some of these initiatives have been discussed in the strategic audits that the Office has undertaken.

Many businesses, often as a commitment to corporate social responsibility, have programs in which they promote environmental volunteering.

In Ballarat the headquarters of Conservation Volunteers provides a lynch-pin for a number of programs which encourage business volunteerism in the environment.[159] The organisation has been operating since 1982, having been started by a Yandoit farmer. It now manages over 100,000 conservation volunteer days per year, and has received multiple accolades and awards, including the Prime Minister's Award for Excellence in Community Business Partnerships.

Conservation Volunteers has also developed the only online booking service for volunteers in Australia, in partnership with Toyota. It is noted that in the nine-year partnership between Conservation Volunteers and Toyota a total of $4.3 million has been assessed as accruing in benefits to society and ecosystem services.[160]

City West Water's Community Grants Support Program for the non-government and community business sector,[161] South East Water's dual-flush toilet program,[162] Yarra Valley Water's Choose Tap program[163] and Melbourne Water's *Know Your River* booklets[164] form a small part of a plethora of programs that deliver better environmental outcomes for their customers.

These programs reduce resource use, waste and greenhouse gas emissions and inform and enrich our knowledge of the ecosystem services provided by our local environments. They also produce co-benefits in cost savings and better social outcomes.

EPILOGUE

Victoria:
STATE OF THE
ENVIRONMENT
2013

BETTER MEASURES OF PROGRESS

EPILOGUE
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EPILOGUE
BETTER MEASURES OF PROGRESS

In the face of increasing pressures such as climate change and population growth, in this closing section of *Victoria: State of the environment 2013, Science, Policy, People* we make the following observations: our understanding of ecological processes and our protection of ecosystem services would be invaluably served by better measures of human progress and a more sophisticated understanding of social resilience.

More broadly, we hope that the recommendations of this report complement and inform environmental management and sustainability reporting in Victoria and promote a significant strategic shift in the way we approach the interface between the natural world and human progress.

The United Nations Rio+20 summit (Brazil 2012) committed governments to create a set of sustainable development goals (SDGs). Responding to this call from the UN, many governments, NGOs and members of civil society have started to frame SDGs. A well advanced international framework has been developed by Professor David Griggs and a group of eminent scientists. The concepts contained in the framework are useful guides as we consider improving social resilience and supporting the continued wellbeing of the Victorian community.

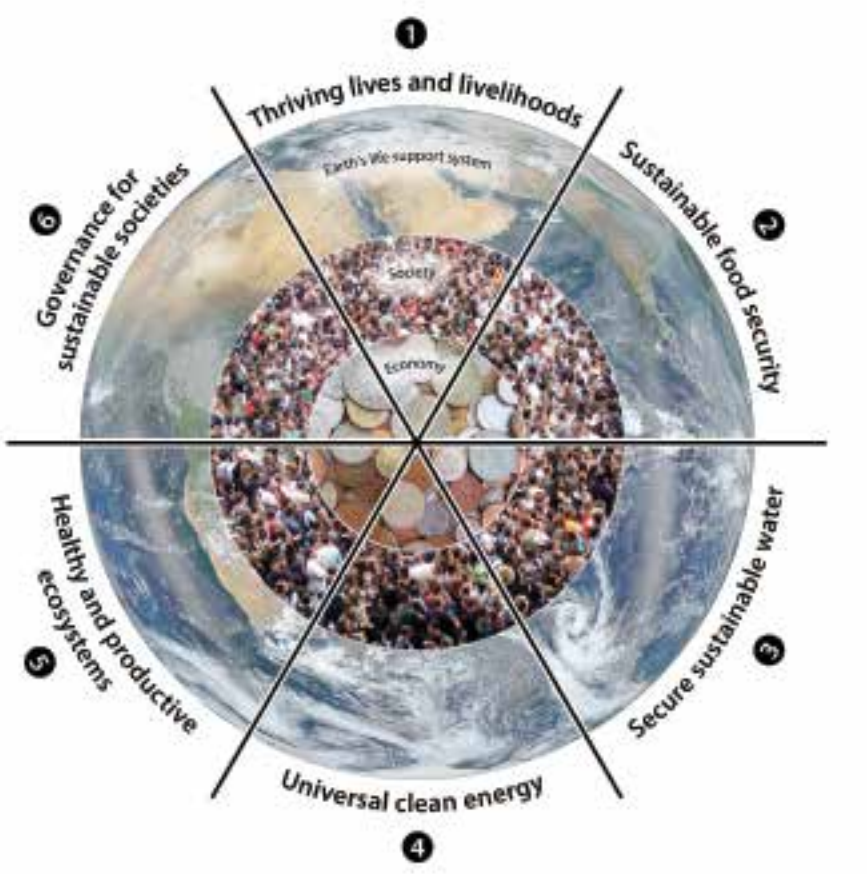

Figure E.1: The Six Universal Sustainable Development Goals cutting across economic, social and environmental domains.*

* David Griggs, Mark Stafford-Smith, Owen Gaffney, Johan Rockström, Marcus C. Öhman, Priya Shyamsundar, Will Steffen, Gisbert Glaser, Norichika Kanie, and Ian Noble. Sustainable development goals for people and planet. Nature, 495: 305-307. (21 March 2013). 2013.

E.1 Measuring Differently

Our key measure of economic growth, gross domestic product (GDP), has in many ways become our default measure of social progress. It is widely acknowledged that growth in GDP, or gross *state* product for Victoria, is not a measure for assessing progress towards a sustainable future. GDP is defined by the ABS as:

> ***'...the total market value of goods and services produced in Australia within a given period after deducting the cost of goods and services used up in the process of production, but before deducting allowances for the consumption of fixed capital. Thus gross domestic product, as here defined, is 'at market prices'. It is equivalent to gross national expenditure plus exports of goods and services less imports of goods and services.'*****

Ever-increasing GDP (beyond a basic threshold) does not translate into additional human welfare. The need to shift away from growth as the only determinant of a development strategy is increasingly being discussed.[1, 2]

Efforts are underway around the world to develop better measures, found in the OECD's 'Measuring Progress of Societies' and the ABS's 'Measures of Australia's Progress' consultation process. These efforts are attempting to develop systems that measure the things that truly benefit society and explicitly maximise, and understand the constituents of, wellbeing.

A leading example is the Canadian Index of Wellbeing.[3] This takes account of eight 'domains': community vitality, democratic engagement, education, environment, healthy populations, leisure and culture, living standards, and time use. Each of these is composed of a collection of 'headline indicators', and together the eight domains provide a composite index of wellbeing. When first released in October 2011, the composite index revealed that quality of life in Canada had increased by 11% since 1994 – much less than the 31% increase in GDP.

Regular reporting of progress against diverse measures of progress is an important step in separating material consumption from improved social wellbeing.

The process of developing alternative measures of progress for Victoria, or Australia, must involve significant community consultation: what kind of society and environment do we really want to live in? This is reflected in the recently launched *Australian National Development Index* and the ABS's *Measuring Australia's Progress*.[4]

The Happy Planet Index[5] ranks Australia well below Costa Rica (ranked No. 1). The index is based on three key metrics: experienced wellbeing, life expectancy and ecological footprint. Costa Ricans enjoy almost identical wellbeing and life expectancy as Australians, but with an ecological footprint 2.5 times smaller than our own.

** http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/930F0CF385EC166FCA257AD8000EE7CA/$File/52160_2012_edition3_v2.pdf

The Australian Conservation Foundation identified eight themes that could contribute to a society that values wellbeing and quality of life alongside economic growth.[6] These were:

- Emphasising measurements of social and individual wellbeing, and ecological health over GDP
- Balancing paid and non-paid work, family and leisure time
- Making cradle-to-cradle manufacturing a reality
- Consuming less and consuming smarter
- Ensuring that the full environmental and social costs are included in the price of goods and services
- Supporting non-profit business models
- Shifting taxes away from productive activity such as income generation and towards pollution and resource use
- Government cost-benefit analysis that includes all aspects of wellbeing.

E.1.1 A new wellbeing index for Australia

Deakin University in Victoria will host the Australian National Development Index (ANDI), a new measure of Australian wellbeing and progress that will advise federal policy development.[7] ANDI was officially launched by Australian scientist Sir Gustav Nossal in August 2013 through the release of a new report from the Australian Council of Learned Academies (ACOLA) and VicHealth.

Called *Australia's Progress in the 21st Century*, the report for the first time provides a scientific foundation for developing an indicator of progress that goes beyond gross domestic product (GDP). Consultation will be undertaken, and Australians will decide on aspirations and goals for wellbeing and progress, and ANDI will measure progress against those goals.

ANDI is part of a growing global movement to redefine how societal progress is measured. The Australian version is supported by Australia's Chief Scientist and the Australian Council of Learned Academies (ACOLA). When established, ANDI will include 12 domains within which annual 'dipstick' readings of progress in areas such as health, Indigenous wellbeing and education will be taken and reported against targets.

E.2 Understanding Social Resilience in Victoria

Over the coming decades, Victorian communities will need to adapt to the hazards of a changing climate: fires, floods and extreme heat. Resilience is necessary to achieve this adaptation while retaining the fundamental character of our communities – in essence, to 'deal with change and continue to develop'.[8]

At the same time, we need to avoid maladaptation – responses that relieve problems initially but exacerbate pressures in the long term by degrading our natural and social assets. There are numerous complex elements that underlie resilience and these are often unique to particular communities. These are factors that influence the vulnerability of populations to hazards, their social cohesion, and their capacity to adapt to repeated shocks. The challenge lies in identifying common factors that can be monitored over long time scales and used to determine the relative resilience of communities.

It is important that the Victorian Government investigates methods that may be used to develop, monitor, maintain, refine and validate consistent metrics of the components of social resilience: vulnerability, adaptive capacity and cohesion. It is important that these measures are used to inform policy and empower communities to make locally relevant decisions in adapting to climate change. In the longer term, robust measures can provide the basis for profiling changes in resilience and for modelling potential outcomes of policy and planning options.

E.2.1 Resilience and disaster response

Resilience has numerous definitions that vary in their nuances. However, resilience can be broadly considered as the ability of natural and social systems to respond, and adapt to, external shocks while remaining within critical thresholds and retaining desired functions.[9]

In Foundation Paper One, *Climate Change, Victoria: The Science, Our People and Our State of Play* we have presented the potential impacts and outcomes associated with climate change. As the world warms, extreme weather events will be more frequent and more intense. The environmental and economic costs associated with natural disasters have been rising steadily and are expected to continue to do so,[10] prompting calls from the Australian business community and others for increased investment to reduce impacts by improving resilience.[11]

It is likely that changes in climate will not be gradual but abrupt.[12] Climate hazards that are expected to increase in frequency and intensity will include bushfires, heatwaves, floods and seasonal drought. This will occur against a backdrop of long-term stressors – such as increased likelihood of multi-year drought, and rising sea level – that act to increase the vulnerability of populations in affected areas.

In Foundation Paper Two, Land and Biodiversity, we discussed the roles we all play in ensuring ecosystem services are protected and maintained.

In Foundation Paper Three, *Water, Victoria: The Science, Our Urban Communities and Our Water Futures* we discussed the risk and uncertainty associated with water availability in our cities and towns, and the work we can and are doing to address this. In the light of circumstances changing we need to work strategically to cultivate environmental, economic and social resilience while avoiding measures that exacerbate these problems in the long term.

The National Strategy for Disaster Resilience (NDRS)[13] characterises resilient communities as:

- able to function well under stress
- capable of successful adaptation
- self-reliant
- having 'social capacity'.

Communities are dynamic and heterogeneous, so any program that seeks to quantify resilience needs to be grounded in knowledge of local conditions. With this in mind, researchers have sought to identify the characteristics that are shared by successful initiatives. Factors that enable resilience[14] and could be targeted by government are:

- Physical characteristics: The assets available to a population, including existing infrastructure and natural assets; emergency infrastructure and strong health and emergency services
- Procedural characteristics: Emergency planning incorporating local knowledge and collaborations
- Social characteristics: Cohesion and inclusion; strong local identity and knowledge guided by local leadership.

Furthermore, an expert review of social networks and psychological effects following global disaster responses and recoveries identified five essential underpinnings for success:[15]

- safety
- calming
- hope
- connectedness
- self and collective efficacy (i.e. confidence, power, capacity to get life back together).

In practice, social resilience has been recognised by governments as an essential component of recovery after several natural disasters here and internationally.[16] The study areas have included:

- Black Saturday bushfires (2009) in Victoria
- flooding in Queensland (2010–11)
- earthquakes in Canterbury, New Zealand (2010–12).

Swift and substantial responses by state and federal agencies focused on coordinating initial response and recovery and improving resilience, even though methodologies varied due to the particular specifics of each community.[17]

A rapid review was conducted by the Victorian Department of Health of the elements that informed a 'community resilience based recovery strategy' after the 2009 bushfires.[18] Connectedness was highly correlated with speed and strength of response.

In 2012, the former National Climate Change Research Facility (NCCARF) updated its research plan for emergency management to reflect the increasing importance of community resilience. Greater priority has been placed on identifying the behaviours and processes that promote community resilience and preparedness.[19] We can hope, therefore, to gain new insights about this in coming years.

E.2.2 Understanding vulnerability and the capacity to adapt

Assessing the relative resilience of populations (or ecosystems) to climate hazards requires a consideration of several factors. Two of the most important are vulnerability and adaptive capacity.

The degree of vulnerability is shaped by both potential exposure to hazards (e.g. fires and floods) and the other stressors that people experience (e.g. poverty or ill health). The capacity of populations to adapt to changing conditions in a sustainable way is the second factor. Assessment of this is complex and relies on accurate estimations of the financial, social and environmental assets available to community members.

E.2.2.1 Vulnerability

Vulnerability of individuals/communities to climate shocks based on socioeconomic status can be assessed using clearly defined indicators. For example, socioeconomic disadvantage is collected and reported at multiple scales over the whole state by agencies such as the Australian Bureau of Statistics (as part of the Socio-Economic Indexes for Areas)[20] and DTPLI (which provides disadvantage data for Victorian towns).[21] Socioeconomic disadvantage is a metric that has been linked to increased exposure to pollution.[22] However, the links between disadvantage and vulnerability to climate hazards are not well understood.

Research has been carried out by Geoscience Australia (GA) for the Bushfire Cooperative Research Centre (CRC) considering the links between social disadvantage indicators and vulnerability following the Black Saturday fires.[23] The indicators considered were:

- young at risk (under 5)
- aged at risk (over 65)
- insufficient English
- not completed Year 12
- need for assistance (e.g. feeding, washing, communication)
- volunteering rate
- low income households
- no motor vehicle access
- new to the region (moved within 1 to 5 years)
- single parent families
- Indigenous people
- public housing
- unoccupied homes.

The Bushfire CRC concluded that no single indicator could be used to identify vulnerability but that a combination of these factors increased a community's vulnerability. Some of these factors are cultural, some physical. A number of them quite clearly suggest the need for better ecological information and public awareness efforts, across socioeconomic and cultural divides.

This work was undertaken using the National Exposure Information System (NEXIS) – a national project being undertaken by Geosciences Australia.[24] NEXIS is a tool for estimating the location of populations and their characteristics. This information can be used to assess exposure to, and impacts of, hazards and will be a valuable tool for emergency planning and for directing programs intended to reduce vulnerability.

NEXIS has been developed to collate and manage the data needed to assess multi-impact hazards and is a valuable tool for providing information to decision makers. The system has been applied after the Black Saturday fires to assess the relative importance of a number of vulnerability indicators. Given that it is combinations of factors that contribute to vulnerability, research of this nature will be valuable in developing monitoring frameworks.

Future development of NEXIS will include projections of spatial distribution and daily activity and this research could be used as the basis for identification and continual assessment of best metrics of vulnerability, risk from climate hazards and adaptive capacity (see below).

E.2.2.2 Adaptive capacity

The factors that contribute to the adaptive capacity of families and communities can be characterised as a product of available skills and knowledge, relationships and social connectivity, and material and financial resources. These assets are underpinned by the resources (food, fibre), services (clean air and water, climate regulation) and value (recreational, cultural and intrinsic) provided by healthy ecosystems.

A strong base of natural assets and ecosystem services is essential for resilient communities. When leading the response to the Black Saturday bushfires, the Victorian Bushfire Reconstruction and Recovery Authority (VBRRA) recognised that community cohesion could improve individual health and wellbeing after traumatic events[25] and made this a focus of its activities.

An assessment of the operation of the VBRRA reported that:

> **'Communities felt they had been brought together and their networks were strengthened after the fires. However, they also believed that over time they would become weaker due to loss of members and resentment against community decisions taken during and after the fires. Nevertheless, community resilience against future extreme events appears to have been successfully built. Participants in the study believed their communities were far better prepared for bushfire events than before 2009.'**[17]

After the fires, the people that had suffered personal losses reported high satisfaction with their perceptions of safety and community.[26] This suggests that affected communities are, at least in the short-term, relatively prepared for future climate impacts.

The Victorian Department of Heath assessed the role of community connectedness in recovery after the 2009 bushfires.[18] It recommended that future strategies should focus on community building. The anticipated outcomes of the community-building recovery strategy would include but not be limited to:

- a lower than expected burden of mental health problems
- a more connected community socially, providing an improved platform for disaster readiness
- a sustained community infrastructure for problem solving and addressing community needs
- the retention of population and amenities
- the restoration of quality of life.

Social cohesion is already measured to some degree in Victoria. The Department of Planning and Community Development (DPCD) began collecting information on the components of community strength in 2001 and last reported on these indicators in 2010.[27] In the context of Victorians' experience of disasters, these indicators informed a framework that was developed to enhance:

- close personal bonding networks of family and close friends
- broader bridging networks generated through participation in education, employment and public life
- governance networks linking communities to decision making institutions.[28]

The data from this framework has been collected, with other state government information on community cohesion, by the Community Indicators Victoria (CIV) web portal.[29] Environment, natural resources and natural capital feature in the growing list of sustainability indicators that underpin resilience at the local and wider scale.[30]

Social connectivity is a vital component in the capacity of communities to adapt to a changing climate, but there are many other factors that require investigation. There is, therefore, a pressing need for research and practical methodologies to gather available information on social connectivity in a community and integrate this knowledge with those attributes contribute to adaptive capacity. Other considerations would include ecosystem benefits and infrastructure resilience.

In essence, it is necessary to quantify the relative strength of all available natural and social assets and use these as a proxy measurement tool for determining the likely adaptive capacity of a community.

One suggested method of achieving this is the 'asset amoeba'.[31] This approach integrates the status of financial and infrastructure capital with social and population characteristics and the natural assets that provide ecosystem services.

Figure E.2: A hypothetical 'asset amoeba' that estimates community capacity in social, natural, human and economic capital to assess overall capacity.[31]

This approach, and others that seek to quantify adaptive capacity as a function of natural and social capital, will need to be assessed for suitability in Victoria. This will require rigorous study of their usefulness across cultural and social settings where, for instance, social equity and access to assets may be widely and unevenly distributed.[32–35]

The issue of data availability will also need to be addressed before assessment tools can be applied effectively. Local councils have recognised a need for information on social indicators such as community cohesion, participation in communal activities, and access to amenities and services. However collection of such information is sparse at best.[36] Improved forms of environmental monitoring are discussed in 5.1 Monitoring and Data Collection.

Regular assessment would allow government agencies to employ disaster response strategies that, to a certain degree, can be tailored to specific communities – thus further allowing communities to participate in their own recovery and protect and encourage social networks. It is important that these strategies are monitored against the criteria for maladaptation (see below).

Findings from this process could be incorporated into long-term planning at state, local government and local authority level.

RECOMMENDATION 34

It is recommended that the Victorian Government benchmark vulnerability and adaptive capacity at a community level.

ATTRIBUTES

The benchmarking will take into account natural hazards associated with climate change and other environmental threats.

Benchmarking will involve:

- **improved knowledge of population characteristics**
- **agreed metrics for vulnerability and adaptive capacity**
- **consistent monitoring over time**
- **evaluation of metrics against actual shocks**
- **comparisons of community responses**
- **periodic review to assess continued relevance.**

Ultimately, consistent and coordinated evaluation of vulnerability and adaptive capacity metrics could form the basis of resilience modelling.

E.2.3 Maladaptation

Maladaptation is defined as: 'action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups'.[37] It is important that initiatives that are intended to reduce risks adopt a coherent approach in respect of both mitigation and adaptation efforts. It is crucial that planning is undertaken that avoids maladaptation and guides transition to a climate change ready environment.

Maladaptive measures will ultimately decrease resilience producing one or more of the following conditions:[37]

- increasing emissions of greenhouse gases
- disproportionately burdening the most vulnerable, already disadvantaged by social inequity[38]
- imposing high opportunity costs
- reducing social, cultural and economic incentives to adapt
- imposing path dependency.[39, 40]

It is important that adaptation programs be evaluated using these criteria to avoid pitfalls, allowing measures that truly increase resilience to be pursued. Improved methods of assessing relative vulnerability are critical to avoid maladaptive measures that affect communities disproportionally. As climate change adaptation progresses, governments and the communities they represent will need to be vigilant to avoid maladaptive responses.

For example, defending some coastal assets in the face of sea level rise will be environmentally and socially challenging and economically prohibitive. Engineering works that solve one problem but exacerbate another are undesirable and would represent a maladaptive response.

Another example is found in emergency management planning. The adaptive response would not emphasise 'response and recovery' processes over 'strategic planning for resilience'. Committing disproportionate resources to the former at the expense of the latter may prove to be ultimately maladaptive by leading to institutional path dependencies which will ultimately make resilience more difficult to build.

E.2.4 Measuring resilience

The Australian Academy of Sciences (AAS) has reviewed the desirable characteristics for assessments such as resilience profiling.

The AAS recommends the following resilience assessment attributes:

1. **Timescale.** The assessment should have a time horizon of 2050 at least.
2. **Context.** The assessment is informed by a range of alternative global scenarios and a set of projections for feasible Australian futures (e.g. population trajectories).
3. **Specified Resilience.** The assessment characterises 'specified resilience' – the resilience of particular aspects of Australian society to defined shocks (such as climate change hazards).
4. **General Resilience.** The assessment characterises 'general resilience' – our ability to cope with all kinds of shocks, known and unknown so as to continue functioning in a desired way.
5. **Transformation.** The assessment explicitly explores options for transformational changes in the system, both at fine scales and, if needed, at the scale of the whole system.
6. **Dynamics.** The assessment draws on complex systems insights and methods to characterise the dynamics of connected social–technical–biophysical systems.
7. **Participatory, Adaptive Processes.** The assessment is conducted in a participatory manner and as part of an adaptive learning process so that it contributes usefully to effective and ongoing engagement with individuals, communities, businesses and governments.

Resilience assessments that employ meaningful participatory processes can be used to identify and overcome barriers to adaptation (see Case Study: Design-Led Engagement by VEIL). The adoption of these processes reflects a number of the factors outlined in the community outreach work undertaken by the Office of the Commissioner for Environmental Sustainability and reflected in the report *Many Publics: Participation, Inventiveness and Change*.[41]

In that report we cited the scholarship, which tells us that participation encourages social learning, resourcefulness and resilience. People who start with a participatory ethic will respond more effectively to the challenges of 'rapid onset emergency interventions' and resist dependency. This group of people also has the capacity to produce more creative and compelling outcomes.

Case Study: Design-Led Engagement by Victorian Eco-Innovation Lab (VEIL)

The Victorian Eco-Innovation Lab is currently leading a project to explore barriers to local resilience building in response to future climate extremes. A key aspect of the project is participatory design workshops with community members from two case study towns: Anglesea and Creswick.

The process has proved valuable in inviting community members to safely explore the more extreme mid-term implications of climate change (to 2037) and identify locally appropriate adaptation options – many of which propose a radical departure from the status quo.

‘Glimpses’ of the future are based on proposals developed by people in Anglesea and Creswick, and were used to communicate the ideas beyond the design workshops. The public exhibition of future visions is a useful tool for promoting new conversations and generating new ideas about what is possible when planning for the future.

The project’s rationale is that cultures of decision making that prioritise response and recovery more than long-term preparation and adaptation will leave communities exposed to rare, high-impact weather events. However, moving from prediction-oriented planning to an emphasis on systemic resilience will meet challenges in changing ingrained institutional practices.

Key stages in the workshop process include:

1. **Stakeholder interviews.** These were conducted over a number of months to develop an understanding of the case study communities – focusing on influential individuals and groups, shared assets and values, and perceived vulnerabilities.
2. **Developing local narrative climate scenarios.** Regional climate change projections were analysed to determine plausible ‘worst case’ climate conditions for 2037. These were translated into a series of narratives that depicted multiple (and overlapping) impacts from climate change as seen by three fictional future residents.
3. **Participatory visioning workshops.** Two-day facilitated workshops were run in Anglesea and Creswick with approximately 20–30 people attending. Participants were led through a process of identifying key local assets and functions and using the future scenarios to identify and rank vulnerabilities. People then explored options for adaptation guided by design principles that emphasised building resilience of critical functions.
4. **Showcasing visions for feedback.** Workshop outcomes were worked into a series of visual images by professional designers and then into different formats to encourage wider stakeholders to comment. Different media were used including a facebook page, website and public posters and these reflected the different communities in both towns and helped explore how alternative modes of communication would affect feedback.
5. **Agency workshops.** Workshops were held in Melbourne, Hepburn Shire and Surf Coast Shire to explore institutional barriers to the proposed strategies. In each workshop, participants represented different state and regional agencies and formal stakeholders.

As the project is still underway at the time of writing this report, its impact on planning and community decision making is still emerging. However, a number of lessons are already clear about the strengths of the process and the barriers to adaptation for climate extremes.

Communities are more than capable of exploring the negative realities of extreme climate change over the medium term (approximately 25 years) and equally capable of proposing sophisticated ways to build resilience in response. Key success factors include:

- perceived independence of the process (from a political agenda)
- minimal direct emphasis on ‘climate change’
- a structured process that balances positivity and creativity with confronting plausible future impacts
- using tailored narratives to convey implications of climate change.

Getting a broad cross-section of the community to participate is very difficult, as is developing buy-in from the wider community. Online engagement, as used in this project, was successful in terms of the breadth of audience reached but not in terms of garnering strong feedback.

Cognitive barriers can pose a strong barrier to agencies supporting community-led adaptation. Agency professionals may readily accept the likelihood of extreme climate events but still only accept adaptation pathways based on incremental, rather than radical, change.

E.2.5 Role of government

The role of the government is currently outlined in the Victorian Climate Change Adaptation Plan, released in April 2013.[42] The plan sets out six key strategies to build Victoria's climate resilience, providing a new framework for adaptation planning across the Victorian Government:

- managing risks to public assets and services
- managing risks to natural assets and natural resource-based industries
- building disaster resilience and integrated emergency management
- improving access to research and information for decision making
- supporting private sector adaptation
- strengthening partnerships with local government and communities.

There is still a substantial public debate to be had regarding the extent of the role of government in engagement with communities that display low levels of resilience. Is the government merely the insurer of last resort? In which case, there also needs to be a clear demarcation of personal responsibilities. For example, should people who choose to live in areas prone to flood or bushfire be expected to assume associated risks?[43]

It is critical that resilient systems, as a function of the circumstances and means by which they are developed, avoid maladaptive development. It is therefore important to ensure that we profile and develop resilience systematically and systemically to inform private and public decision making.

Government has a major role to play in facilitating these changes and in supporting the formal adoption and application of resilience mechanisms. But, government should not assume the role of sole decision maker and practitioner when communities themselves need to acquire the skills and ability to respond effectively. Initiatives should include policy, regulation and strategic planning.

Where government uses resilience monitoring as the basis for increased investment in programs that seek to improve long- and short-term responses to climate change, it is crucial that these measures:

- consider, formulate and address a suite of measures of vulnerability
- audit as many community assets as is practical to assess adaptive capacity
- avoid maladaptation.

Pocket Park with olive trees and rosemary, West Melbourne

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GLOSSARY

AAS	Australian Academy of Sciences
ABC	Actions for Biodiversity Conservation
ACOLA	Australian Council of Learned Academies
AD	Anaerobic Digestion
AEMO	Australian Energy Market Operator
AGEIS	Australian Greenhouse Emissions Information System
AHURI	Australian Housing and Urban Research Institute
ALGA	Australian Local Government Association
ALS	Aquatic Life Scores
AMB	Australian Maritime Boundaries
AMSIS	Australian Marine Spatial Information System
ANDI	Australian National Development Index
ANDS	Australian National Data Services
AODN	Australian Ocean Data Network
API	Airborne Particle Index
AURIN	Australian Urban Research Infrastructure Network
AustLII	Australian Legal Information Institute
BAU	Business As Usual
BISON	Biodiversity Information Serving Our Nation
BLANkET	Base Line Air Network of EPA Tasmania
BOM	Bureau of Meteorology
BRCIM	Bushfires Royal Commission Implementation Monitor
BREE	Bureau of Resource and Energy Economics
BRT	Bus Rapid Transit
CAD	Central Activity Districts
CAPIM	Centre for Aquatic Pollution Identification and Management
CFA	Country Fire Authority
CfES	Commissioner for Environmental Sustainability
CHD	Critical habitat determinations
CIV	Community Indicators Victoria
CMA	Catchment Management Authority
COAG	Council of Australian Governments
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DART	Doncaster Area Rapid Transit
DEPI	Department of Environment and Primary Industries
DPC	Department of Premier and Cabinet
DPCD	Department of Planning and Community Development
DTF	Department of Treasury and Finance
DTPLI	Department of Transport, Planning and Local Infrastructure
EP&L	Environmental Profit and Loss
EPA	Environment Protection Authority
EPM	Ecological Processes Management
ESD	Environmentally Sustainable Development
ESI	Energy Saver Incentive
ESO	Environmental Significance Overlay
EVD	Ecological Vegetation Division
EWR	Environmental Water Reserve
FAO	Food and Agriculture Organization
FFG	Flora and Fauna Guarantee Act
GA	Geoscience Australia
GAA	Growth Areas Authority
GDP	Gross domestic product
GEMS	Greenhouse and Energy Minimum Standards
GHG	Greenhouse gas
GM	Genetically modified
GMA	Groundwater Management Areas
GWP	Global warming potential
IEA	International Energy Agency
IMOS	Integrated Marine Observing System
INFFER	Investment Framework for Environmental Resources
IPCC	Intergovernmental Panel on Climate Change
ISC	Index of Stream Condition
ITS	Integrated Transport Systems
IWC	Index of Wetland Condition
IWCM	Integrated Water Cycle Management
LCA	Life-Cycle Assessment
LCI	Life-Cycle Inventory
LIAC	Logical Inclusions Advisory Committee
LULUCF	Land use, land-use change and forestry
MAC	Ministerial Advisory Council
MAV	Municipal Association of Victoria
MDB	Murray-Darling Basin
MEFL	Moreland Energy Foundation Ltd
MERI	Monitoring, Evaluation, Reporting and Improvement
MES	Modern Energy System
MITOD	Mixed-Income Transit-Oriented Developments
MLDRIN	Murray Lower Darling Rivers Indigenous Nations
MMBW	Melbourne and Metropolitan Board of Works
MPA	Marine protected areas
MPA	Melbourne Planning Authority
MSSI	Melbourne Sustainable Society Institute
NABERS	National Australian Built Environment Rating System
NatHERS	Nationwide House Energy Rating Scheme
NCCARF	National Climate Change Research Facility
NCI	National Computational Infrastructure
NDC	Neighbourhood Development Corporations
NEM	National Electricity Market
NEPM	National Environment Protection Measure
NEXIS	National Exposure Information System
NGO	Non-Governmental Organisation

Continued from previous page.

NIMPIS	National Introduced Marine Pest Information System
NPEI	National Plan for Environmental Information
NPI	National Pollution Inventory
NRM	Natural Resource Management
NVIM	Native Vegetation Information Management
NWC	National Water Commission
NWI	National Water Initiative
OECD	Organisation for Economic Co-operation and Development
OLV	Office of Living Victoria
OVGA	Office of the Victorian Government Architect
PAO	Public Acquisition Overlay
PCB	Polychlorinated biphenyls
PCV	Permissible Consumptive Volumes
PEU	Primary energy use
PPA	Pest plants and animals
PTDM	Parking and Transportation Demand Management
PTV	Public Transport Victoria
RCS	Regional catchment strategies
RET	Renewable Energy Target
RIS	Regulatory Impact Statement
RMIT	Royal Melbourne Institute of Technology
SA	Statistical Areas
SAM	Strategic adaptive management
SCATS	Sydney Coordinated Adaptive Traffic System
SDL	Sustainable diversion limits
SEAP	Sustainable Energy Action Plan
SEEA	System of Economic and Environmental Accounting
SEPP	State Environment Protection Policies
SEQ	South East Queensland
SPPF	State Planning Policy Framework
SV	Sustainability Victoria
TEEB	The Economics of Ecosystems & Biodiversity
TERN	Terrestrial Ecosystem Research Network
TFI	Tolerable fire interval
TOD	Transit-oriented developments
TRACE	Transport Resilience and Climatic Extremes
UDIA	Urban Development Institute of Australia
UGB	Urban Growth Boundary
ULED	Ultra-Low Emission Discount
UNAA	United Nations Association of Australia
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNSW	University of New South Wales
USAID	United States Agency for International Development
USGS	United States Geological Survey
VAGO	Victorian Auditor-General's Office
VBA	Victorian Biodiversity Atlas
VBRC	Victorian Bushfire Royal Commission
VBRRA	Victorian Bushfire Reconstruction and Recovery Authority
VCAT	Victorian Civil and Administrative Tribunal
VCC	Victorian Coastal Council
VCCCAR	Victorian Centre for Climate Change Adaptation Research
VCMC	Victorian Catchment Management Council
VCS	Victorian Coastal Strategy
VEET	Victorian Energy Efficiency Target
VEWH	Victorian Environmental Water Holder
VFMP	Victorian Forest Monitoring Program
VLUIS	Victorian Land Use Information System
VOC	Volatile organic compounds
VPP	Victoria Planning Provisions
VSIS	Victorian Soil Information System
VVP	Victorian Volcanic Plain
WSPA	Water Supply Protection Areas
WSUD	Water-sensitive urban design

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53. *2011 Australia. State of the Environment report* (Commonwealth of Australia) found at http://www.environment.gov.au/soe/2011/ accessed on 2 September 2013.

54. See our report *Many publics. Participation, inventiveness and change 2011* for an extensive discussion of the differences inherent in data, knowledge and information.

55. Objectives are outlined in *Commissioner for Environmental Sustainability Act 2003* section 7 and include reporting on the condition of the natural environment; encouraging decision making that facilitates ecologically sustainable development; enhancing knowledge and understanding of issues; and encouraging sound environment practices and procedures in the Victorian and local governments.

56. Accountabilities are outlined in *Commissioner for Environmental Sustainability Act 2003* section 10 and include integrating environmental, economic and social considerations to benefit the community and future generations; reporting to add value and achieve benefits for Victorians; focusing on developing solutions and improvements; and operating with impartiality and openness.

57. See State of the Environment reporting from all jurisdictions including the *2011 Australia. State of the Environment report* (Commonwealth of Australia) found at http://www.environment.gov.au/soe/2011/ accessed on 2 September 2013.

58. See *Climate Change Victoria: the Science, our people and our state of play* found at www.ces.vic.gov.au and consider *Driving Force*, Part 2, 2008 *State of the Environment Report* also found at www.ces.vic.gov.au.

59. In all the footnotes which describe recommendations from the 2008 State of the Environment report the abbreviations are as follows: PCW – Production Consumption and Waste; E – Energy; WR – Water Resources; M – Materials; SOE – State of the Environment; A – Atmosphere; LB – Land and Biodiversity; IW – Inland Waters; CES – Coasts, Estuaries and the Sea; LW – Living Well in the Environment.

60. This goal is considered in our foundation paper *Climate change Victoria: the science, our people and our state of play* found at www.ces.vic.gov.au and is reflected in the recommendations contained in the *State of the Environment Report 2008* and numbered LB8.1,CES0.1,LW17,LW22,A0.1,A14,A1.6, A1.3,LB9.8,LB9.5,LB9.3,LB3.4, LB9.11, IW6.1, LB9.9, LB9.10, A1.11, A1.5, A2.3, A2.4.

61. This goal is reflected in the recommendations contained in the *State of the Environment Report 2008* and numbered IW5.1,IW5.3,IW5.4,IW5.5,IW6.2,IW6.3,IW6.4,LB4.1,LB6.1, LB6.2,LB9.6.

62. This goal is reflected in the recommendations contained in the *State of the Environment Report 2008* and numbered IW0.2,IW0.3,LB2.11

63. This goal is reflected in the recommendations contained in the State of the Environment Report 2008 numbered CES4.8, CES3.10, CES 2.1, CES2.2,CES2.3, CES2.4,CES1.7,CES0.4,CES3.1, CES3.2,CES3.4,CES3.6, CES3.7,CES2.7,CES2.8,CES2.9, CES2.10, CES2.11

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