

BIODIVERSITY (B)

SCIENTIFIC ASSESSMENTS Part III



Commissioner
for Environmental
Sustainability
Victoria





Traditional Owners

The Commissioner for Environmental Sustainability proudly acknowledges Victoria's Aboriginal community and their rich culture and pays respect to their Elders past and present.

We acknowledge Aboriginal people as Australia's first peoples and as the Traditional Owners and custodians of the land and water on which we rely. We recognise and value the ongoing contribution of Aboriginal people and communities to Victorian life, and how this enriches us.

We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

Biodiversity

The Biodiversity chapter has 35 indicators divided across 5 themes, including: Invasive Plants and Animals, Threatened Species, Protecting Victoria's Biodiversity, Freshwater Biodiversity and *Biodiversity 2037* Indicators. This chapter does not include indicators on marine and coastal biodiversity or forests biodiversity which are reported in the Marine and Coastal Environments and Forests chapters respectively.

Background

Healthy land, water and biodiversity are essential for the health and wellbeing of all Victorians. For example, providing ecosystem services such as clean air, drinking water, improved soil health for food production and human to nature contact resulting in a variety of health benefits. A healthy Country is fundamental to the cultural, spiritual, physical and economic wellbeing of Traditional Owners and Aboriginal Victorians.

Victoria's terrestrial area covers 22.8 million hectares, with public land making up 8.4 million hectares or 37% of the state.¹ Public land includes all Crown land and land owned by Victorian Government entities and excludes private freehold land, land owned by local councils and Commonwealth land. The 2017 Victorian Environmental Assessment Council (VEAC) Assessment of Public Land found that terrestrial biodiversity values were highest on public land, with over 70% categorised as having the highest biodiversity values.² Victoria's protected area system supports 40% of the highest biodiversity values on less than 20% of public land.³

Biodiversity in this chapter is defined as the diverse range of native animal and plant species that create ecological communities (habitats) that form Victoria's natural environment. Local and international tourism contributes \$26 billion to Victoria's economy annually.⁴ Of this, \$1.4 billion is spent visiting Victoria's parks to experience the

state's natural environment.⁵ This generates \$1 billion gross value added to Victoria's economy, while supporting 14,000 jobs across the state.⁶ Biodiversity is also essential for Victoria's agriculture, forestry and fisheries sectors, which economically contribute approximately \$8 billion, comprising 2.8%, of the annual Gross State Product. Biodiversity research also attracts significant investment from multiple research institutions, where on average 215 research permits are issued annually for land managed by Parks Victoria.⁷ This research contributes to a greater understanding of Victorian biodiversity while supporting local community economies.

Victoria has experienced extensive biodiversity loss over the past two centuries due to land clearing, fire, pest plants and animals, land development, river regulation, water pollution and, more recently, reduced resilience under climate change. This loss and degradation impacts the supply of essential ecosystem services, posing a potential risk to sectors dependent on functioning ecosystems and the future health, wellbeing and prosperity of all Victorian communities.

Victoria's native species are integral to the functioning of Victoria's natural and agricultural systems. Due to the cumulative physical pressures, and a historically fragmented approach to policy investment and management implementation, many of Victoria's native species are now considered threatened.⁸

Native vegetation continues to be lost at approximately 4,000 habitat hectares per year.⁹ Native vegetation clearing has created fragmented and degraded habitats across Victoria. Reduced extent and quality of native vegetation increases risk, vulnerability and exposure of native animals and plants to other pressures and threats.

1 VEAC 2017, 'Statewide Assessment of Public Land Final Report', Melbourne, Victoria.

2 Ibid

3 Ibid

4 Victorian Tourism Industry Council 2018, <https://www.vtic.com.au> Accessed 24 October 2018.

5 DELWP 2017, 'Protecting Victoria's Environment – Biodiversity 2037', Melbourne, Victoria.

6 Ibid

7 VEAC 2017, 'Statewide Assessment of Public Land Final Report', Melbourne, Victoria.

8 DEPI 2014, 'Advisory list of rare or threatened plants in Victoria – 2014', Melbourne, Victoria.

DEPI 2013, 'Advisory list of threatened vertebrate fauna – 2013', Melbourne, Victoria.

DEPI 2009, 'Advisory list of threatened invertebrate fauna in Victoria – 2009', Melbourne, Victoria.

9 Ibid

Victoria has the highest number of threatened species by subregion in Australia. Since European settlement there has been a progressive rate of native animal and plant extinction with Victoria losing 18 mammal species, 2 birds, 1 snake, 3 freshwater fish, 6 invertebrates and 51 plants.¹⁰ Conserving habitats and connecting fragmented native vegetation to create nature corridors that allow species movement will minimise the vulnerability of Victoria's threatened species.

There are several overarching policy and management challenges facing Victoria's biodiversity now and into the future, including:

- streamlining land management units, for example: bioregions; Catchment Management Authority (CMA) regions; State Environment Protection Policy (SEPP) bioregions; forest regions; Victoria's weed biomes; and Department of Environment, Land, Water and Planning (DELWP) Biodiversity Response Planning regions, to present a coherent and integrated evidence base to improve management interventions and, ultimately, biodiversity outcomes
- complementary investment in improving data capability to routinely monitor progress towards biodiversity outcomes
- lack of coordination and a strategic approach to investing in the critical research that will enable better, and timelier, decision making and policy interventions
- protecting native vegetation to halt habitat loss and reduce habitat fragmentation and degradation, especially on private land
- reducing the increasing number and distribution of invasive species across public and private land and water systems that are causing habitat degradation and impacting on native species populations
- maintaining and/or increasing populations of the growing number of threatened native species and threatened ecological communities
- planning and implementing environmental adaptation to climate change pressures
- annual reporting on biodiversity investment programs to increase transparency of spending and improve consistency and accuracy of results and outcomes from management actions to better understand and manage Victoria's biodiversity
- increasing rigour of rehabilitation programs and access to them and, as a last resort, offsetting schemes to achieve strategic biodiversity outcomes on private land
- The general lack of an integrated and well-designed monitoring and assessment program to answer key biodiversity, ecological and management questions poses persistent challenges in conserving Victoria's natural assets, including:
 - cessation of funding for long-term strategic biodiversity monitoring programs
 - disparate biodiversity datasets that are not routinely updated, reducing accessibility and utility of available data for real-time application and planning
 - lack of data making it difficult to establish the status of threatened species, specifically their abundance, population age structure and distribution
 - methodological changes and new emerging short-term funded target projects that make it difficult to determine biodiversity trends over time. While changes can improve data quality, it is often unclear whether biodiversity changes are due to actual ecological changes or increased accuracy in the methodological approach
 - difficulty in establishing the distribution and abundance of invasive plants and animals due to the lack of data
 - the need to improve poor knowledge regarding the status of reptiles, amphibians, invertebrates, lichens and fungi

¹⁰ Ibid

Current Victorian Government Settings: Legislation, Policy, Programs

In 2017, the Victorian Government released *Protecting Victoria's Environment – Biodiversity 2037 (Biodiversity 2037)* with the aim of stopping the decline of Victoria's biodiversity and achieving an overall biodiversity improvement over the next 20 years.¹¹ Under the two goals of 'Victorians value nature', and 'Victoria's natural environment is healthy', *Biodiversity 2037* is committed to providing an opportunity for Traditional Owners and Aboriginal Victorians to be involved in biodiversity planning, management and decision-making; self-determination; land justice; and economic advancement. Key targets under the plan include five million Victorians acting to protect the natural environment; ensuring that endangered species will persist in natural environments; and achieving a net gain in the overall extent and condition of terrestrial, marine and waterway habitats.

Under *Biodiversity 2037*, State Government funding has been made available to support on-ground biodiversity action to protect and manage threatened species and communities. Incentives include:

- 2018 Community and Volunteer Action Grants – \$2.4 million for 73 projects across Victoria, with durations of between 1 and 3 years, to support communities to conserve their local biodiversity and threatened species
- regional landscapes and targeted action – \$4.7 million to fund 67 projects that include large-scale and targeted management projects to protect threatened species and research to better understand native flora and fauna conservation
- 2018 biodiversity response planning – \$35.6 million for on-ground biodiversity actions and \$2.5 million for marine-targeted actions to be delivered across 3 years over 11 geographic areas

- 2018 crowdfunding – \$116,000 to match efforts of community crowd-funded projects in 2018 to support threatened species and biodiversity conservation campaigns
- regional biodiversity hubs – \$7.7 million for 26 large-scale regional hubs and associated projects to remove woody weeds, pest plants and animals and implement protection measures. Additional funding of over \$1 million allocated to delivering eight urgent projects and \$2 million to support intensive management actions for iconic threatened species such as the Baw Baw frog, brushtailed rock wallaby, eastern barred bandicoot, mountain pygmy possum, orange-bellied parrot, hooded plover, regent honeyeater and plains-wanderer
- support programs – DELWP in collaboration with scientists and communities to increase and share knowledge to manage and respond to biodiversity risks, including seminars, regional events, forums and tools to complement on-ground activities.

All the above incentives, and their projects, will be assessed on how well they contribute to *Biodiversity 2037* targets under the goal 'Victoria's natural environment is healthy'.

The Guidelines for the Removal, Destruction or Lopping of Native Vegetation aim to prevent net loss to biodiversity.¹² The guidelines provide a three-step approach:

- Avoid the removal, destruction or lopping of native vegetation.
- Minimise impacts from the removal, destruction or lopping of native vegetation that cannot be avoided.
- Provide an offset to compensate for the biodiversity impact from the removal, destruction or lopping of native vegetation.

¹¹ DELWP 2017, 'Protecting Victoria's Environment – Biodiversity 2037', Melbourne, Victoria. This plan is supported by a technical document *Protecting Victoria's Environment – Biodiversity 2037: Supporting Technical Supplement* containing references, further reading and sources for all factual statements included in the Plan.

¹² DELWP 2017, 'Guidelines for the removal, destruction or lopping of native vegetation', Melbourne, Victoria.

The guidelines are an incorporated document in Victoria's planning system, which requires a permit to remove native vegetation. The three-step approach is applied when assessing whether or not to grant a permit, and when determining the conditions on any permits granted.

The Victorian Government has also reviewed the *Flora and Fauna Guarantee Act 1988* (FFG Act) with the aim to more effectively protect Victoria's biodiversity in the face of existing and emerging threats. The Flora and Fauna Guarantee Amendment Bill was introduced to Parliament on 23 May 2018 to amend the Act with a new framework for biodiversity protection and management, including Victoria's native species and important habitats. The Bill was debated in the Legislative Assembly and passed without amendment. It was subsequently introduced into the Legislative Council but was not debated before the final scheduled parliamentary sitting day of the 58th Parliament of Victoria.

The Invasive Plants and Animals Policy Framework (IPAPF) represents the government's approach to managing existing and potential invasive species across the whole of Victoria.¹³ It prioritises actions based on a biosecurity approach that aims to:

- prevent the entry of new high-risk invasive species
- eradicate those that are at an early stage of establishment
- contain where possible species that are beyond eradication
- take an asset-based approach to managing widespread invasive species.

DELWP's *Science Statement*, released in 2017, outlines how DELWP will increase connectivity and discoverability and promote science across the department, with department agencies, partners, stakeholders and the community.¹⁴ The statement has three main foci: community participation and ownership, informing policy and operational decisions, and building blocks for the future. DELWP's *Science Statement Implementation Plan*, launched in 2018, is structured on four key themes: we value and lead in science, we build our capability, we connect and collaborate, and we share.¹⁵ Each key theme will be delivered through priority actions during 2018, with finalisation and release of a *Science Statement* evaluation framework, data standards and data catalogues in 2019.

13 DEDJTR 2018, 'Invasive plants and animals policy framework', Melbourne, Victoria <http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/protecting-victoria-from-pest-animals-and-weeds/invasive-plants-and-animals/invasive-plants-and-animals-policy-framework> Accessed 3 October 2018

14 DELWP 2017, 'DELWP Science Statement', Melbourne Victoria.
15 DELWP 2018, 'DELWP Science Statement Implementation Plan', Melbourne, Victoria.

Invasive Plants and Animals

This theme will report on invasive (pest) terrestrial and freshwater plants and animals. These are defined as species that have been brought into a natural system by humans across a geographical barrier and are recognised as a serious threat to biodiversity.¹⁶ Their impacts are likely to be exacerbated by operating in combination with other emerging and ongoing threats such as climate change and habitat degradation.¹⁷ These animal and plant species pose a major threat to biodiversity, ecosystem health, primary production and landscape aesthetics. The terms 'invasive' and 'pest' are used interchangeably in this section of the report. Current Victorian legislation that addresses the management of invasive plants and animals includes: *Catchment and Land Protection Act 1994* allows weeds to be declared noxious, the *FFG Act*, *National Parks Act 1975* and *Sustainable Forests (Timber) Act 2004*. These regulatory frameworks set out environmental objectives to manage invasive plants and animals. The IPAPF provides a whole-of-Victorian-Government approach to managing existing and potential invasive species. Marine and coastal invasive plants and animals are reported in the Marine and Coastal Environments chapter.

¹⁶ White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.

¹⁷ Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:01 Invasive freshwater plants and animals					?	 Poor
Data custodian DELWP, DEDJTR						

The following SoE biodiversity indicators have been aggregated to inform the distribution and management of freshwater invasive species:

- trends in the types and extent of freshwater invasive plants and animals
- threatening processes impacting on native freshwater plants and animals.

Freshwater invasive plant species can form dense infestations that reduce the diversity of freshwater plants and have secondary impacts on freshwater animals such as invertebrates and fish.¹⁸ These impacts can alter freshwater habitats and threaten their long-term function if not managed.¹⁹ Freshwater invasive plants can also impact on recreational values such as swimming, fishing and boat navigation. In some cases of dense plant populations, unpleasant odours can affect those living near the water body or interacting with it.²⁰ In irrigation channels, invasive plant species can limit water flow, and, in some cases of excessive plant growth, cause channels to overflow.²¹

The costs of the impact that invasive species have on waterways in Victoria have not been fully estimated.²² The Victorian Waterway Management Strategy outlines a risk-based approach framework for managing invasive species dependent on freshwater and riparian habitats in Victorian waterways.²³ Investment spent on controlling and preventing the spread of freshwater and riparian invasive species to date includes:²⁴

- approximately \$15.8 million per annum spent on carp control in Australia
- \$1.8 million spent in 2006 at Rocklands Reservoir to restrict the spread of carp in the Glenelg River
- approximately \$250,000 per annum spent by Goulburn–Murray Water and Murray Irrigation Ltd to control the spread of arrowhead (an inland aquatic weed) in irrigation channels and natural waterways in northern Victoria
- considerable sums spent on willow control by Victorian waterway managers.

In addition to the direct costs of freshwater invasive species management, invasive species can undermine the outcomes of previous investment into waterway management activities.²⁵

Aside from carp (*Cyprinus carpio*), the SoE 2018 is unable to report on these indicators. There is a lack of comprehensive and accurate statewide data on population numbers and trends of invasive freshwater pest plants and animals, and their threatening processes. Where data is available, it is limited to artificial standing water bodies and irrigation channels²⁶ and some regulated rivers such as the Murray–Darling Basin river.²⁷

18 Dugdale TM, Hunt TD, Clements D 2013, 'Aquatic weeds in Victoria: where and why are they a problem, and how are they being controlled?' *Plant Protection Quarterly*, 28(2), pp. 35–40.

19 Ibid

20 Ibid

21 Ibid

22 DEPI 2013, 'Improving our waterways. Victorian waterway management strategy', Melbourne, Victoria.

23 DEPI 2013, 'Improving our waterways, Victorian waterway management strategy', Melbourne, Victoria.

24 Ibid

25 Ibid

26 Ibid

27 DELWP 2017, 'Victorian environmental flows monitoring and assessment program (VEFMAP) stage 6. Project update – 2017 pilot monitoring of aquatic and river bank vegetation', Melbourne, Victoria.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:01A Trend in Carp (<i>Cyprinus carpio</i>) Distribution						 DATA QUALITY Good
Data custodian DELWP, DEDJTR						

Carp is a highly prolific, invasive fish species, abundant in south-east Australia. Carp are considered pests because they can dominate aquatic environments to the detriment of native fish species and other parts of the freshwater ecosystem. Control of carp is difficult; actions to date have largely been localised, with a focus on harvesting adult fish. Carp control through mortality is only part of the approach to manage populations. Management needs to consider the capacity of populations to increase through reproduction and recruitment, both locally and from movements from other locations.²⁸

Reproduction and movement of carp is linked to flows – especially over-bank flows that inundate wetlands and floodplains, giving them access to favoured habitats for spawning and recruitment of young. The delivery of water, either for irrigation demands or to achieve environmental outcomes, may inadvertently benefit carp by enhancing their access to preferred breeding habitats, creating management trade-offs.²⁹

In 2016, the Australian Government initiated the National Carp Control Plan.³⁰ The plan, due to be completed in 2018, will be based on research, planning and consultation necessary to enable an informed decision on carp biocontrol using cyprinid herpesvirus 3 (CyHV-3), a naturally occurring strain of carp herpesvirus. As part of the National Carp Control Plan, Victoria's Arthur Rylah Institute for Environmental Research, in partnership with La Trobe University, will lead a five-state collaborative project to determine how many carp are in eastern Australia.³¹ The project, 'A carp biomass

estimate for eastern Australia', will be undertaken across a range of habitat types including rivers, lakes, billabongs and estuaries and will allow for fluctuating carp numbers through time. The project aims to:

- provide a robust estimate of carp abundance, distribution and biomass
- contribute to the development of virus release strategies
- help predict locations where there may be high carp mortalities to plan for clean-up and management of potential impacts on water quality
- benchmark environmental condition prior to release of the carp virus.

The results of this study and any management actions will inform future SoE reporting for this indicator.

²⁸ Koehn JD, Todd CR, Zampatti BP, Stuart IG, Conallin A, Thwaites L, Ye Q 2018, 'Using a population model to inform the management of river flows and invasive carp (*Cyprinus carpio*)', *Environmental Management*, 61, pp. 432-442.

²⁹ Ibid

³⁰ Australian Government 2018, 'National carp control plan restoring native biodiversity', <http://www.carp.gov.au/> Accessed 16 November 2018.

³¹ Arthur Rylah Institute 2018, 'Preparing for carp herpesvirus', <https://www.arivic.gov.au/research/pests-weeds-and-overabundant-species/preparing-for-carp-herpesvirus> Accessed 24 November 2018.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:02 Invasive terrestrial plants						 DATA QUALITY Good
Data custodian DELWP, DEDJTR						

This SoE 2018 indicator includes the following terrestrial pest plant categories:

- Naturalised flora taxa – Naturalised taxa originate from either outside Australia or interstate, or they are Victorian natives that have become established long-term self-sustaining populations outside their pre-European range. Examples of Victorian natives that have become naturalised taxa include spotted gum (*Corymbia maculata*) and coastal umbrella-bush (*Acacia cupularis*), used as ornamental plantings.³² Naturalised flora taxa may not adversely impact native plants and/or animals or functioning ecosystems.
- Environmental weeds – Environmental weeds are a subset of naturalised taxa. These plants invade native ecosystems and have the potential to adversely affect the survival of native plants, animals and functioning ecosystems. They include plant species that have been introduced to Australia from other countries, as well as native plant species that have spread beyond their previous natural range due to changed land management or practices (examples include sallow wattle, coastal wattle and coastal tea tree).³³ Environmental weeds are a threat to Australia’s biodiversity because they can displace native plant species, disrupt ecological processes such as fire and soil erosion patterns, and alter the genetic composition of native plant populations.³⁴

The number of naturalised plants has increased steadily since settlement, with a fivefold increase since the early 20th century (Table B.1).^{35,36} Victoria is home to at least 1,451 naturalised plant taxa which is about 25% of the total flora.^{37,38} Of these, 1,235 species (85%) are environmental weeds that are established in Victorian native vegetation (Figure B.1).³⁹ This is almost double the number of environmental weeds identified in 1992 (584, equating to 48%) (Figure B.2).^{40,41} Many more plant species than those currently recognised as environmental weeds have been introduced into Victoria, and a proportion of these are likely to escape their current confines (such as gardens and aquariums) and become established in the wild.⁴²

³² White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.

³³ Ibid

³⁴ Ibid

³⁵ Carr GW, 1993, 'Exotic flora of Victoria and its impacts on indigenous biota', In: Flora of Victoria Volume 1, pp 256–97. Foreman, D. B and Walsh, N. G. (eds). Inkata Press, Port Melbourne, Victoria.

³⁶ White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.

³⁷ VNPA 2014, 'Natural Victoria: conservation priorities for Victoria's natural heritage. Nature conservation review. Full Report', Melbourne, Victoria.

³⁸ White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.

³⁹ Ibid

⁴⁰ Carr GW, Yugovic JV, Robinson KE 1992, 'Environmental weed invasions in Victoria: conservation and management implications', Department of Conservation and Environment, Melbourne, Victoria.

⁴¹ White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.

⁴² Ibid

Table B.1 Increasing trend in the number of naturalised plants and environmental weeds established in Victorian native vegetation, 1909–2018⁴³

Year	Naturalised plants	Environmental weeds
1909	363	Unknown
1928	461	Unknown
1976	747	Unknown
1988	878	Unknown
1992	1,221	584
1993	1,221	584
2018	1,451	1,235

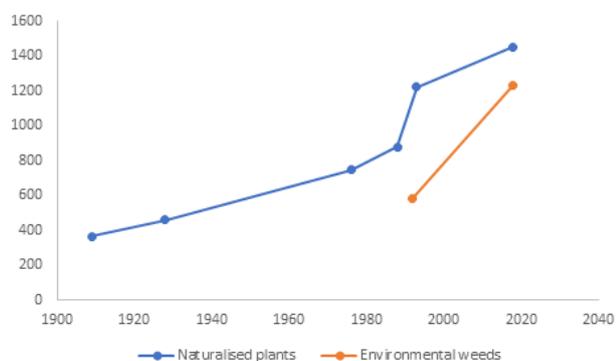


Figure B.1 Number of naturalised plants and environmental weeds in Victoria, 1909–2018

Note: The steep incline in naturalised plants between 1988 and 1993 coincides with the publication of the *Flora of Victoria*, which created awareness of the distribution and impact of these species on native vegetation.⁴⁴

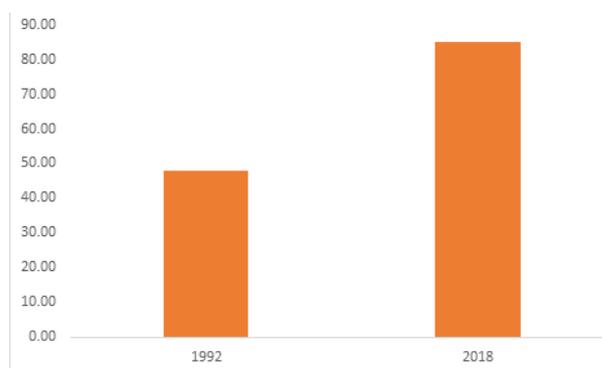


Figure B.2 Increase in percentage of naturalised plants considered to be environmental weeds, 1992–2018⁴⁵

43 Carr GW, Yugovic JV, Robinson KE 1992, 'Environmental weed invasions in Victoria: conservation and management implications', Department of Conservation and Environment, Melbourne, Victoria.
Carr GW, 1993, 'Exotic flora of Victoria and its impacts on indigenous biota', In: *Flora of Victoria Volume 1*, pp 256-97. Foreman, D. B and Walsh, N. G. (eds). Inkata Press, Port Melbourne, Victoria.
White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.
Forbes SJ, Ross JH 1988, 'A Census of the vascular plants of Victoria (2nd ed)', Department of Conservation, Forests and Lands, Melbourne, Victoria.

44 White M, Cheal D, Carr GW, Adair R, Blood K, Meagher D 2018, 'Advisory list of environmental weeds in Victoria', Arthur Rylah Institute for Environmental Research Technical Report Series No. 287, Heidelberg, Victoria.

45 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:03 Invasive terrestrial animals						 DATA QUALITY Poor
Data custodian DELWP, DEDJTR						

Pest animals originate from either outside Australia or interstate, and they have established long-term self-sustaining populations. Overabundant population numbers of local native animals can also be pest animals (for example, koalas, kangaroos and possums). Pest animals are also referred to as invasive animals in this indicator.

Established terrestrial pest animals in Victoria include foxes, rabbits, feral pigs, feral goats, feral horses, deer and feral cats, with their impacts recognised through several listings under the FFG Act (Table B.2). Statewide pest animal population numbers in Victoria are currently unknown, however, it is thought that populations, and their distribution, are expanding across Victoria.⁴⁶ Although specific population numbers are not available, the issues posed by increasing deer and horse numbers are described in detail below.

The Environment, Natural Resources and Regional Development Committee Inquiry into the Control of Invasive Animals on Crown Land found that there is a lack of robust data about population numbers and extent of invasive animals and the effectiveness of control methods.⁴⁷ Additionally, the Inquiry found that Victoria’s complex legislative framework and division of responsibilities have contributed to confusion and inefficiencies in controlling invasive animals. Of the 33 Inquiry recommendations, the Victorian Government accepted 29 with one under review.

Recommendation 1 tasked government to allocate resources to the appropriate authority to undertake work to quantify and measure the numbers and impact of invasive species populations.⁴⁸ The government supports this recommendation in principle, with Agriculture Victoria – in the Department of Economic Development, Jobs, Transport, Resources (DEDJTR) – having responsibility for the government’s investment in research and development to advance effective policy tools for invasive animal management.⁴⁹ The government agencies involved in the development of the government’s response will be responsible for prioritising the delivery of the 29 recommendations. Decisions about resourcing to implement these recommendations will be subject to budget processes in the context of the government’s investment and service delivery priorities.⁵⁰

⁴⁶ Environment, Natural Resources and Regional Development Committee 2017, 'Inquiry into the control of invasive animals on Crown land', Parliament of Victoria, Melbourne, Victoria.
⁴⁷ Ibid

⁴⁸ Ibid
⁴⁹ DELWP 2017, 'Government response to the Environment, Natural Resources and Regional Development Committee Inquiry into the control of invasive animals on Crown land. Final Report', Melbourne, Victoria <https://www.environment.vic.gov.au/invasive-plants-and-animals/invasive-animals-parliamentary-inquiry>
⁵⁰ Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:03A Trend in deer populations and their distributions						 DATA QUALITY Poor
Data custodian DELWP, DEDJTR						

Increasing populations of four deer species have been expanding their distribution across Crown and private land. The environmental impacts of deer include: destruction to native vegetation and regeneration; increased revegetation costs; and damage to orchards, vegetable gardens, pastures and fencing.⁵¹ Deer can also cause soil erosion and concentration of nutrients.⁵² An understanding of deer ecology could guide deer management, yet at present this is limited. Addressing this knowledge gap can assist in developing and prioritising cost-effective management strategies.⁵³ At the time of writing this report, the Draft Deer Management Strategy, a partnership document between DELWP and DEDJTR, has been released for public comment.⁵⁴ The strategy is an action under the Victorian Government’s *Sustainable Hunting Action Plan 2016–2020* and it is recognised in the *Biodiversity 2037 Implementation Framework*. The objectives of the draft strategy are to protect ecological, social, economic, cultural and agricultural assets from the impacts of deer and provide diverse, quality hunting opportunities. The performance objectives and associated management actions of the final management strategy will be assessed in the next SoE report.

Sambar Deer

There is a wild, self-sustaining breeding population of sambar deer across an estimated 66,915 km² of Crown land in Victoria, equivalent to 29% of the state’s land area. There are four discrete – that is, reproductively isolated – populations located in eastern Victoria (population distribution range 66,300 km²), French Island (170 km²), Mount Cole (330 km²) and Timboon (115 km²).⁵⁵

Fallow Deer

There are 61 wild, self-sustaining breeding populations of fallow deer in Victoria distributed across 21,400 km².⁵⁶ Population distribution has increased since the 1980s, due to deliberate releases, escapes from farms and dispersal from established populations. It is likely that the distributions will continue to increase in Victoria.

Red Deer

There are 27 wild, self-sustaining breeding populations of red deer in Victoria distributed across 3,900 km².⁵⁷ They have greatly increased their distribution since the 1980s, due to deliberate releases, escape from farms and dispersal from established populations. It is likely that the distributions will continue to increase in Victoria.

Hog Deer

There is one wild, self-sustaining breeding population of hog deer in Victoria with a current breeding distribution of 2,336 km²,⁵⁸ confined to the coastal strip between Tarwin River and Point Hicks. The current population number and its distribution in Victoria is limited by the biophysical factors of its geography and will not further increase from natural dispersal. However, there is a possibility that new hog deer populations could establish themselves in the coastal strip in western Victoria as a result of deliberate releases or escapes from farms.⁵⁹

51 VCMC 2017, ‘Catchment Condition and Management Report 2017’, Melbourne, Victoria.
 52 ibis
 53 Davis NE, Bennett A, Forsyth DM, Bowman DMJS, Lefroy EC, Wood SW, Woolnough AP, West P, Hampton JO, Johnson CN, 2016, ‘A systematic review of the impacts and management of deer (family Cervidae) in Australia. *Wildlife Research*, 43, pp. 515-532.
 54 DELWP 2018, ‘Draft deer management strategy’, Melbourne, Victoria <https://www.environment.vic.gov.au/invasive-plants-and-animals/draft-deer-management-strategy> Accessed on 24 October 2018.

55 Forsyth DM, Stamatation K, Woodford L, 2015, ‘Distributions of Sambar Deer, Rusa Deer and Sika Deer in Victoria’, Arthur Rylah Institute for Environmental Research unpublished client report for the Biosecurity Branch, Department of Economic Development, Jobs, Transport and Resources, Heidelberg, Victoria.
 56 Forsyth DM, Stamatation K, Woodford L, 2016, ‘Distributions of Fallow Deer, Red Deer, Hog Deer and Chital Deer in Victoria’, Arthur Rylah Institute for Environmental Research unpublished client report for the Biosecurity Branch, Department of Economic Development, Jobs, Transport and Resources, Heidelberg, Victoria.
 57 Ibid
 58 Ibid
 59 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:03B Trend in horse populations and their distributions <i>(Equus caballus)</i> Data custodian DELWP, DEDJTR						 DATA QUALITY Fair

Australia has the largest population of wild horses in the world, being in excess of 300,000 animals.⁶⁰ Significant populations of feral horses (*Equus caballus*) occur in two Victorian National Parks: Alpine National Park and Barmah National Park. Feral horse population surveys in the Alpine National Park across two decades have shown that, without management control or severe natural events such as fire, feral horse populations can increase by 10 to 20% every two to four years.⁶¹ At the time of writing this report, the *Alpine National Park – Feral Horse Action Plan 2018–2021* had been approved, with performance objectives and management actions to be assessed in the next SoE report.

Table B.2 Pest animal species and their impacts on Victoria's native ecosystem as listed in the FFG Act

Pest animal	Impact listed under the FFG Act
Feral horse <i>(Equus caballus)</i>	Degradation and loss of native vegetation habitats
Cat <i>(Felis catus)</i>	Predation on native Victorian wildlife
Introduced red fox <i>(Vulpes vulpes)</i>	Predation on native Victorian wildlife
Sambar deer <i>(Cervus unicolor)</i>	Reduction and degradation in biodiversity of native Victorian vegetation
European rabbit <i>(Oryctolagus cuniculus)</i>	Reduction in biomass and biodiversity of native vegetation through grazing
Feral goat <i>(Capra hircus)</i>	Soil degradation and reduction of biodiversity through browsing and competition

60 Hobbs RJ, Hinds LA 2018, 'Could current fertility control methods be effective for landscape-scale management of populations of wild horses (*Equus caballus*) in Australia?', *Wildlife Research*, 45, pp. 195-207.

61 Hobbs RJ, Hinds LA 2017, 'Review of the feasibility of current fertility control methods for management of wild horse populations (*Equus caballus*) in Kosciuszko National Park', Summary report to the Science Division, Office of Environment and Heritage, New South Wales.

Threatened Species

The current Holocene (or Anthropocene) extinction spike represents the sixth and latest extinction episode in the earth's history.⁶² Human activities are the main cause of the Holocene extinction.⁶³ Since European settlement, 18 mammal, 2 bird, 1 snake, 6 invertebrate and 51 plant species are known to have become extinct in Australia. Further, 6 Australian frog species have not been observed in the wild for the past 15 to 36 years, with concerns that they may be extinct.⁶⁴

The FFG Act provides the Victorian framework for listing threatened species, conserving threatened species and communities, and managing potentially threatening processes. Under this legislation, there are over 700 fauna and flora species and ecological communities listed as threatened. In addition to the FFG lists, DELWP also maintains Threatened Species Advisory Lists. Currently, these include Rare or Threatened Plants in Victoria; Threatened Vertebrate Fauna and Threatened Invertebrate Fauna. The Advisory Lists do not have a legislative basis, and they include species that are considered likely to be threatened but have not been through the formal listing processes required under the FFG Act. The Advisory Lists are based on technical information and advice obtained from a range of experts, and they are reviewed periodically. The information in these lists can be used in planning processes, such as the preparation of National Park Management Plans, local government planning schemes and regional catchment strategies, and in setting priorities for actions to conserve biodiversity.

There are no direct legal requirements or consequences that flow from inclusion of a species in an Advisory List, although they are afforded some protection through Victoria's Native Vegetation Management Framework. Also, some of the species in these advisory lists are also listed as threatened under the FFG Act. The FFG Act Threatened List only includes species and communities that have been nominated, assessed by the Scientific Advisory Committee and approved for listing by the Minister for Energy, Environment and Climate Change and the Minister for Agriculture.

The increase in the number of Victorian flora and fauna species and ecological communities listed as threatened is due to the loss, fragmentation and degradation of habitat due to clearing for agriculture, urban development, timber harvesting, weed invasion, inappropriate fire regimes, grazing, climate change and alternation to flows and temperatures in rivers and streams.⁶⁵ Competition for resources and predation by introduced species (such as foxes, rabbits, deer and carp) has had a significant effect on many native species.⁶⁶

In 2018, Victoria signed the Intergovernmental Memorandum of Understanding Agreement on a Common Assessment Method for Listing of Threatened Species and Threatened Ecological Communities (CAM MoU).⁶⁷ The CAM MoU requires signatory parties to adopt the International Union for Conservation of Nature (IUCN) Red List of Threatened Species categories and criteria through legislative reform, to establish a single operational list of threatened species in each jurisdiction and to collaborate in the assessment and periodic review of the conservation status of native species in Australia.

62 Clemann N 2015, 'Cold-blooded indifference: a case study of the worsening status of threatened reptiles from Victoria, Australia', *Pacific Conservation Biology*, 21, pp.15-26.

63 Ibid

64 Skerratt LF, Berger I, Clemann N, Hunter DA, Marantelli G, Newell DA, Phillips A, McFadden M, Hines HB, Scheele BC, Brannelly LA, Speare R, Versteegen S, Cashins SD, West M 2016, 'Priorities for management of chytridiomycosis in Australia: saving frogs from extinction', *Wildlife Research*, 43(2), pp.105-120.

65 Arthur Rylah Institute 2018, 'Threatened plants and animals', Heidelberg, Victoria <https://www.ari.vic.gov.au/research/threatened-plants-and-animals> Accessed 27 September 2018.

66 Ibid

67 Intergovernmental Memorandum of Understanding 2017, 'Agreement on a common assessment method for listing of threatened species and threatened ecological communities' <https://www.environment.gov.au/system/files/resources/36e4ab-82dc-4de9-aac6-9cc54bd7a820/files/mou-cam.docx> Accessed 27 September 2018.

The IUCN Red List of Threatened Species provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using the IUCN Red List Categories and Criteria.⁶⁸ This system is designed to determine the relative risk of extinction, with the main purpose to catalogue and highlight those plants, fungi and animals that are facing higher risk of global extinction. Applying the IUCN Red List Categories and Criteria can assess and determine whether plants, fungi and animals are: Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, Extinct, or Not Evaluated.⁶⁹ DELWP is midway through a project to reassess all currently listed Victorian rare and/or threatened species, according to the IUCN Red List Categories and Criteria, including species listed in the FFG Act Threatened List and the DELWP Advisory Lists. Apart from yielding a single, comprehensive list of Victorian threatened species, this work will also provide the baseline for key targets in *Biodiversity 2037*. This new list will not be comparable to the current DELWP Advisory Lists, creating a new baseline for future trend reporting. An update on this new comprehensive Victorian threatened species list will be made available in 2019.

At the time of writing this report, DELWP was leading a review process for the FFG Act. This review process included public consultation which informed the development of reforms to the FFG Act, resulting in the Flora and Fauna Guarantee Amendment Bill.

68 IUCN 2018, 'IUCN Red List of Threatened Species', <http://www.iucnredlist.org> Accessed 27 July 2018.

69 IUCN 2018, 'IUCN Red List of Threatened Species Technical Documents', <http://www.iucnredlist.org/technical-documents/categories-and-criteria> Accessed 27 July 2018.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04 Trend in populations and distributions of threatened freshwater species in the wild.						 DATA QUALITY Poor

Data custodian DELWP

Since European settlement, three freshwater fish are known to have become extinct and 55% of freshwater fish are considered to be threatened.⁷⁰ Due to a lack of statewide data for the majority of threatened freshwater animal and plant species, the following SoE biodiversity indicators have been aggregated:

- conservation status of freshwater species – measuring the change in the status of FFG Act-listed threatened freshwater species
- trends in populations of selected threatened freshwater species – measuring change in population and distribution of selected freshwater threatened species over time
- management of freshwater threatened species – providing information on threatened species management programs
- recovery and action plans for threatened freshwater species – assessing the comprehensiveness of plans and actions for threatened freshwater species
- re-establishment of threatened freshwater species in the wild, where feasible under climate change – assessing the percentage of critically endangered and endangered species that have at least one option available for being conserved ex situ or re-established in the wild by 2037.

Statewide information is available for three freshwater fish species: trout cod (*Maccullochella macquariensis*), Macquarie perch (*Macquaria australasica*) and Murray Crayfish (*Eustacus armatus*) and three frog species: spotted tree frog (*Litoria spenceri*), Booroolong tree frog (*Litoria booroolongensis*) and Baw Baw frog (*Philoria frosti*) which are reported below. There is no statewide information on threatened freshwater plant species. Some localised threatened species information is available for Victorian rivers which receive environmental watering, such as the Murray–Darling Basin.⁷¹

⁷⁰ DELWP 2016, 'Protecting Victoria's Environment – Biodiversity 2036 Supporting Technical Supplement', Melbourne, Victoria.

⁷¹ DELWP 2017, 'Progress towards outcomes from environmental water in Victoria. Five years into Basin Plan implementation', Melbourne, Victoria.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04A Trend in population number and distribution of trout cod (<i>Maccullochella macquariensis</i>) Data custodian DELWP						 DATA QUALITY Fair

Since 2008, trout cod has been monitored in the Ovens River, Murray River, Goulburn River and Seven Creeks. Since 2010, populations across all of these water systems have been stable or increasing in their abundance and distribution.⁷²

⁷² Lyon JP, Todd C, Nicol SJ, MacDonald A, Stoessel D, Ingram BA, Barker RJ, Bradshaw CJ 2012, 'Reintroduction success of threatened Australian trout cod (*Maccullochella macquariensis*) based on growth and reproduction', *Marine and Freshwater Research*, 63(7), pp. 598-605.
 Koehn JD, Lintermans M, Lyon JP, Ingram BA, Gilligan DM, Todd CR, Douglas JW 2013, 'Recovery of the endangered trout cod, *Maccullochella macquariensis*: what have we achieved in more than 25 years?', *Marine and Freshwater Research*, 64(9), pp. 822-837.
 Lyon JP, Lintermans M, Koehn JD 2018, 'Against the flow: the remarkable recovery of the trout cod in the Murray–Darling Basin', *Recovering Australian Threatened Species: A Book of Hope*, p.199.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04B Trend in population number and distribution of Macquarie perch (<i>Macquaria australasica</i>)						
Data custodian DELWP						DATA QUALITY Good

Since 2008, Macquarie perch has been monitored in the following water systems: Ovens River, Lake Dartmouth, Seven Creeks, King Parrot Creek, Hughes Creek, Yea River, Hollands Creek, Yarra River, Broken River and Buffalo (upper) River. It should be noted that some water systems have only been surveyed three times during this monitoring period. Similar to trout cod, most of these populations have been stable or are increasing in abundance and distribution since 2012. The upper Broken River has seen little recovery from the millennium drought, lasting from 1996 to 2010, creating concern for the remaining Macquarie perch population.⁷³

Trend drivers for Macquarie perch and trout cod will vary between species and populations; however, as a whole, stable-to-improving trends are likely due to a combination of post-drought recovery, riparian and in-stream habitat restoration, environmental water delivery (for relevant water systems), conservation stocking; and improved community education and fisheries regulations.

⁷³ Tonkin Z, Lyon J, Ramsey DS, Bond NR, Hackett G, Krusic-Golub K, Ingram BA, Balcombe SR 2014, 'Reservoir refilling enhances growth and recruitment of an endangered remnant riverine fish', *Canadian Journal of Fisheries and Aquatic Sciences*, 71(12), pp. 1888-1899.
 Tonkin, Z, Kearns, J, Lyon, J, Balcombe, SR, King, AJ and Bond, NR 2017, 'Regional-scale extremes in river discharge and localised spawning stock abundance influence recruitment dynamics of a threatened freshwater fish', *Ecohydrology*, 10(6), pp. 1-11.
 Pavlova A, Beheregaray LB, Coleman R, Gilligan D, Harrison KA, Ingram BA, Kearns J, Lamb AM, Lintermans M, Lyon J, Nguyen TTT, Sasaki M, Tonkin Z, Yen JDL, Sunnucks P 2017, 'Severe consequences of habitat fragmentation on genetic diversity of an endangered Australian freshwater fish: A call for assisted gene flow', *Evolutionary Applications*, 10(6), pp. 531-550.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04C Trend in population number and distribution of Murray crayfish (<i>Euastacus armatus</i>)						 DATA QUALITY Fair
Data custodian DELWP						

The Murray crayfish occurs in the southern Murray–Darling Basin, south-east Australia. It is the second largest freshwater crayfish in the world, growing up to 0.5 m in length and 3 kg in weight and living to 25 years or more.⁷⁴ Commercial harvest of this species stopped in 1987 but there is an active recreational fishery. The cumulative pressures from recreational harvesting, river regulation, pesticides and pollutants, habitat change and events of low dissolved oxygen (hypoxic ‘blackwater’ disturbance) have contributed to declines in both its distribution and abundance. It is now considered a threatened species.⁷⁵

A population viability model for the Murray crayfish assessed the potential effects of a population decline due to the occurrence of a hypoxic blackwater event and the effects of recreational fishing. Results highlighted that Murray crayfish face high risk of population declines due to increasing fishing pressure, particularly when combined with a hypoxic blackwater event. By testing various fishery regulations (such as length limits), the modelling showed that recent changes to the harvestable length limit (10–12 cm, occipital carapace length) for legally harvesting crayfish appears to be a suitable protection measure, given background levels of blackwater disturbance. While the modelling was based on the best available information, some parameters are uncertain due to lack of knowledge associated with survival rates of young crayfish.

74 Todd CR, Whiterod N, Raymond SMC, Zukowski S, Asmus M, Todd MJ 2018, ‘Integrating fishing and conservation in a risk framework: a stochastic population model to guide the proactive management of a threatened freshwater crayfish’, *Aquatic Conservation: Marine and Freshwater Ecosystems*, 28, pp.954-968.

75 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04D Trend in population number and distribution of spotted tree frog (<i>Litoria spenceri</i>)						 DATA QUALITY Good
Data custodian DELWP						Good

The spotted tree frog is currently listed as endangered nationally (*Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) and at state level (FFG Act). It occurs in upland streams of south-eastern Australia. A main driver for decreasing population numbers is the infectious disease chytridiomycosis, caused by the temperature sensitive chytrid fungus *Batrachochytrium dendrobatidis*.⁷⁶ Another driver is the introduction of predatory fish, specifically the brown trout (*Salmo trutta*) and rainbow trout (*Onchorhynchus mykiss*) preying on tadpoles of this species.⁷⁷

⁷⁶ DEE 2016, 'Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis', Australian Government, Commonwealth of Australia.

⁷⁷ Gillespie GR 2001, 'The role of introduced trout in the decline of the spotted tree frog (*Litoria spenceri*) in south-eastern Australia', *Biological Conservation*, 100, pp.187-198.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04E Trends in population number and distribution of Booroolong tree frog (<i>Litoria booroolongensis</i>) Data custodian DELWP						 DATA QUALITY Good

The Booroolong tree frog is currently listed as endangered nationally (EPBC Act) and at state level (FFG Act). It occurs predominantly in streams west of the Great Dividing Range in Victoria. Populations have declined due to habitat degradation, the infectious disease chytridiomycosis and predation by introduced predatory fish, such as European carp (*Cyprinus carpio*), redfin perch (*Perca fluviatilis*) and mosquito fish (*Gambusia hobrooki*) preying on tadpoles of this species.^{78,79}

78 Hunter DA, Smith MJ, Scroggie MP, Gilligan D 2011, 'Experimental examination of the potential for three introduced fish species to prey on tadpoles of the endangered Booroolong frog, *Litoria booroolongensis*', *Journal of Herpetology*, 45(2), pp.181-185.

79 DEE 2016, 'Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis', Australian Government, Commonwealth of Australia.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:04F Trends in population number and distribution of Baw Baw frog (<i>Philoria frosti</i>)						
Data custodian DELWP						DATA QUALITY Good

The Baw Baw frog is the only Victorian endemic frog species. It is currently listed as endangered nationally (EPBC Act) and at state level (FFG Act). Reasons for decline in population numbers and distribution include habitat loss and degradation of their restricted range on the Baw Baw plateau and escarpment area (totalling only 135 km²), and spread of the infectious disease chytridiomycosis.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:05 Threatened species that are wetland dependent					?	 DATA QUALITY Poor
Data custodian DELWP						

Wetlands are defined as natural, modified or artificial areas subject to permanent or temporary inundation that hold static or very slow-moving water and develop, or have the potential to develop, biota adapted to inundation and the aquatic environment.⁸⁰ Data for five fauna groups (Table B.3), based on the Threatened Species Advisory Lists for Victoria, has been used as a proxy for the percentage of Victoria's threatened species that are wetland-dependent.

Table B.3 Number of wetland-dependent threatened species as per the Advisory Lists for Victoria⁸¹

Fauna group	n (%)
Mammals	1 (2%)
Birds	54 (42%)
Reptiles	7 (15%)
Amphibians	13 (72%)
Fish	13 (39%)

80 DELWP 2018, 'Wetlands', <https://www.water.vic.gov.au/waterways-and-catchments/rivers-estuaries-and-waterways/wetlands> Accessed 9 September 2018.

81 DEPI 2014, 'Advisory list of rare or threatened plants in Victoria – 2014', Melbourne, Victoria.
DEPI 2013, 'Advisory list of threatened vertebrate fauna – 2013', Melbourne, Victoria.
DEPI 2009, 'Advisory list of threatened invertebrate fauna in Victoria – 2009', Melbourne, Victoria.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:06 Trends in populations and distributions of threatened terrestrial species Data custodian DELWP						 DATA QUALITY Poor

The following SoE 2018 biodiversity indicators have been aggregated to inform the status of terrestrial threatened species:

- conservation status of terrestrial threatened species – measuring changes in the status of threatened terrestrial species
- trends in population and distribution of selected threatened terrestrial species over time
- threatening processes impacting and affecting terrestrial threatened species.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:06A Vascular Plants						 DATA QUALITY Fair
Data custodian DELWP						

There has been an increasing trend in the number of endangered, vulnerable and rare vascular plants in Victoria. Of the 3,330 known Victorian species, 49 are extinct and 2,097 (63%) are on the Threatened Species Advisory Lists.⁸²

Table B.4 Increasing number of vascular plants on the Advisory Lists for Victoria 2003–14⁸³

Year	Presumed extinct	Endangered	Vulnerable	Rare	Poorly known	Total
2003	48	250	473	818	311	1,900
2005	51	280	493	834	305	1,963
2014	49	366	516	854	318	2,103

⁸² DEPI 2014, 'Advisory list of rare or threatened plants in Victoria – 2014', Melbourne, Victoria

⁸³ Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:06B Vertebrates						
Data custodian DELWP						DATA QUALITY Fair

There has been an increasing trend in the number of critically endangered and vulnerable vertebrate groups, specifically reptiles. To a lesser extent, there has been an increase in the number of endangered vertebrates. Of the known species, those that are threatened include: 22% terrestrial mammals, 19% birds, 30% reptiles and 43% amphibians.⁸⁴

Table B.5 Number of vertebrates on the Advisory Lists for Victoria 2003–13⁸⁵

Year	Extinct	Regionally extinct	Extinct in the wild	Critically endangered	Endangered	Vulnerable	Near-threatened	Data deficient	Total
2003	10	14	-	37	53	70	71	20	275
2007	9	15	-	37	52	72	68	24	277
2013	9	15	1	50	57	84	64	14	294

⁸⁴ DEPI 2013, 'Advisory list of threatened vertebrate fauna – 2013', Melbourne, Victoria.

⁸⁵ Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:06C Invertebrates						
Data custodian DELWP						Fair

There is limited trend information on the number of threatened invertebrates, where currently 178 known species are considered to be threatened.⁸⁶

Table B.6 Number of invertebrates on the Advisory Lists of threatened invertebrate fauna for Victoria, 2009⁸⁷

Year	Extinct	Regionally extinct	Extinct in the wild	Critically endangered	Endangered	Vulnerable	Near-threatened	Data deficient	Total
2009	1	5	0	20	28	79	7	38	178

In 2016, the State Government funded \$2 million across 98 projects in Round Two of the Threatened Species Protection Initiative Community Volunteer Action Grants. At the time of writing this report, the results from these projects were not available.

DELWP is also participating in a research project under the National Environmental Science Program that aims to develop a prototype Threatened Species Index for Australia. The research partners, led by University of Queensland and Birdlife Australia, have already developed a 'proof of concept' index for birds and are now expanding their focus to consider other groups. The index would be accessible via an interactive, web-based application, allowing users to display trend data for particular regions and/or groups of species. The index is based on the methods of the Living Planet Index and incorporates multiple time-series datasets for species populations. A key feature is the ability to combine datasets based on differing parameters and survey methods into one index.

⁸⁶ DEPI 2009, 'Advisory list of threatened invertebrate fauna in Victoria – 2009', Melbourne, Victoria.

⁸⁷ Ibid

Protecting Victoria's Biodiversity

This theme will report on the management for protecting and conserving Victoria's biodiversity on both Crown and private land.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:07 Private Land Conservation						 DATA QUALITY Good
Data custodian Trust for Nature						

Two biodiversity indicators from previous SoE reports have been combined for this report:

- conservation on private land – assessing the area of private land under conservation agreements
- management of biodiversity on private land, assessing activities taken to conserve species, conserve communities and maintain, improve or restore habitat on private land.

It should be noted that data from this indicator can also contribute to *Biodiversity 2037* indicators – Net gain in extent and condition of native vegetation, Landscape scale change, Change in suitable habitat, Area of management in priority locations and Victorians valuing nature – where private land conservation contributes to environmental stewardship.

Victoria has nearly 23 million hectares of land, public land accounts for 37% and private land 63%.⁸⁸ Private land conservation data reported here has been provided by Trust for Nature (the Trust). Other private land conservation agreement types – such as Bush Tender, Bush Heritage and Land for Wildlife – are not reported here as data was not available. Since its establishment under the *Victorian Conservation Trust Act 1972*, the Trust has assisted with the permanent protection of more than 100,000 hectares of native habitat on private land using a range of conservation tools including conservation covenants, land acquisition, donations of land and its Revolving Fund

(Figure B.3).⁸⁹ At the time of writing this report, there were 1,416 voluntary conservation covenants and 43 Trust for Nature properties and/or reserves.

Results from on-ground management actions include:

- 3,700 hectares of weed control
- 68,000 hectares of invasive animal control
- more than 135 ecological surveys and assessments mostly for threatened species

The Trust's current strategic plan commits to an additional 50,000 hectares of permanent protection by 2021, in its own right and with partners. This target closely aligns with *Biodiversity 2037*, which includes a target to protect 200,000 hectares on private land in the next 20 years. Since 2000–01, the Trust has seen an average annual growth of 57 covenants and 2,654 hectares under permanent protection (Figure B.4).

⁸⁸ VEAC 2016, 'Statewide assessment of public land discussion paper', East Melbourne, Victoria.

⁸⁹ Trust for Nature 2018, 'Impact Report 2017–18. Conserving Melbourne, Victoria's most threatened native plants and wildlife for future generations', https://issuu.com/tfnvictoria/docs/tfn3979_2018impactreport_web?e=33399755/65188052 Accessed 24 October 2018.

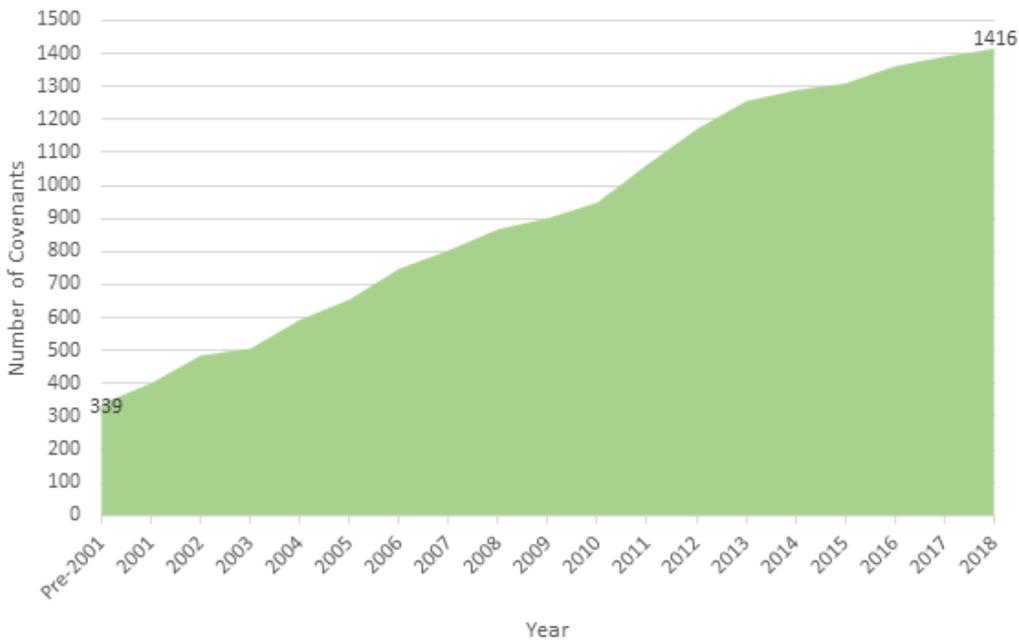


Figure B.3 Growth in the total number of private land covenants, 2001–18

(Data source: TfN, 2018)

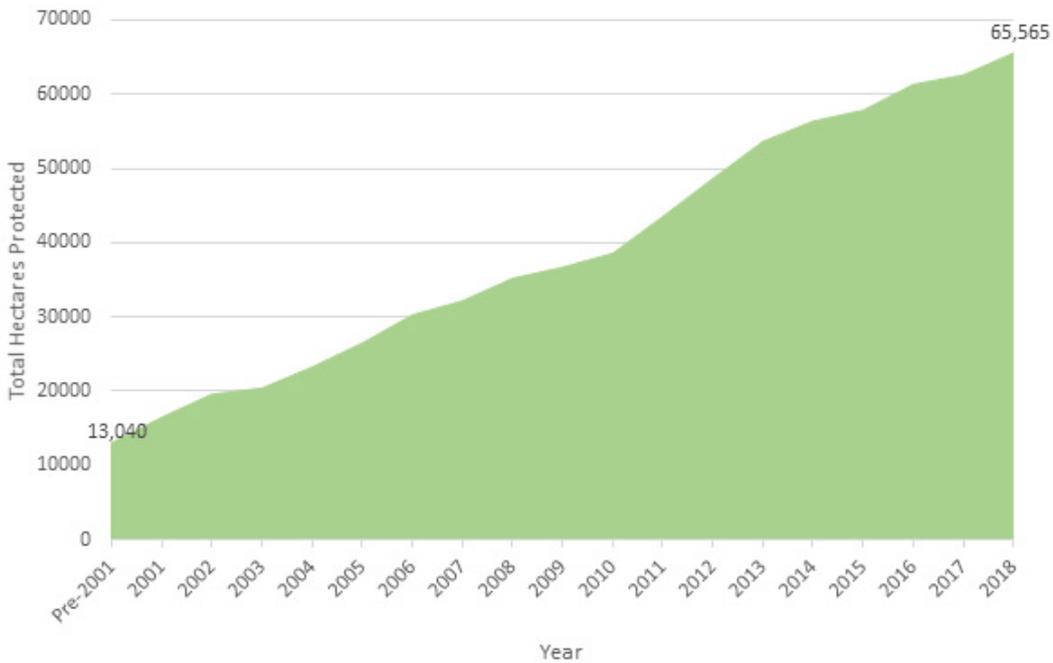


Figure B.4 Growth in total hectares of private land under covenant, 2001–18

(Data source: TfN 2018)

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:08 Conservation of Victorian Ecosystems						
Data custodian Parks Victoria, DELWP						DATA QUALITY
						Good

This indicator assesses Victorian conservation categories, their area in hectares and threatened species in conservation areas. Of the Parks Estate, the top three conservation category types with the greatest area are:

1. National Parks with 2,908,941 hectares
2. Wilderness Parks (Schedule 2A, National Parks Act) with 262,480 hectares
3. State Park (Schedule 2B, National Parks Act) with 149,325 hectares ⁹⁰

These are illustrated in Table B.7.

⁹⁰ Victorian conservation categories and their area have been obtained from VICGRID94 <https://www.data.vic.gov.au/data/dataset/vicgrid94-graticule-1-km-interval> Accessed August 20 2018.

Table B.7 Parks Estate conservation categories and their area in hectares

Category of conservation area	Area (ha)
Coastal Reserve	8,657.4
Education Area	9,715.9
Historic Reserve	36,001.1
Lighthouse Reserve	344.0
Marine National Park - Schedule 7, National Parks Act	52,244.5
Marine Sanctuary - Schedule 8, National Parks Act	864.2
Metropolitan Park	6,609.4
National Park - Schedule 2, National Parks Act	2,908,941.9
National Parks Act Schedule 4 park or reserve	76,857.1
Natural Features Reserve	3,300.0
Natural Features Reserve - Bushland Reserve	44,526.1
Natural Features Reserve - Cave Reserve	527.1
Natural Features Reserve - Geological Reserve	402.3
Natural Features Reserve - Gippsland Lakes Reserve	7,086.2
Natural Features Reserve - Highway Park	387.7
Natural Features Reserve - Lake Reserve	64,418.4
Natural Features Reserve - Natural Features and Scenic Reserve	8,491.5
Natural Features Reserve - River Murray Reserve	14,832.8
Natural Features Reserve - Scenic Reserve	9,263.0
Natural Features Reserve - Streamside Reserve	7,707.9
Natural Features Reserve - Wildlife Reserve (hunting)	63,852.0
Natural Features Reserve - Wildlife Reserve (State Game Reserve classification pending reservation)	16,914.6
Nature Conservation Reserve	131,108.0
Nature Conservation Reserve - Flora and Fauna Reserve	101,388.7
Nature Conservation Reserve - Flora Reserve	19,333.6
Nature Conservation Reserve - Wildlife Reserve (Nature Conservation Reserve classification pending reservation)	947.0
Nature Conservation Reserve - Wildlife Reserve (no hunting)	8,950.6
Other	29,181.7
Other Park - Schedule 3, National Parks Act	68,934.3
Port & Coastal Facility	553.9
Proposed National Parks Act park or park addition	10,254.7
PV Management Services Agreement Other Land	1,249.3
Regional Park - not scheduled under National Parks Act	51,860.4
Reservoir Park	465.3
State Park - Schedule 2B, National Parks Act	149,325.8
Wilderness Park - Schedule 2A, National Parks Act	200,699.4
Grand total	4,116,197.8

(Data source: VicGrid94)

The total number of threatened native Victorian plant and animal species in Parks Estate conservation areas⁹¹ varies across advisory lists (Table B.8).

Table B.8 The total number of threatened native Victorian flora and fauna species, for various advisory lists, in Victorian Parks Estates⁹²

	FFG Act	EPBC Act	DELWP Threatened Species Advisory Lists
Fauna	222	98	313
Flora	334	127	1,702

For the Parks Estate, the top three endangered ecological vegetation divisions (EVDs) are high-altitude alpine sphagnum bogs and associated fens⁹³ (68.5%) followed by closed-forest (33%) and damp scrub (11%). The EVDs of least concern are lowan Mallee (69%), hummock-grass Mallee (65.7%) and broombush whipstick (57.6%) (Figure B.5). Bioregional threat status determines how EVDs' conservation statuses are defined. Due to the large number of ecological vegetation classes (EVCs) in Victoria and the challenge of graphing them in a meaningful way for SoE 2018, EVDs were applied for this indicator's assessment.

Outside of Parks Victoria managed estate, there are a number of EVCs protected on Crown and private land through permanent protection mechanisms, for example Trust for Nature Covenants, Section 69 and Indigenous Protected Areas. At the time of writing this report, DELWP was updating this EVC extent map and bioregional conservation status based on new native vegetation extent mapping. It is intended that this update be available towards the end of 2019.

The 2017 VEAC Statewide Assessment of Public Land found that native vegetation is a key indicator for the overall state of terrestrial biodiversity. Approximately 45% (11.2 million hectares) of Victoria's original coverage of native vegetation remains. This consists mostly of native trees (92%), which occur in large connecting blocks in Victoria's east and north-west.⁹⁴

This assessment also identified Victorian areas where there is a concentration of poorly represented EVCs on public land outside of current protected areas. The top three Victorian areas with poor EVC representation include Strzelecki Ranges and Gippsland Plains, South West Victoria, and Central Victorian Uplands.⁹⁵ The VEAC report identified that rainforest is rare in Victoria, where only 80% of the original 50,500 hectares remains.⁹⁶ Additionally, the 2011 VEAC Remnant Native Vegetation Investigation found that used and unused road reserves and rail reserves support a significant proportion of native vegetation in Victoria's fragmented landscapes. These linear reserves make a major contribution to ecological connectivity and in some landscapes provide key habitat for many species.⁹⁷

⁹¹ Note: Parks Estate conservation areas applying VicGrid94 spatial delineation.

⁹² Ibid

⁹³ High altitude alpine sphagnum bogs and associated fens are referred to as high altitude wetlands in Figure B.5.

⁹⁴ VEAC 2017, 'Statewide assessment of public land final report', Melbourne, Victoria.

⁹⁵ VEAC 2017, 'Statewide assessment of public land supplement to the discussion paper. Melbourne, Victoria. Note: an extensive list of under-represented EVCs can be found in Table 4.1 on page 23.

⁹⁶ Ibid

⁹⁷ VEAC 2011, 'Remnant native vegetation investigation final report', Melbourne, Victoria.

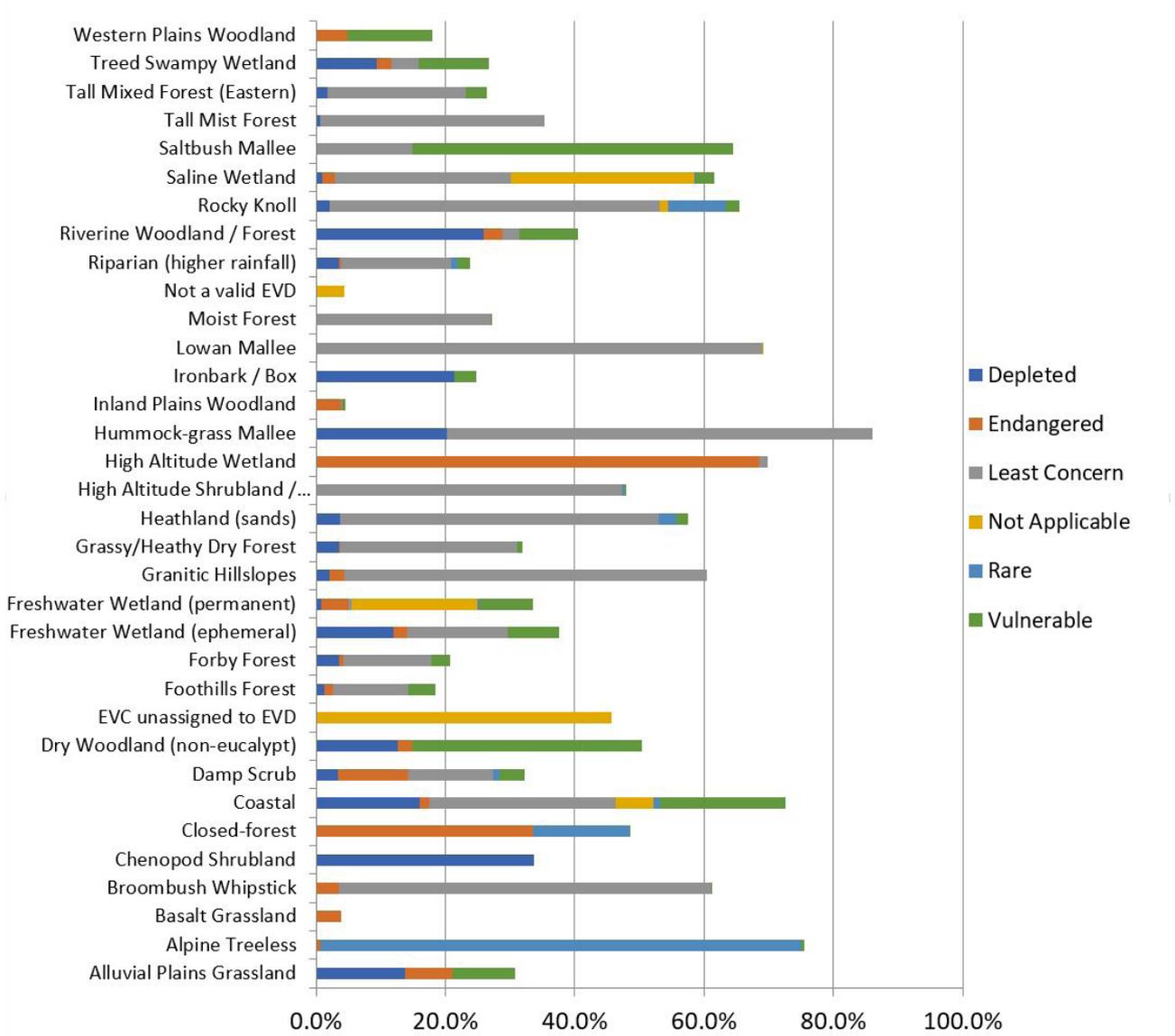


Figure B.5 Current state of EVDs for Parks Estate defined by bioregional threat status

(Data source: Parks Victoria 2018)

Freshwater Biodiversity

This theme will report on freshwater ecosystem health and management. Freshwater ecosystems are defined here as all terrestrial aquatic systems including rivers (streams, creeks and tributaries) lakes, wetlands and ponds that are not estuarine or marine (see Marine and Coastal Environments chapter). Freshwater ecosystems support environmental values such as native animals (including fish, riparian vegetation, bird habitat and drought refuges) and provide habitat for rare and threatened species. These freshwater systems provide water for food and energy production, purify drinking water, provide spaces for recreation and play an important role in flood and erosion control. For an assessment of water quality and resources, refer to the Water Quality and Water Resources chapters.

Indicator	Status	Trend	Data Quality
	UNKNOWN POOR FAIR GOOD		
B:09 River Health			 DATA QUALITY Good
Data custodian DELWP			

Biodiversity indicators from previous SoE reports have been combined for this report:

- river health
- percentage of major rivers that remain in a near pristine or largely unmodified state
- assessment of freshwater biodiversity information
- area of management in priority locations
- restoration of habitat

The indicators have been combined because, since the publication of SoE 2013, no updated Index of Stream Condition (ISC) data is available to inform them. The ISC provides a snapshot, informed by trends, across the following datasets:

- aquatic macroinvertebrates
- streamside zone vegetation
- the river channel
- water quality and quantity.

The next ISC data analysis is due to be completed in 2028.

The lack of data to inform this report is due to the shift in the ISC’s monitoring regime from every 6 years to every 12 years. The reduced frequency of ISC statewide assessments is due to a redesign and implementation of monitoring programs that can detect ecological change at scales relevant to waterway management. The previous three ISC assessments (1999, 2004 and 2010) indicated that overall stream condition had remained largely stable across Victoria during that period.⁹⁸

Two other assessments that provide information on Victorian river health are the 2001 national Assessment of River Condition (ARC) program and the national Assessment of River Condition and River Monitoring and Assessment Program (RiverMAP).

⁹⁸ DEPI 2010, 'Index of stream condition: The third benchmark of Victorian river condition', Melbourne, Victoria.

ARC found that 79% of Victorian river lengths have been moderately or substantially modified, due to: catchment disturbance, hydrological disturbance, habitat and nutrient/suspended sediment load.⁹⁹ Of these Victorian rivers, 33% were observed to have damage to biological (macroinvertebrate) communities.¹⁰⁰ Rivers in catchments with agricultural activity are affected by added stressors, such as elevated nutrient concentration, increased inputs of fine sediments and pesticides, alterations in flow regimes and disturbances to the riparian habitat.¹⁰¹ Degradation of Victorian rivers and streams, and loss of freshwater biodiversity is a result of growing human populations and expanding land use.¹⁰²

Similarly, RiverMAP found that Victorian river health was influenced by grazing, land clearing for agriculture, timber production and urban development causing disturbance to natural river drivers.¹⁰³ Disturbances cause river health issues such as increased sedimentation, runoff, nutrient and pollutant loads, removal and/or reductions of riparian vegetation and loss of in-stream habitat for aquatic biota.¹⁰⁴

99 EPA 2016, 'River monitoring and assessment program (RiverMAP): river health modelling project technical report', Melbourne, Victoria.

100 Norris RH, Prosser I, Young B, Liston P, Bauer N, Davies N, Dyer F, Linke S, Thoms M, 2001, 'The assessment of river conditions (ARC): An audit of the ecological condition of Australian rivers', Cooperative Research Centre for Freshwater Ecology, University of Canberra; Commonwealth Scientific and Industrial Research Organisation, Division of Land and Water, Canberra.

101 Allan JD 2004, 'Landscapes and riverscapes: the influence of land use on stream ecosystems', *Annual Review of Ecology, Evolution and Systematics*, 35, pp.257-84.

102 Strayer DL, Dudgeon D 2010, 'Freshwater biodiversity conservation: recent progress and future challenges', *The North American Benthological Society*, 29(1), pp.344-358.

103 EPA 2016, 'River monitoring and assessment program (RiverMAP): river health modelling project technical report, Melbourne, Victoria.

104 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:10 Riparian Vegetation Habitat Extent						 DATA QUALITY Poor
Data custodian DELWP						

Riparian refers to the land and vegetation that adjoins a freshwater system such as a river, creek or wetland. The national ARC in 2001 identified that riparian zones have been extensively degraded in Victoria.^{105,106} Between 25 and 28% of Victorian river lengths have substantially to severely modified riparian condition.^{107,108} Results of the SoE Report 2013 highlighted that 21 of 29 river basins had less than 50% of assessed river length with riparian vegetation in good condition. Removal of riparian vegetation impacts terrestrial and aquatic food webs by reducing the inputs of food in forms of leaves, branches, and terrestrial invertebrates into the aquatic system, and by limiting the availability of prey from the aquatic environment to terrestrial predators such as spiders, birds and bats.¹⁰⁹ Riparian vegetation removal also has downstream impacts on estuarine and marine ecosystems.

Riparian zone removal and degradation in Victoria is due to agricultural activity that occurs alongside rivers and the channelisation of drainage (through drainage channels) from agriculture and urban land rather than using naturally-formed stream channels. This has resulted in a decreased ability of the stream network to retain flow and hold and transform nutrients and organic matter to prevent their input into downstream river ecosystems.¹¹⁰

A reduced dependence on streams to drain water also results in the loss of critical habitat and breeding habitat for amphibians, some fish and many macroinvertebrates.¹¹¹ Riparian habitat loss is also linked to natural increased light levels due to vegetation loss, nutrient concentration and water temperature, all of which are associated with increased algal production and changes in autotroph assemblages (organisms that can produce their own food using light, water, carbon dioxide or other chemicals).¹¹² Under certain circumstances, these changes can lead to toxic algal blooms which can pose a risk to both freshwater plants and animals and human health.¹¹³

The Riparian Intervention Monitoring Program led by DELWP in partnership with the Arthur Rylah Institute, Victorian Catchment Management Authorities and Melbourne Water aims to understand how riparian systems change in response to management for various sites across Victoria.¹¹⁴ Developed in 2014, this program assesses vegetation condition and bank stability at intervention sites where management actions are planned and implemented and at similar control sites where no management actions are carried out. Comparing changes that occur at intervention sites with those that occur at control sites will inform:

- the degree of change that is due to management actions
- the length of time it takes for condition to change
- understanding on variability in changes in response to management actions.

105 Norris RH, Prosser I, Young B, Liston P, Bauer N, Davies N, Dyer F, Linke S, Thoms M, 2001, 'The assessment of river conditions (ARC): An audit of the ecological condition of Australian rivers', Cooperative Research Centre for Freshwater Ecology, University of Canberra; Commonwealth Scientific and Industrial Research Organisation, Division of Land and Water, Canberra.

106 EPA 2016, 'River monitoring and assessment program (RiverMAP): river health modelling project technical report;', Melbourne, Victoria.

107 Ibid

108 Norris RH, Prosser I, Young B, Liston P, Bauer N, Davies N, Dyer F, Linke S, Thoms M, 2001, 'The assessment of river conditions (ARC): An audit of the ecological condition of Australian rivers', Cooperative Research Centre for Freshwater Ecology, University of Canberra; Commonwealth Scientific and Industrial Research Organisation, Division of Land and Water, Canberra.

109 Ibid

110 Ibid

111 Ibid

112 EPA 2016, 'River monitoring and assessment program (RiverMAP): river health modelling project technical report;', Melbourne, Victoria.

113 Ibid

114 ARI 2018, 'Riparian intervention monitoring program fact sheet', Heidelberg, Victoria. https://www.arivic.gov.au/_data/assets/pdf_file/0025/72754/RIMP-overview-fact-sheet-2017.pdf Accessed 27 July 2018.

Riparian Intervention Monitoring Program management actions can be a single intervention (such as livestock exclusion) or a combination intervention (such as livestock exclusion, revegetation and weed management). The riparian attributes that are monitored to determine effectiveness of management actions include: invasive vegetation cover and stem density, native vegetation cover and composition, bare ground and litter cover, vegetation structure, recruitment of native trees and shrubs, native vegetation extent and continuity, and bank stability. To date, 12 sites have been monitored across Victoria after three years of management action. Prior to management action, these sites were generally of poor riparian condition. Changes across all 12 sites after three years of management action include:¹¹⁵

- total native vegetation cover increased by approximately 2-fold
- native species richness increased by approximately 1.5-fold
- planted and natural woody recruits increased by approximately 9-fold
- woody weed abundance decreased to almost zero at most sites
- bare ground cover did not increase as compared to unmanaged sites.

Future site monitoring over the next five to eight years (medium term) and greater than ten years (long-term) will determine whether improvement in vegetation condition at this early stage will be maintained over time or deteriorate over time due to pressures such as weed invasion.

A preliminary program of re-capture and assessment of Light Detection and Ranging data over the 2018–19 summer will be conducted by DELWP to estimate change in Riparian and Physical Form measures. Metrics will include: large trees, tree cover, shrub cover, vegetation structure, vegetation overhang, riparian fragmentation, vegetation width and geomorphic change. These results will form a subset of the ISC 2028 data (making up approximately 12% of the total data) to assess change from the ISC 2010 data. Preliminary results will also be available in late 2019.

¹¹⁵ DELWP 2018, 'Riparian intervention monitoring program (RIMP): early signs of improved riparian condition following management. fact sheet', Melbourne, Victoria.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:11 Area of functional floodplain					?	 DATA QUALITY Poor
Data custodian DELWP						

This SoE 2018 indicator assesses change to floodplain area as a natural approach to mitigate and reduce the risk of flood and drought impacts and provide refuge to plants and animals during extreme weather events. Future predictions under climate change suggests an increasing intensity and frequency of floods and drought. Strengthening the capacity of ecosystems to deal with climate extremes is a key management strategy for minimising the adverse effects of climate change on flora and fauna.¹¹⁶ Floodplains are potential drought refuges as they:¹¹⁷

- are cooler
- have localised microclimates compared to adjacent areas
- have greater water availability through groundwater and flooding.

An example is the Murray–Darling Basin, where floodplains with high vegetation productivity have greater resistance to climate change impacts such as drought.^{118,119} Protecting floodplains by maintaining vegetation productivity and condition through environmental watering and ecological restoration can enhance the system’s resistance to more frequent and severe climate change threats.¹²⁰ The black box (*Eucalyptus largiflorens*) woodlands situated in the floodplains along the

Murray River has received different flooding regimes (a mixture of natural flooding and environmental watering) between 1993 and 2018 across different sites.¹²¹ Examining the effects of different flooding regimes found that frequently flooded sites (due to environmental watering and natural flooding) were healthier, with greater canopy foliage cover and canopy extent, greater growth of new leaf tips, and greater reproductive output (buds, flowers and fruits). At frequently flooded sites there was a greater range of life stages present with more saplings and seedlings, and fewer dead trees. At sites that had not been flooded for over 23 years, no seedlings or saplings were recorded, suggesting that the structure of the black box woodland is not sustainable under these conditions. These results suggest that flooding, using environmental water, is important in maintaining the health of black box woodlands and their value for native flora and fauna. The challenge for using environmental watering to achieve such flooding is to determine an optimal regime including the timing, frequency and duration of managed flood events.

Although the Murray River black box woodlands is a good example of protecting floodplains, a statewide assessment for this indicator could not be completed. This is due to a lack of statewide data on functional floodplain areas and how they are changing over time associated with land use and climate change pressures.

¹¹⁶ Selwood KE, McGeoch MA, Clarke RH, Mac Nally R 2018, 'High-productivity vegetation is important for lessening bird declines during prolonged drought', *Journal of Applied Ecology*, 55, pp.641-650.

¹¹⁷ Selwood KE, Thomson JR, Clarke RH, McGeoch MA, Mac Nally R 2015, 'Resistance and resilience of terrestrial birds in drying climates: do floodplains provide drought refugia?', *Global Ecology and Biogeography*, 24, pp.838-848.

¹¹⁸ Selwood KE, McGeoch MA, Clarke RH, Mac Nally R 2018, 'High-productivity vegetation is important for lessening bird declines during prolonged drought', *Journal of Applied Ecology* 55, pp.641-650.

¹¹⁹ Selwood KE, Thomson JR, Clarke RH, McGeoch MA, Mac Nally R 2015, 'Resistance and resilience of terrestrial birds in drying climates: do floodplains provide drought refugia?', *Global Ecology and Biogeography*, 24, pp.838-848.

¹²⁰ Ibid

¹²¹ Moxham C, Duncan M, Moloney P 2018, 'Tree health and regeneration response of Black Box (*Eucalyptus largiflorens*) to recent flooding', *Ecological Management & Restoration*, 19, pp. 58-65.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:12 Distribution and abundance of frogs						
Data custodian DELWP						DATA QUALITY Good

There have been declines in the population number of native frog species (threatened and non-threatened species) over the past few decades.¹²² There are 37 amphibian species in Victoria, with 17 frog species listed as threatened, excluding species for which data is insufficient to assess the extinction risk.¹²³ Approximately 86% of Victorian frog species are dependent on permanent or ephemeral wetlands to complete their life cycle. Of these wetland-dependent species, 7 frogs are listed as threatened (Table B.9). In the last 20 years, the number of threatened frog species on the FFG Act list has doubled.¹²⁴

Threats facing Victorian frog populations include: climate change (and associated issues, such as droughts, increasing frequency of large fires and change in long-term temperatures), elevated predation rates due to feral terrestrial and aquatic predators, habitat destruction, degradation and the impacts of exotic herbivores on frog breeding habitats. The main driver for decreasing frog population numbers is the infectious disease chytridiomycosis, caused by the temperature-sensitive chytrid fungus *Batrachochytrium dendrobatidis*.^{125,126} This fungus is capable of causing sporadic deaths in some populations and 100% mortality in other populations.¹²⁷ The disease was introduced in Australia in the 1970s and has been recorded in four regions including the east coast. A threat abatement plan was

developed to address this key threatening process under the Commonwealth EPBC Act.¹²⁸ Poor advice and planning in matters such as putative mitigation strategies and biodiversity trading also contributes to declines and losses of threatened frog populations.¹²⁹ Current ongoing research has found that some native frog species, such as the common eastern froglet (*Crinia signifera*), are hosts to the chytrid fungus and are sustaining the ongoing impact of this disease by transmitting it to declining threatened species populations.¹³⁰ This has implications for trying to reintroduce locally extinct species as they will be susceptible to the fungus with reintroductions unlikely to be effective.

122 Hunter DA, Smith MJ, Scroggie MP, Gilligan D 2011, Experimental examination of the potential for three introduced fish species to prey on tadpoles of the endangered Booroolong frog *Litoria booroolongensis*, *Journal of Herpetology*, 45(2), pp.181-185.

123 Morris K 2012, 'Wetland connectivity: understanding the dispersal of organisms that occur in Victoria's wetlands', Arthur Rylah Institute for Environmental Research Technical Report Series No.225, Heidelberg, Victoria.

124 Clemann N 2015, 'Cold-blooded indifference: A case study of the worsening status of threatened reptiles from Victoria, Australia', *Pacific Conservation Biology*, 21, pp.15-26.

125 DEE 2016, 'Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis', Department of Environment and Energy, Australian Government, Commonwealth of Australia.

126 Skerratt LF, Berger I, Clemann N, Hunter DA, Marantelli G, Newell DA, Philips A, McFadden M, Hines HB, Scheele BC, Brannelly LA, Speare R, Versteegen S, Cashins SD, West M 2016, 'Priorities for management of chytridiomycosis in Australia: saving frogs from extinction', *Wildlife Research*, 43(2), pp.105-120.

127 Ibid

128 Ibid

129 Ibid

130 Brannelly LA, Webb RJ, Hunter DA, Clemann N, Howard K, Skerratt LF, Berger I, Scheele BC 2017, 'Non-declining amphibians can be important reservoir hosts for amphibian chytrid fungus', *Animal Conservation*, 21, pp.91-101.

Table B.9 Threatened Victorian frog species that are wetland-dependent for completing their life cycle¹³¹

Common name	Species name
Giant bullfrog	<i>Limnodynastes interioris</i>
Alpine tree frog	<i>Litoria verreauxii alpina</i>
Baw Baw frog	<i>Philoria frosti</i>
Growling grass frog or southern bell frog	<i>Litoria raniformis</i>
Giant burrowing frog	<i>Heleioporus australiacus</i>
Green and golden bell frog	<i>Litoria aurea</i>
Rugose toadlet	<i>Uperoleia rugosa</i>

Frogs rely on water for reproduction and some species move hundreds of metres away from water to forage and find shelter. Over winter, shelter sites can be considerable distances from water. The terrestrial elements of frog habitat, and connectivity between aquatic and terrestrial elements of these habitats, are important for maintaining frog populations. The habitat boundary for some Victorian frog species may be 300–1,000 m beyond the wetland perimeter.¹³²

In temperate landscapes the prevalence and diversity of amphibians declines where the distances among wetlands is large, road densities are high, or habitats are surrounded by agriculture or other intensive land uses.¹³³ All these factors decrease the capacity of amphibians to move between habitats and maintain populations across multiple habitats.¹³⁴

¹³¹ Morris K 2012, 'Wetland connectivity: understanding the dispersal of organisms that occur in Victoria's wetlands', Arthur Rylah Institute for Environmental Research Technical Report Series No.225, Heidelberg, Victoria.

¹³² Ibid

¹³³ Ibid

¹³⁴ Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:13 Distribution and abundance of fish						
Data custodian DELWP						DATA QUALITY Good

This indicator assessment was informed by fish data from Victorian rivers that receive environmental watering, also referred to as regulated rivers. Data was obtained from the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) Stage 5¹³⁵ and Stage 6¹³⁶ reports. VEFMAP Stage 5 includes 2004–16 monitoring results across nine regulated river systems: the Goulburn, Campaspe, Loddon, Broken, Thomson, Glenelg, Macalister, Yarra and Wimmera. VEFMAP Stage 6 monitoring results from 2016–17 focused on:

- coastal rivers – Barwon, Werribee, Bunyip, Tarwin, Glenelg and Thomson Rivers and Cardinia Creek
- northern rivers – Murray, Campaspe, Goulburn, Loddon and Broken Rivers, Little Murray River and Pyramid Creek.

Further VEFMAP Stage 6 monitoring will continue to take place in 2018–19, with a full analysis and program evaluation in 2020.

Monitoring of these rivers provides data on environmental responses to environmental watering. Both VEFMAP Stage 5 and Stage 6 fish data results were linked to regional environmental flow delivery schedules to:

- understand the relationship between environmental flows and native fish species population demography, dispersal and immigration
- understand if environmental flow management used for large-bodied fish species enhance their survival, abundance and distribution¹³⁷

- enable DELWP and its water-delivery partners to demonstrate the ecological value of environmental water management to the community and water industry stakeholders¹³⁸
- fill knowledge gaps to improve planning, delivery and evaluation of environmental water management in regulated rivers across Victoria
- examine the importance of environmental flows in promoting immigration, dispersal and subsequent recruitment of diadromous fish (fish that spend portions of their life cycles partially in fresh water and partially in salt water) in coastal rivers, specifically for Stage 6.^{139,140}

¹³⁵ DELWP 2018, 'Victorian environmental flows monitoring and assessment program – Stage 5 report', Melbourne, Victoria.

¹³⁶ DELWP 2017, 'VEFMAP stage 6 project update 2017. Fish study – northern Victoria rivers', Melbourne, Victoria.

DELWP 2017, 'VEFMAP stage 6 Part A: program context and rationale', Melbourne, Victoria.

¹³⁷ DELWP 2017, 'VEFMAP stage 6 project update 2017. Fish study – northern Victoria rivers', Melbourne, Victoria.

¹³⁸ DELWP 2017, 'VEFMAP stage 6 Part A: program context and rationale', Melbourne, Victoria.

¹³⁹ Ibid

¹⁴⁰ DELWP 2017, 'VEFMAP stage 6 project update 2017. Fish study southern Victorian rivers', Melbourne, Victoria.

VEFMAP Stage 5

The Stage 5 sampling period coincided with hydrological extremes across Victoria, including the millennium drought (1996–2010) and the major statewide floods of 2010–11. The final sampling period occurred before the winter/spring floods of 2016.¹⁴¹ Across all sampling periods, seasonal and interannual variation influenced the abundance and biodiversity of all fish populations.

Monitoring outcomes reported 45 fish species across Victoria, of which 28 were native species that regularly inhabit inland aquatic ecosystems. Sampling included 127,646 individual fish with their weight equating to more than 15 tonnes. The native species catch was dominated by two species that are flow and habitat generalists: 36% Australian smelt and 15% flathead gudgeon.¹⁴² (See Table B.10 for a full list of common and species names for inland aquatic fish reported in this indicator). Non-native fish dominated fish community composition. Non-native carp comprised on average 75% of the fish biomass, and up to 92% of the biomass in some rivers.¹⁴³ Eleven native fish species of conservation significance were collected: Macquarie perch, Murray cod, silver perch, golden perch, trout cod, freshwater catfish, Yarra pygmy perch, variegated pygmy perch, obscure galaxias, flat-headed galaxias and Australian grayling.¹⁴⁴

¹⁴¹ DELWP 2018, 'Victorian environmental flows monitoring and assessment program – stage 5 report', Melbourne, Victoria.

¹⁴² Ibid

¹⁴³ Ibid

¹⁴⁴ Ibid

Table B.10 Common and species names for all native and non-native fish taxa reported in VEFMAP Stage 5 and 6 results

Native Victorian species	
Common name	Species name
Australian smelt	<i>Retropinna semoni</i>
Flathead gudgeon	<i>Philypnodon grandiceps</i>
Macquarie perch	<i>Macquaria australasica</i>
Murray cod	<i>Maccullochella peelii</i>
Silver perch	<i>Bidyanus bidyanus</i>
Golden perch	<i>Macquaria ambigua</i>
Trout cod	<i>Maccullochella macquariensis</i>
Freshwater catfish	<i>Tandanus tandanus</i>
Yarra pygmy perch	<i>Nannoperca obscura</i>
Variiegated pygmy perch	<i>Nannoperca variegata</i>
Southern pygmy perch	<i>Nannoperca australis</i>
Estuary perch	<i>Percalates colonorum</i>
Obscure galaxias	<i>Galaxias oliros</i>
Flat-headed galaxias	<i>Galaxias rostratus</i>
Common galaxias	<i>Galaxias maculatus</i>
Australian grayling	<i>Prototroctes maraena</i>
Murray River rainbowfish	<i>Melanotaenia fluviatilis</i>
Carp gudgeon	<i>Hypseleotris spp.</i>
Mountain galaxias	<i>Galaxias olidus</i>
Unspecked hardyhead	<i>Craterocephalus stercusmuscarum fulvus</i>
Short-finned eel	<i>Anguilla australis</i>
Long-finned eel	<i>Anguilla reinhardtii</i>
River blackfish	<i>Gadopsis marmoratus</i>
Australian bass	<i>Percalates novemaculeata</i>
Short-headed lamprey	<i>Mordacia mordax</i>
Tupong	<i>Pseudaphritis urvillii</i>
Non-native species	
Common name	Species name
Carp	<i>Cyprinus carpio</i>
Gambusia	<i>Gambusia spp.</i>
Goldfish	<i>Carassius auratus</i>
Redfin	<i>Perca fluviatilis</i>
Oriental weatherloach	<i>Misgurnus anguillicaudatus</i>
Common roach	<i>Rutilus rutilus</i>

Statewide results found that the native fish community is degraded, with 24 of the 28 species caught comprising less than 5% of the total catch. At the landscape scale, Wimmera, Loddon and Campaspe native fish communities showed little signs of recovery, apart from Murray River rainbowfish.¹⁴⁵ Fish population trends varied across each regulated river system, but a common trend across all systems was non-native carp dominating the mean sampled catch. The Thomson had the highest native fish species richness ($n=19$) and the Campaspe had the lowest ($n=9$). Detailed results for each water system follow.

- Broken:** Non-native fish dominated the sampling catch, with non-native carp comprising 20% of the mean annual catch, gambusia 10% and goldfish 9%. Carp gudgeon dominated the native fish catch, representing 30.6% of the mean annual catch followed by Murray River rainbowfish 9.6% and Australian smelt 5.6%.
- Goulburn:** The native catch was strongly dominated by native Australian smelt (50% of the mean annual catch), followed by native carp gudgeon (16%). This was followed by non-native carp (15%). Four other non-native species were caught in relatively low numbers ($\leq 1\%$ of the mean annual catch).
- Campaspe:** Native flathead gudgeon and carp gudgeon dominated the native catch (24% and 20% of the mean annual catch, respectively). Murray River rainbowfish comprised 6.7% of the mean annual catch and Australian smelt 3%. Of each non-native fish, carp represented 23% of the mean annual catch, redfin and gambusia 9% and goldfish 4%. As with many of the other rivers, fish biomass was dominated by non-native carp, which represented 85% of the mean biomass.
- Loddon:** Native flathead gudgeon (21%) and carp gudgeon (12%) dominated the native fish mean catch. The non-native fish community was dominated by carp (28% of the mean catch) Gambusia, redfin, goldfish and oriental weatherloach were also collected (10%, 10%, 7% and 1% of the mean catch respectively). Non-native carp represented 74% of the mean total biomass catch.
- Wimmera:** Flathead gudgeon and Australian smelt dominated the native catch (26% and 4% of mean catch respectively). Golden perch represented 2.7% of the mean annual catch (a maximum of 75 were caught in 2015–16) while relatively few carp gudgeon, silver perch, Murray cod, freshwater catfish, common galaxias and mountain galaxias were caught. No unspotted hardyhead and Murray River rainbowfish were caught in the monitoring period. Of the non-native species, carp were dominant, representing 29% of the mean catch, followed by gambusia (15%), redfin (11%) and goldfish (3%). Notably the Wimmera was the only inland catchment where native freshwater catfish were detected. Non-native Carp dominated the fish biomass in the Wimmera River representing 77% of the mean biomass.
- Thomson:** Fish species richness was the highest compared to all other river systems. Australian smelt were dominant, representing 72% of the mean catch, followed by short-finned eels (3.4%). Native tupong and long-finned eels were also common (3% and 1.3% of the mean catch respectively). There were low catch numbers of river blackfish, Australian bass, short-headed lamprey and Australian grayling. Non-native carp and gambusia were abundant (8.7% and 3.7% of the mean catch, respectively). Non-native carp strongly dominated the fish biomass, representing 91% of the mean biomass.
- Glenelg:** Species richness was also high in this river system. Flathead gudgeon dominated the native catch (31.4% of mean catch), followed by gambusia (30.6%). Variegated pygmy perch (10% of mean catch), river blackfish (5.9%) and southern pygmy perch (5.2%) were also reasonably common. There were lower catch numbers of common galaxias, obscure galaxias and estuary perch. With the exception of gambusia there were relatively low numbers of non-native fish. Carp comprised 36% of the mean fish sample biomass.

145 Ibid

- **Macalister:** Australian smelt strongly dominated the native catch (58% of the mean catch). Other native fish such as short-finned eels, tupong and long-finned eels were reasonably common – each representing 2% of the mean catch. There were low catch numbers of Australian bass, Australian grayling, common galaxias, estuary perch, river blackfish, short-headed lamprey and southern pygmy perch. Of the non-native fish, carp, gambusia and redfin were common at 16%, 9% and 4% of the mean catch, respectively. Carp comprised 92% of the mean fish sample biomass.
- **Yarra:** Australian smelt were strongly dominant, representing 49% of the mean catch, followed by short-finned eels (7.5%). Macquarie perch and common galaxias were also reasonably common, representing 7% and 5% of the mean catch respectively. There were low catch numbers of Australian bass, Australian grayling, river blackfish, short-headed lamprey and southern pygmy perch. Of the non-native fish species, carp were caught in large numbers and comprised 13% of the mean catch, followed by roach (8%) and redfin (4%).
- **Additional note on Glenelg, Thomson–Macalister and Yarra Rivers:** There was freshwater range expansion of native coastal river fish populations with a diadromous life-history (that is, they make obligatory movements between the sea/estuary and freshwater) due to improved connectivity and environmental flows, including:

Glenelg – estuary perch and tupong

Thomson–Macalister and Yarra –
Australian grayling and tupong.

VEFMAP Stage 5 case studies focused on Australian grayling, silver perch and golden perch, with results informing future planning and management of water flows. Case study results found that:

- Longer-duration, moderate environmental flow events (for example, over five days) can change river hydrodynamics. This can potentially result in increased spawning of Australian grayling.
- Australian grayling spawning migration in the Bunyip, Thomson and Yarra systems was in response to environmental flow variations from prevailing conditions rather than flow events of a specific magnitude, indicating that even low flows can trigger downstream spawning movements. For fish species higher in the catchment, flow durations may need to be extended to enable fish to reach downstream spawning habitats.
- Bank-full spring flows, and flows within river channels, can lead to successful golden perch spawning without the need for over-bank flows in the Goulburn system. Low, stable flows do not result in golden perch spawning.
- Trends from a 20+ year dataset of the Torrumbarry Weir fishway demonstrated that juvenile golden perch and silver perch responded to small increases in summer river height by migrating upstream of the Murray system. There is potential for water managers to stimulate summer water rises in the Campaspe, Gunbower, Loddon and Goulburn to attract and enhance regional native fish communities.

Data quality was an issue with VEFMAP Stage 5 monitoring and assessment. Due to equipment operation, there was inconsistency in sampling techniques throughout the program, with marked variation in sampling techniques used across years, rivers and sites.¹⁴⁶ Future procedures will be required to ensure high-quality data is collected, as per the Sustainable River Audit protocols.¹⁴⁷

Data was not analysed or modified to account for detection efficiency, differences between field teams, hydrological conditions or fieldwork timing. There were also numerous data entry errors and inconsistencies. For the Stage 5 analyses, these errors were subsequently corrected as much as possible by the VEFMAP database system administrator. Data quality and database reliability was an ongoing problem throughout VEFMAP Stage 5 and greater planning and resources have been addressed for VEFMAP Stage 6.¹⁴⁸

VEFMAP Stage 6

Surveys in 2016–17 investigated species population immigration, dispersal and distribution and recruitment across regulated rivers, as follows:

- immigration – the lower reaches of the Barwon, Werribee, Bunyip, Tarwin, Murray (Torrumbarry Weir fishway), Campaspe and Goulburn Rivers and Cardinia Creek (October–December 2016)
- dispersal – Glenelg River (January–March 2017), Loddon River Catchment and fishway trapping at The Chute, Kerang Weir and Box Creek fishlock (March–April 2017)
- distribution and recruitment – Glenelg and Thomson Rivers (February–March 2017)
- population Demography – Broken, Campaspe, Goulburn, lower Loddon and Little Murray Rivers and Pyramid Creek (March–May 2017).

Coastal Rivers

Cardinia Creek is regulated but does not have a seasonal watering plan or environmental flow targets. The Tarwin River is unregulated and has been included in VEFMAP Stage 6 to provide response data on natural fluctuations in freshwater discharge that may attract juvenile diadromous fish from marine into freshwater environments.¹⁴⁹ During this study, rain events occurred from September to December 2016, resulting in a number of natural flow peaks in all coastal rivers. The Werribee River experienced an environmental flow release in late 2016. Rainfall events and base flow environmental flow releases were experienced in the Glenelg River during 2017, with a summer fresh environmental flow release resulting in a discharge peak in mid-March 2017.

Immigration survey results found that over 130,000 fish were captured across the five coastal rivers. Juvenile diadromous galaxias comprised the bulk of the catch at approximately 95%. Two threatened diadromous species, Australian grayling (*Prototroctes maraena*) and Australian mudfish (*Neochanna cleaveri*) were collected.

146 Ibid
147 Ibid
148 Ibid

149 Ibid

Other diadromous species collected were tupong and short-finned eels (*Anguilla australis*).^{150,151} The highest catch rates of galaxias in Cardinia Creek and the Bunyip and Werribee rivers occurred early in the spring sampling period following multiple relatively large natural discharge pulses. Whether this was due to higher volumes of water or time of year will be investigated over the next two years. In the Werribee River, an increase in young-of-year (less than one year old) galaxias occurred during the peak of an environmental flow release, providing evidence that it was effective in attracting fish from the estuary into freshwater.

Dispersal survey results of the Glenelg River found a total of 99 tupong and 383 common galaxias (*Galaxias maculatus*). A total of 20 tupong were detected between January and May 2017, with most close to their initial tagging location. At five of the six river sites, higher catch rates occurred during the peak of the summer fresh release. No tagged tupong migrated upstream, although because few were subadults there was a limited ability to assess the role of environmental flows in promoting dispersal of subadults upstream. Two large adults moved downstream on a large discharge pulse in late April, which is expected as part of their autumn/winter spawning migration.

Distribution and recruitment surveys in the Thomson River found that a total of 1,531 fish of 14 species (10 native and 4 exotic) were captured, including 5 diadromous species: 69 short-finned eels, 14 long-finned eels (*Anguilla reinhardti*), 36 Australian bass (*Macquaria novemaculeata*), 18 Australian grayling and 174 tupong. Australian smelt (*Retropinna semoni*) and gambusia (*Gambusia affinis*) were the most abundant species. The catch rate of tupong indicated strong recruitment for the 2016–17 season (the highest observed in 13 years of VEFMAP sampling in this river). The 2007, 2011 and 2012 year classes of tupong were also detected, indicating a combination of successful spawning, immigration into freshwater and dispersal upstream. No trend in year classes for Australian grayling

was detected, but this may be the result of low abundance and low detectability in the Thomson River.

Distribution and recruitment surveys in the Glenelg River captured a total of 1,000 fish made up of 12 species (9 native and 3 exotic), including 2 diadromous species: 19 common galaxias and 71 tupong. Flathead gudgeon (*Philypnodon grandiceps*) and gambusia were the most abundant species. Small tupong dispersed as far as 40 km upstream of Dartmoor. Some of this movement may have been stimulated by the summer fresh release. Environmental water was used to maintain river connectivity during summer 2017, allowing fish to migrate throughout the summer.

Northern Rivers

Environmental water was delivered to the Murray, Goulburn and Campaspe rivers in December 2016 and late February 2017 as small flow events (that exceed the baseflow and last for up to several weeks). Environmental water was delivered to the downstream end of the Loddon River in April 2017. There were also two natural rainfall events which resulted in elevated flows in the lower Loddon River in late April and mid-May 2017.¹⁵²

Immigration survey results found a total of 41 subadult silver perch and 23 golden perch were captured at Torrumbarry Weir fishway and tagged with acoustic transmitters. 39 of the subadult silver perch were acoustically detected, moving upstream across 50–150 km in the Murray River from late February to early March 2017. Upstream movement coincided with the Murray River environmental watering event. Approximately half of the tagged silver perch moved from the Murray River into tributaries, coinciding with the environmental flows into tributary rivers. Approximately 70% of these tagged silver perch remained in a tributary, with some returning to the Murray River as the tributary receded.¹⁵³

¹⁵⁰ Ibid

¹⁵¹ DELWP 2017, 'VEFMAP stage 6: Do environmental flows enhance immigration and dispersal of diadromous fishes in Victorian coastal rivers? 2016/17 survey results', Melbourne, Victoria.

¹⁵² DELWP 2017, 'VEFMAP stage 6: Project update 2017. Fish study – northern Victoria rivers', Melbourne, Victoria.
DELWP 2017, 'VEFMAP stage 6: Monitoring fish response to environmental flow delivery in northern Victorian rivers, 2016/17', Melbourne, Victoria.

¹⁵³ Ibid

Of the acoustically tagged golden perch, 22 were detected. These exhibited a diversity of movements locally, across a long-distance and within mainstem-tributaries, where elevated river flows promoted movement.¹⁵⁴

Dispersal surveys across the Loddon River Catchment found a total of 12 fish species (7 native, 5 exotic) were captured during fishway sampling. There were 4 native fish species collected prior to environmental watering and 7 during water release during March and April 2017. With the exception of bony bream, Catch Per Unit Effort (CPUE) of native fish recorded in fishway trapping (and electrofishing) increased during the flow release at The Chute fishway and the Kerang Weir. Issues associated with the Box Creek fishway operation during the surveys prevented an assessment of environmental flow delivery.¹⁵⁵

During this same dispersal survey, 34 golden perch were acoustically tagged and 22 were recorded. Acoustic results suggested that movement of golden perch was related to a water increase at the beginning of the environmental flow in early April in Pyramid Creek. Two fish tagged downstream of Kerang Weir moved substantial distances upstream through the fishway during peak environmental flow release.¹⁵⁶

Population demography surveys revealed the following:¹⁵⁷

- **Broken River:** A total of 526 fish were recorded (8 native and 4 exotic species), with Murray cod, carp and Murray River rainbowfish the most abundant. Temporal trends in CPUE for Murray cod and golden perch showed a decrease from 2008 to 2011, followed by an increase to the highest recorded levels in the system in 2016 and 2017. Murray River rainbowfish showed a similar pattern, although their numbers peaked in 2015.

- **Campaspe River:** A total of 4,745 fish were recorded (9 native and 6 exotic species) with Murray River rainbowfish, carp, Australian smelt and gambusia the most abundant. A total of 25 Murray cod and 48 golden perch were collected, with size structure differing between reaches. There were 12 juvenile silver perch recorded, and Murray River rainbowfish occurred at all sites. There has been an increasing trend in CPUE of Murray cod, golden perch and Murray River rainbowfish across different reaches. Silver perch was detected for the first time since the inception of the VEFMAP program in 2007.
- **Goulburn River:** A total of 2,974 fish were recorded (10 native and 4 exotic species) with Australian smelt, carp and Murray River rainbowfish the most abundant. Trends in CPUE for golden perch, Murray cod, Murray River rainbowfish and silver perch declined from 2008 to 2011, and then increased until 2017. A similar trend was detected for Murray cod, golden perch and Murray River rainbowfish. CPUE for trout cod and silver perch was low throughout the monitoring period, although silver perch CPUE increased significantly in 2017.
- **Loddon system:** A total of 6,273 fish were recorded (8 native and 4 exotic species) with Australian smelt, bony bream and carp the most abundant. Murray River rainbowfish were captured in all sites except Pyramid Creek. There was a decline in CPUE for golden perch from 2008 to 2016, followed by an increase in golden perch and Murray River rainbowfish in 2017.

At a broad level, Stage 6 VEFMAP data suggests a general increase in abundance and distribution for most priority native species in rivers that received environmental flows since the millennium drought (1996-2010). Results highlight that improved flow conditions – including environmental water – have potentially facilitated this recovery. However, further ongoing monitoring and assessments in response to environmental flows are needed to determine the different influences that are facilitating native fish species recovery.

154 Ibid
155 Ibid
156 Ibid
157 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
<p>B:14 Distribution and abundance of waterbirds in the Murray Darling Basin</p> <p>Data custodian DELWP</p>						<p>DATA QUALITY</p> <p>Fair</p>

The Eastern Australian Waterbird Survey has collected and analysed waterbird data annually since 1983, with the latest available report dated 2017.¹⁵⁸ This large-scale biodiversity dataset monitors change in the distribution and abundance of 50 waterbird species, including threatened species, and the health of rivers and wetlands. Waterbird abundances are strongly related to river flows and rainfall. Within Victoria, this survey is limited to the Murray–Darling Basin and coastal Ramsar sites (the latter is discussed in the Marine and Coastal Environments chapter).

There have been ecological impacts to the Murray–Darling Basin’s rivers and floodplains due to reductions in cumulative annual flows extracted by water resource development.¹⁵⁹ Although waterbird abundances were highly variable over the 35-year survey period, a reduction in water flow has contributed to a long-term decline in the total abundance, as well as in functional response groups (ducks, grebes, herbivores, large wading birds and piscivores (fish-eaters)) and in individual species of waterbird at the basin, river and wetland scales. Ecosystem level change has impacted three Ramsar-listed sites including Lower Lakes, Coorong and Murray Mouth.¹⁶⁰

The 2012 Wetland Connectivity study¹⁶¹ recorded 145 waterbird species across Victorian wetlands. This figure excludes pelagic (ocean-going) seabirds and a small number of land birds associated with saltmarsh habitats. Of the 145 species, 83 breed in

Victoria and the remainder are regular migrants (29 species) or rare vagrants which are seen far outside their expected breeding, wintering or migrating range (29 species). Some of the migrants breed in New Zealand, but most of them travel longer distances to breed in arctic or subarctic regions of northern Asia or Alaska.¹⁶² As this study focused on wetland connectivity for birds, rather than being a pure bird population survey, there is no trend analysis to identify how bird numbers are influenced by international drivers or how wetland water availability across Victoria and Australia governs where birds choose to feed and breed.

Populations of waterbirds utilise multiple habitats over varying spatial scales (including wetlands, rivers and estuaries) to moult, roost, breed and forage.¹⁶³ Wetland water regimes strongly influence waterbird populations. Floods trigger breeding in many species, and wetland systems that are flooded after a dry period support large numbers of waterbirds compared to permanently flooded sites.¹⁶⁴

Some waterbirds that occur in Victoria are common, occupying a range of habitats. Other species have more specialised requirements and only occupy habitats with certain levels of aquatic vegetation cover and salinity. Some of the less common species tend to be associated with large and complex wetlands that provide a range of habitat resources.¹⁶⁵

158 Kingsford RT, Bino G, Porter JL 2017, 'Continental impacts of water development on waterbirds, contrasting two Australian river basins: global implications for sustainable water use', *Global Change Biology*, pp.1-12.

159 There are 240 large dams and annual diversions of approximately 6,800GL due to water resource use in the Murray–Darling Basin system.

160 Kingsford RT, Bino G, Porter JL 2017, 'Continental impacts of water development on waterbirds, contrasting two Australian river basins: global implications for sustainable water use', *Global Change Biology*, pp.1-12.

161 Morris K 2012, 'Wetland connectivity: understanding the dispersal of organisms that occur in Victoria's wetlands', Arthur Rylah Institute for Environmental Research Technical Report Series No.225, Heidelberg, Victoria.

162 Ibid
163 Ibid
164 Ibid
165 Ibid

The geographical arrangement of wetlands in the landscape and the dispersal capacity of waterbirds influence the dynamics of waterbird populations. Although there is some information about the dispersal capacity of waterbirds over large scales, there is little information on the frequencies or patterns of waterbird movements between wetlands over small spatial and temporal scales. Knowledge of these finer-scale movements, particularly during critical life stages, is needed to identify the landscapes elements required to sustain waterbird populations.¹⁶⁶

166 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:15 Distribution and abundance of macroinvertebrates						
Data custodian EPA Victoria						DATA QUALITY Fair

Inland aquatic macroinvertebrates are widely used in Australian assessments of ecosystem condition. The RiverMAP Long Term Sites (LTS) Project provides trends in aquatic macroinvertebrate biodiversity across 66 sampling sites. Sampling of inland aquatic macroinvertebrates has taken place since 1990. Between 1990 and 2012, the number of sampled sites, years sampled and total samples have varied. Therefore, trends reported here are heavily weighted towards more frequently sampled sites.

EPA Victoria and DELWP selected and agreed on 66 sites on initiation of the RiverMAP program. Of the 66 LTS, 39 are in DELWP’s high priority locations and 15 are from EPA Victoria’s long-term monitoring sites (sites that have been sampled since the 1990s), which simultaneously maximises coverage across SEPP defined bioregions (Table B.11). The remaining 12 sites were included to add analytical strength to detect change in macroinvertebrate condition at both statewide and SEPP region scales. While reasonably representative of conditions within a bioregion, the LTS do not represent the full range of environmental variability within a bioregion and therefore trends presented here are not indicative of long-term conditions for all stream types within a bioregion.

Table B.11 A description of the 5 SEPP WoV bioregions applied to the LTS Project¹⁶⁷

SEPP Bioregion	Description
Highlands (B1)	This region is in the high country of Victoria, with streams often on steep slopes, generally above 1,000 m and subject to high rainfall. The vegetation tends to be native forest, woodland and grassland. Riparian shading varies from moderate to low cover, depending on the course of streams through forested or grassland areas, respectively.
Forests A (B2)	Six separate areas form this region, comprising upland reaches in the Upper Murray, Mitta Mitta, Kiewa, Goulburn, Yarra, Latrobe and Thomson catchments, and rivers and streams in the Grampians, Strzeleki Ranges, Wilsons Promontory and far East Gippsland. Although not all are geographically connected, they share similar environmental and biological characteristics. The streams are generally located on moderately steep slopes at much lower altitudes than the Highlands Region, but at moderately high altitudes relative to the remaining regions. The region receives moderate to high rainfall. Tall forests and woodlands are the typical vegetation cover, with some forestry and grazing activities. Streams generally have considerable shading from the riparian zone, and tend to be further from their source with a greater upstream catchment area than the Highlands Region. Cool waters with very low alkalinity, turbidity and salinity characterise the region, except in the Grampians where there is low to moderate salinity. Streams typically have both riffle and edge habitat with moderately coarse substrate, and very low macrophyte cover and diversity.
Forests B (B3)	The Forests B Region incorporates the upland reaches in the Ovens, Broken, Goulburn, Macalister, Mitchell, Tambo and Snowy catchments, and rivers and streams in the Otway Ranges. This discontinuous region generally covers an area similar in altitude to the Forests A Region, but stream slopes are less steep. Rainfall is slightly less in this region than in Forests A Region, and supports tall open forests. A greater degree of clearing for forestry, grazing and some intensive agriculture occurs in this region compared with the Highlands Region and Forests A Region. This results in a lower level of riparian shading. Streams are further from their source, with more than double the catchment area of streams in Forests A Region. Alkalinity of the cool waters typical of this region is slightly elevated relative to the Highlands Region and Forests A Region, but still remains low compared to the rest of the state along with turbidity and salinity. Stream habitat is characterised by the presence of riffles and edges, with very coarse substrate and high macrophyte diversity and cover.

¹⁶⁷ EPA Victoria 2004, 'Information bulletin biological objectives for rivers and streams – ecosystem protection', Melbourne, Victoria.

SEPP Bioregion	Description
Cleared Hills and Coastal Plains (B4)	<p>The urban area of Melbourne divides this region, which is characterised by coastal plains in the south and inland plains and low foothills in the north and east. This region includes upper reaches in the Campaspe, Loddon, Avoca, Wimmera and Hopkins catchments, midreaches in the Ovens, Broken and Goulburn catchments, lowland reaches in the Barwon, Yarra, Latrobe, Thomson, Macalister, Mitchell, Tambo and Snowy catchments, all reaches in the Curdies, Moorabool, Werribee, Maribyrnong and Western Port catchments, and river and stream reaches in South Gippsland. Streams flow through an undulating landscape of low altitude with little gradient and relatively low rainfall. The region has been substantially cleared for intensive agriculture including dryland pasture and some irrigated pasture, resulting in poor riparian shading. Warm stream waters with high alkalinity and low to moderate turbidity and salinity characterise the region. The edge habitat is more developed and extensive, and riffles are less common. The substrate tends to be composed of moderate to fine particles, and there is a very high diversity and moderate cover of macrophytes.</p>
Murray and Western Plains Region (B5)	<p>This region incorporates the west and north of the state and covers an area of low altitude plains with very little topographical relief and low rainfall. This region includes lowland reaches in the Kiewa, Ovens, Broken, Goulburn, Campaspe, Loddon, Avoca, Wimmera, Glenelg, and Hopkins catchments, the entire Corangamite catchment and the Portland and Millicent Coast basins. The region has been generally cleared for dryland and irrigated pasture, and broad-acre cropping. It also includes some patches of Mallee woodland. Riparian shading is, therefore, typically very poor. The waters are warm and slow, often seasonally intermittent, tending towards pond-like waterways with high alkalinity, and moderate to high turbidity and salinity. The very fine substrate of the streams means that the principal habitat is along edges, with the high diversity and cover of macrophytes and woody debris being the dominant habitat for invertebrates. Riffles are uncommon.</p>
North-west Victoria	<p>Because of insufficient data in the north-west area of Victoria, and a very different aquatic environment, no specific biological objectives have been set for water bodies in this region. If required, the objectives from the Murray and Western Plains Region (B5) can be used as interim objectives where streams are present.</p>

The analysis explored relationships between trends and environmental variables and applied four macroinvertebrate metrics:¹⁶⁸

- total number of different macroinvertebrate groups (total richness)
- total number of specific macroinvertebrate family groups, specifically Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa
- stream invertebrate grade number average level (SIGNAL2) which is a grading system ranging between 1 and 10 that represents water-quality sensitivities¹⁶⁹ of macroinvertebrates
- an indicator of community composition, Australian River Assessment System observed/expected index (AUSRIVAS O/E).¹⁷⁰

At the statewide scale, the overall condition of inland aquatic macroinvertebrates across Victoria's 66 long-term monitoring sites is stable.^{171,172} Forest and riparian cover were all strongly positively correlated with the condition of macroinvertebrates,¹⁷³ whereas rainfall, streamflow and land use all influenced the differences found in macroinvertebrate assemblages across all SEPP bioregions.¹⁷⁴

Macroinvertebrate trends varied at the SEPP bioregional scale. The Cleared Hills and Coastal Plains and Murray and Western Plains bioregions (Figure B.6) had low numbers of sensitive taxonomic macroinvertebrate groups (EPT taxa) and low SIGNAL2 scores indicating poor stream health compared to Highlands and Forests A and B. Cleared Hills and Coastal Plains had comparatively low SIGNAL2 scores which is partially attributed to streamflow and potentially other variables such as higher proportions of land use.

168 EPA Victoria 2016, 'RiverMAP long term sites project final report', Melbourne, Victoria.

169 Note: water-quality sensitivities includes: water temperatures, turbidity, electrical conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus, in: Chessman B 2003, 'New sensitivity grades for Australian river macroinvertebrates', *Marine and Freshwater Research*, 54, pp.95-103.

170 Note: the AUSRIVAS O/E is a standardised protocol for the assessment of river physical and chemical condition incorporating in-stream physical habitat, catchment geomorphology, riparian condition and water quality, in: Parsons M, Ransom G, Thoms M, Norris R, 2002, 'Australian river assessment system: AusRivAS physical and chemical assessment Module', Monitoring River Health Initiative Technical Report no 23, Commonwealth of Australia and University of Canberra, Canberra.

171 Ibid

172 EPA 2016, 'River monitoring and assessment program (RiverMAP): river health modelling project technical report', Melbourne, Victoria.

173 Ibid

174 EPA Victoria 2016, 'RiverMAP long term sites project final report', Melbourne, Victoria.

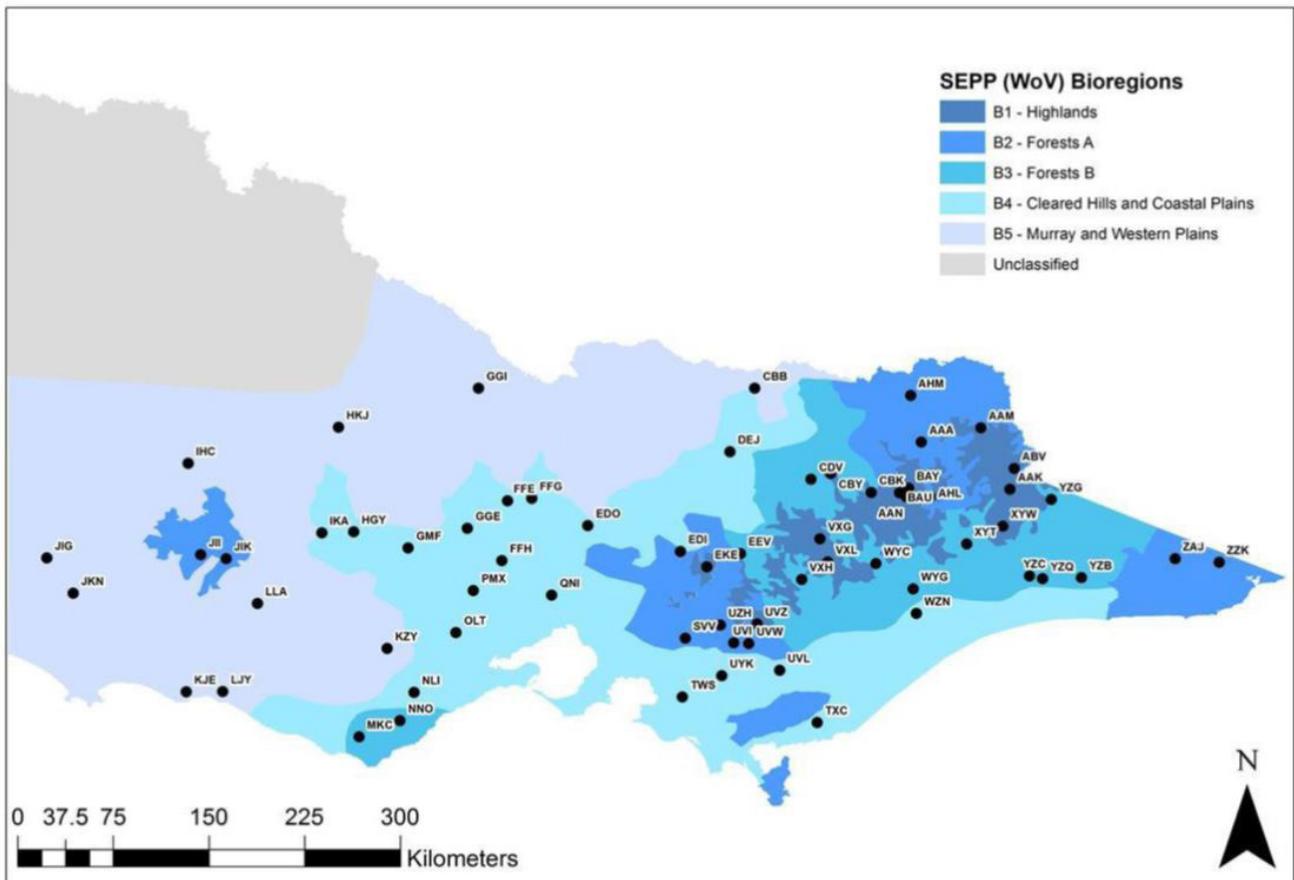


Figure B.6 The 66 sampled sites across SEPP bioregions for the RiverMAP long-term sites monitoring project¹⁷⁵

175 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:16 Wetland extent and condition						 DATA QUALITY Poor
Data custodian DELWP						

Wetlands are defined as natural, modified or artificial areas subject to permanent or temporary inundation that hold static or very slow-moving water and develop – or have the potential to develop – biota adapted to inundation and the aquatic environment.¹⁷⁶ The naming convention for inland (freshwater) wetland types was revised in the *Victorian Wetland Classification Framework 2014*.¹⁷⁷ There are two types of freshwater wetlands:

- lacustrine wetlands categorised by less than 30% vegetation cover such as lakes
- palustrine wetlands categorised by greater than 30% vegetation cover and divided into the following types:
 - swamps (wetlands dominated by woody vegetation)
 - marshes/meadows (wetland dominated by non-woody emergent vegetation)
 - high country peatlands.

Water sources for lacustrine and palustrine wetlands can include groundwater, river or those that are artificially filled and have permanent or periodically inundated water regimes, for example seasonal, intermittent or episodic water availability.¹⁷⁸ Marine and estuarine wetlands are assessed in the Marine and Coastal Environments chapter.

The 2014 inventory of Victoria’s wetlands recorded 23,739 natural wetlands covering 604,322 hectares and 11,060 artificial wetlands covering 170,613 hectares.¹⁷⁹ More than a quarter of Victoria’s wetlands have been lost since European settlement.¹⁸⁰ Of the 149 wetland EVCs,

nearly all are threatened in at least one Victorian bioregion and over 75% of all wetland EVCs across Gippsland Plains, Glenelg Plain, Otway Plain, Victorian Riverina, Victorian Volcanic Plain and Warrnambool Plan are considered endangered and vulnerable.¹⁸¹ There have been no further statewide assessments on wetland condition using the Index of Wetland Condition¹⁸² since the release of the SoE 2013 report.¹⁸³

DELWP is currently developing a statewide wetland monitoring and assessment program for environmental watering (WetMAP). WetMAP represents a short-to-medium term intervention approach and will monitor a subset of Victoria’s wetlands, from each CMA region, before and after environmental water delivery. This long-term program aims to evaluate the effectiveness of wetland management by monitoring and assessing responses to different management approaches.¹⁸⁴

176 DELWP 2018, 'Wetlands', <https://www.water.vic.gov.au/waterways-and-catchments/rivers-estuaries-and-waterways/wetlands> Accessed 9 September 2018.
177 DELWP 2016, 'The Victorian wetland classification framework 2014', Melbourne, Victoria.
178 Ibid
179 Ibid
180 Ibid

181 VEAC 2017, 'Statewide assessment of public land supplementary paper', Melbourne, Victoria.
182 Papas P, Moloney P 2012, 'Victoria’s wetlands 2009–2011: statewide assessments and condition modelling', Arthur Rylah Institute for Environmental Research Technical Report Series No. 229, Heidelberg, Victoria.
183 CES 2013, 'Victoria: State of the Environment Report Science Policy People', Melbourne, Victoria.
184 DELWP 2017, 'VEFMAP Stage 6 Part A: program context and rationale', Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria.

Cropping in Wetlands

The last Index of Wetland Condition found that cropping occurred in 7.5% of the 8,489 wetlands assessed (Figure B.7). An examination of key attributes for wetlands where cropping was recorded found that cropping appears most likely to occur in palustrine, fresh, periodically inundated wetlands with an episodic or seasonal water regime. The nationally, critically endangered ecological community of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains is an example of a wetland community that occurs in Victoria in wetlands with these attributes. This data indicates that cropping in wetlands is reasonably common and that certain types of wetlands are more vulnerable than others to the impacts of cropping.

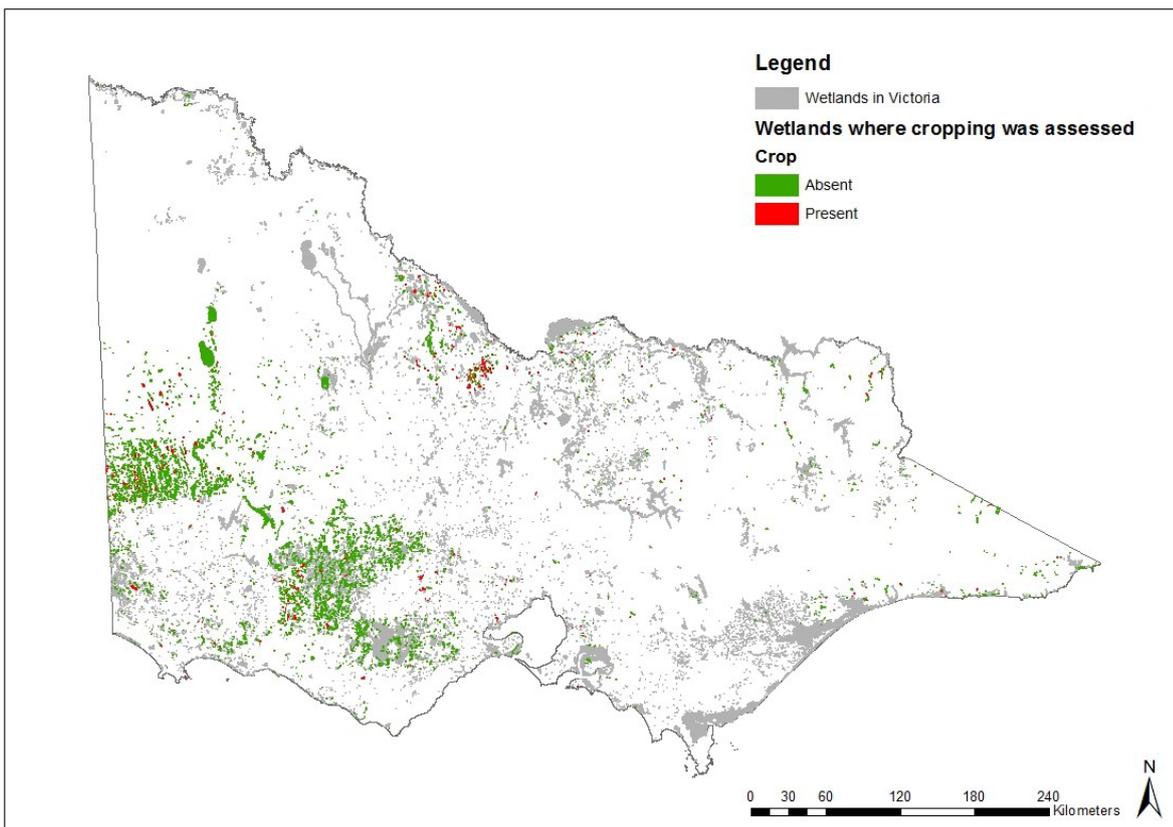


Figure B.7 Locations where wetland cropping occurs, based on results from the last Index of Wetland Condition.

Note: Cropping is marked in red.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:17 Health and status of Ramsar wetlands in Victoria						 DATA QUALITY Poor
Data custodian DELWP						

Victoria has 11 Ramsar sites, of which 6 are inland and cover 98,623 hectares (Table B.12).¹⁸⁵ As part of the Ramsar Convention, management agencies are to maintain the ecological character description for each site. The 2016 Victorian Auditor-General's Office report *Meeting Obligations to Protect Ramsar Wetlands* found limited evidence that ecological character descriptions for each site were being maintained. The status of the ecological character of some sites cannot be fully determined due to limitations such as a lack of data. Therefore, trends in ecological health and status cannot be reported here. Where information is available, it shows that some Ramsar sites are not being effectively managed and protected from ecological decline. These declines are attributed to changed water regimes, water quality, recreational use, agricultural use, invasive species and climate change.¹⁸⁶

Biodiversity 2037 Indicators

This theme will report on indicators that have been developed for *Biodiversity 2037*. These indicators include: Change in suitable habitat, Landscape scale change and Net gain in extent and condition of native vegetation. These indicators are assessed through new methodologies and will provide baselines for future status and trend analysis. Due to these new methodologies, it is not possible to continue previous trend analysis provided in SoE 2008 and 2013 reports. Trend analysis reported for *Biodiversity 2037* indicators are based on time-period data provided by the Data custodian, which varies across each indicator.

Table B.12 Inland aquatic Ramsar sites in Victoria¹⁸⁷

Ramsar site	Area (ha)	Ramsar primary manager
Barmah Forest	29,305	Parks Victoria
Gunbower Forest	20,218	Parks Victoria and DELWP
Hatta-Kulkyne Lakes	977	Parks Victoria
Lake Albacutya	5,659	Parks Victoria
Kerang Wetlands	9,793	Parks Victoria and Goulburn–Murray Water
Western District Lakes	32,671	Parks Victoria

¹⁸⁵ VAGO 2016, 'Meeting obligations to protect Ramsar wetlands', Melbourne, Victoria.

¹⁸⁶ Ibid

¹⁸⁷ Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:18 Net Gain in Extent and Condition of Native Vegetation						
Data custodian DELWP						DATA QUALITY Good

This indicator combines the following biodiversity indicators from previous Victorian SoE reports:

- Habitat Condition – measured as change in the extent and quality of vegetation by EVC categories
- Habitat Extent – measured as fragmentation of native vegetation
- Native Vegetation Extent – assessed as change in the extent of vegetation by EVCs
- Quality, Condition and Fragmentation of Victoria’s native vegetation – provided as overall condition of native vegetation using modelled quality assessments.

These historical indicators are now reported here under the new *Biodiversity 2037* key performance indicator, ‘Net gain in extent and condition of native vegetation’. This measure provides estimates of the overall rate of change in extent and quality of native vegetation on public and private land in Victoria. It should be noted that DELWP is currently designing a ‘net gain’ key performance indicator for freshwater and marine habitats.

Previous ‘net gain’ results, reported in 2008, were based on a once-off modelled overall rate of change in extent and quality of native vegetation on Victorian public and private land in 2007.¹⁸⁸ These results were based on a range of assumptions regarding specific transactions (such as investment, permitted clearing, management actions and offsets) and broad changes (based on imagery and data taken at regular intervals for comparison over time). Results were subject to high variability and poorly quantified levels of uncertainty.

The updated ‘net gain’ methodological approach applied to this indicator keeps the core modelling change categories, but adjusts the assumptions based on collated evidence. Change categories include:

- gain activities – government investment, general management, voluntary actions, improved security
- loss activities – entitled uses, exemptions, controlled management regimes on public land
- neutral activities – permits and offsetting, wildfire, forest harvesting and regeneration.

The impact of controlled management regimes is included as a loss where recent planned burns have resulted in native vegetation being below the tolerable fire interval.¹⁸⁹ While planned burns may provide some benefits for native vegetation extent and condition, this relationship needs further investigation and is not included in this report’s calculations. Controlled management decisions on public land are made in the context of many factors including community health and safety. These decisions and their trade-offs are not within the scope of any ‘net gain’ calculations.

There has been a loss in native vegetation on public and private land between 2008 and 2014 (Table B.13). The largest contributors to net loss in native vegetation on private and freehold land are entitled uses (for example, grazing and removal of trees and fallen logs for personal use), unmanaged threats beyond legislative obligations (for example, environmental weeds) and clearing that is exempt from requiring a permit (such as fences and fire

¹⁸⁸ DSE 2008, ‘Native vegetation net gain accounting. First approximation report’, Melbourne, Victoria.

¹⁸⁹ Tolerable fire interval is defined as the minimum or maximum recommended time intervals between successive fire disturbance events at a site or defined area for a particular vegetation community. It guides how frequent fires should be in the future to allow the persistence of all species at the site or defined area, in: Cheal D 2010, ‘Growth stages and tolerable fire intervals for Victoria’s native vegetation data sets’, Fire and Adaptive Management Report No.84, Melbourne, Victoria.

protection)¹⁹⁰ (Figure B.8). There is also limited data available on some native vegetation losses, such as permitted clearing through local government approvals, exemptions and illegal clearing.¹⁹¹ It should be noted that native vegetation removal regulations and offsets for the removal of native vegetation will also influence future 'net gain' results and should be carefully assessed in all calculations.

Table B.13 Six-year trend in 'net gain' calculations on Victorian public and private land

	Public Land (habitat ha/yr)		Private Land (habitat ha/yr)	
	2008	2014 (a)	2008	2014
Gains subtotal	+ 8,760	+10,500	+ 4,560	+3,100
Losses subtotal	- 2,860	- 8,400	- 14,550	- 13,400
'Net gain' outcome (b)	+ 5,900	+ 2,100	- 9,990	-10,300

(a) The 2014 calculations contain information that was not included in the 2008 Net Gain First Approximation Report.

(b) Due to significant uncertainties associated with underlying assumptions and availability of site specific data, these figures may be under or over estimates, possibly up to 20%.

(Data source: DELWP, 2018)

There has been no acquisition of new imagery for vegetation condition data since 2008. Updated data provided by DELWP (see B:19) will apply Landsat imagery together with resources required to resample previous monitoring sites across the state to model vegetation condition.¹⁹² This will inform new monitoring sites that sample the native vegetation 'space' based on type, extent and other factors. DELWP has developed a framework and standards for monitoring native vegetation to inform management effectiveness studies and to help test assumptions.¹⁹³

¹⁹⁰ DELWP 2015, '2015 qualitative update of the 2008 net gain accounting first approximation report', Melbourne, Victoria.

¹⁹¹ Ibid

¹⁹² Ibid

¹⁹³ Ibid

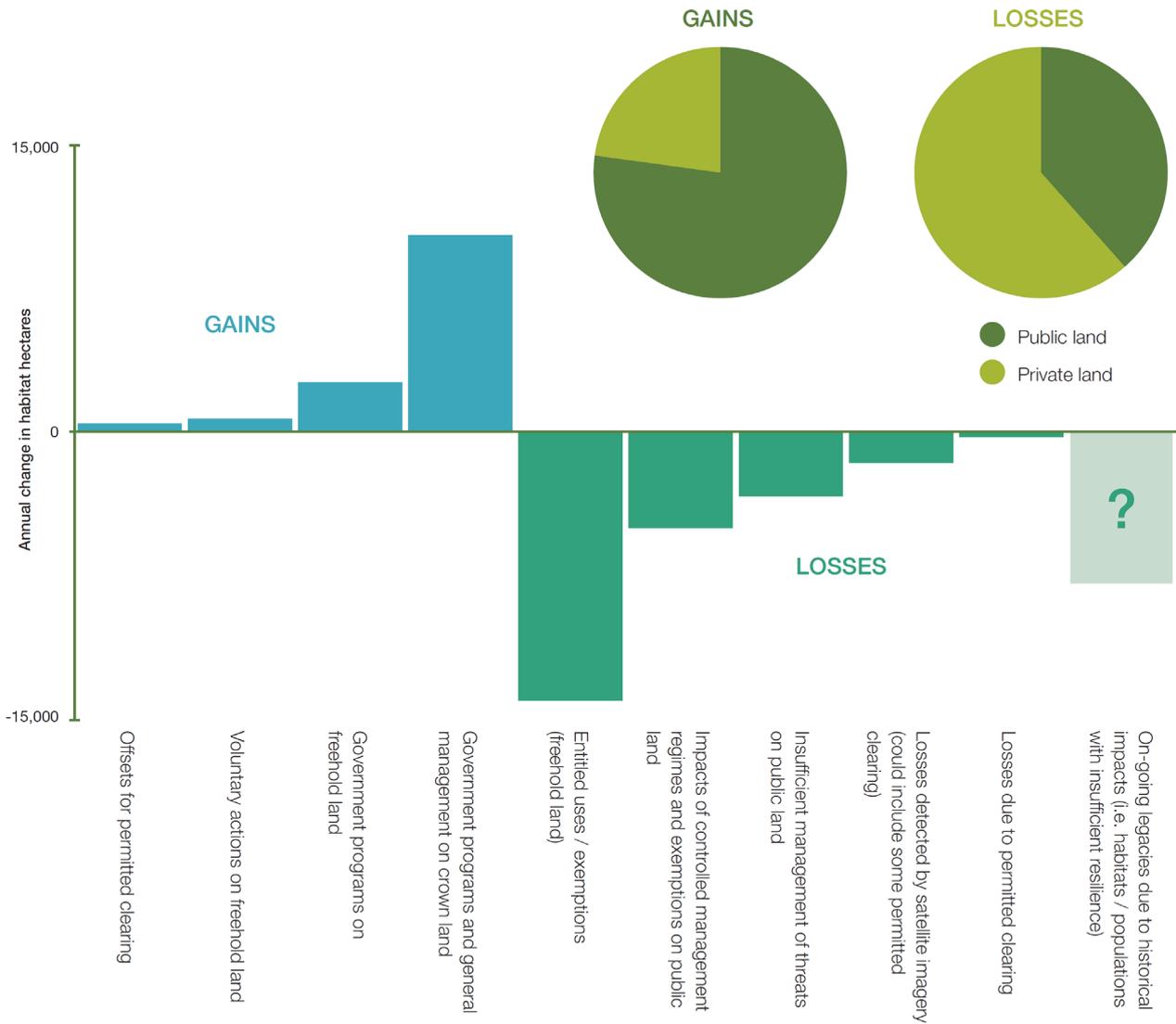


Figure B.8 Relative changes in native vegetation in 2014 estimated using the 'net gain' accounting approach¹⁹⁴

194 DELWP 2016, 'Draft protecting Victoria's environment – Biodiversity 2036', Melbourne, Victoria.

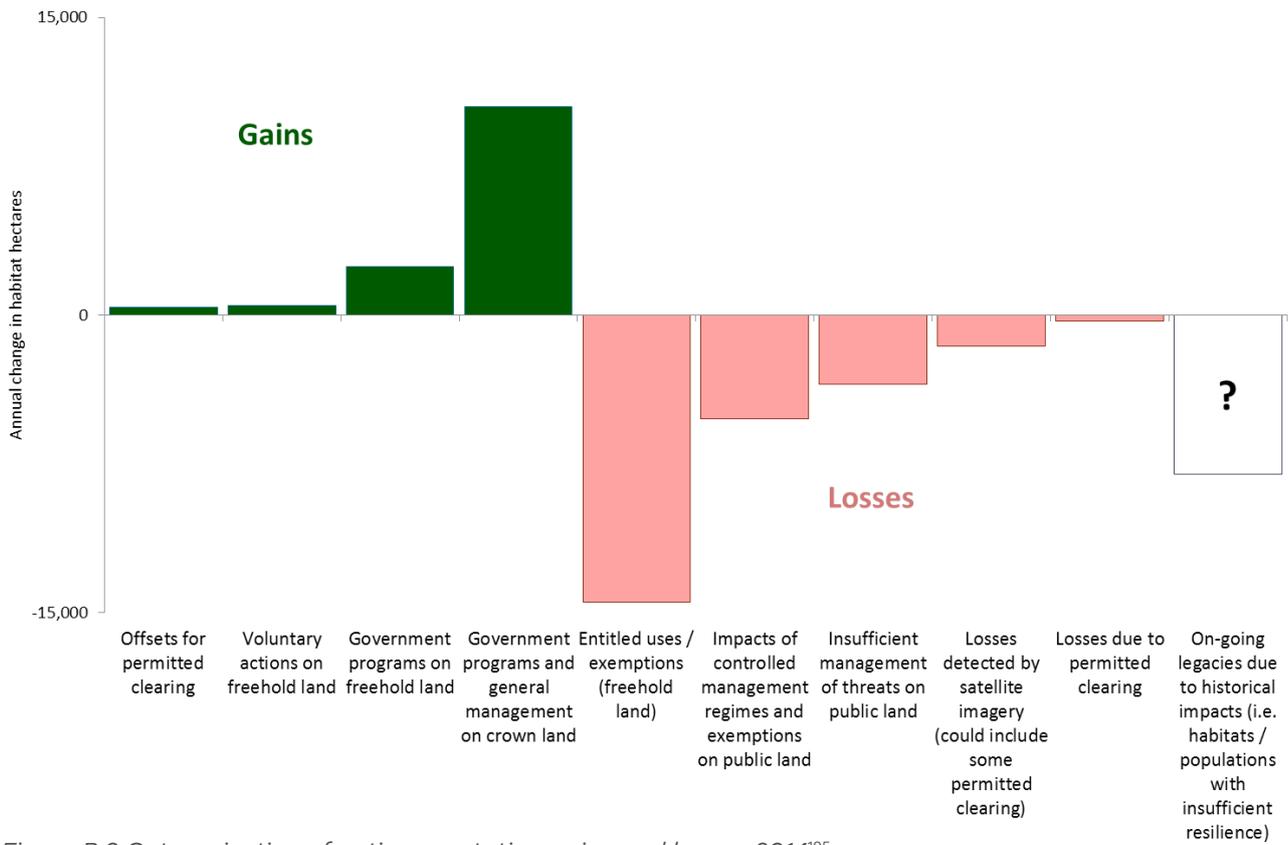


Figure B.9 Categorisation of native vegetation gains and losses, 2014¹⁹⁵

Please note, the question mark in this figure denotes a lack of data to accurately measure on-going legacies.

¹⁹⁵ DELWP 2015, '2015 qualitative update of the 2008 net gain accounting first approximation report', Melbourne, Victoria..

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:19 Landscape Scale Change						 DATA QUALITY Fair
Data custodian DELWP						

Landscape scale change is a new *Biodiversity 2037* indicator. Results provide new information on trends in native vegetation extent and land use from 1987 to 2015. Broken into six time epochs, Landscape scale change will be assessed on five-year groupings. The acquisition of Landsat (satellite) imagery, together with existing (and a small amount of new) training data, will provide a basis for modelling the distribution of native vegetation from a range of variables derived from satellite datasets. Training data is used to predict the relationship between the satellite imagery and native vegetation extent. This methodology will enable the quantification of how vegetation extent (measured as hectares) has changed across Victoria since 1987.

Analysis of landscape scale change shows an increase in landscapes associated with human-based activities and an overall decrease in native vegetation and intermittent and seasonal wetlands not of a marine water source.¹⁹⁶ The urban landscape, most notably in Melbourne's western suburbs and some regional areas such as Bendigo, has increased from 193,200 hectares in 1990 to 270,547 hectares in 2015, representing a 40% increase (Table B.14 and Figure B.10). This urban expansion has resulted in a loss of native grasslands and increased pressures on surrounding native vegetation in terms of asset protection from fire.¹⁹⁷ The built-up landscape, often associated with urban expansion, has also increased from 10,180 hectares to 13,089 hectares (29% increase) for the same time period. Additional landscape type increases between the years 1990 and 2015 include:

- hardwood plantations from 51,084 hectares to 243,609 hectares (377% increase)
- dryland cropping from 4,382,138 hectares to 5,145,877 hectares (17% increase) – specifically around the vicinity of Lake Bolac, Mallee, Mooroopna and Melbourne's western suburbs¹⁹⁸
- native grasslands and herblands specifically in Kerang, most likely attributed to climate change due to variable rainfall resulting in drought and wet years¹⁹⁹
- irrigated horticulture from 460,525 hectares in 1990 to 585,312 hectares in 2015 (27% increase) – specifically expansions in Robinvale²⁰⁰
- exotic woodlands from 77,137 hectares in 1990 to 109,837 hectares in 2015 (42% increase) – most notably around Lake Eppalock.

There have been decreases for the following landscape types between the years 1990 and 2015:

- native grasslands and herblands from 2,282,992 hectares to 1,820,093 hectares (20% decrease) – most notably around the vicinity of Lake Bolac, due to the expansion of dryland cropping and non-native pastures. This is also causing pressure on intermittent and seasonal wetlands and in Melbourne's western suburbs due to urban expansion and dryland cropping.
- native scattered trees from 542,201 hectares to 393,147 hectares (27% decrease)
- native shrubs from 165,262 hectares to 116,620 hectares (29% decrease)
- intermittent and seasonal wetlands, 47,286 hectares to 42,133 hectares 2015 (11% decrease) and 418,611 hectares to 342,955 hectares (18% decrease) respectively.

¹⁹⁶ Note: definition of wetlands in the biodiversity chapter applies the Victorian wetland classification framework 2014. DELWP 2016, 'The Victorian wetland classification framework 2014', Melbourne, Victoria.
¹⁹⁷ DELWP 2018, Data Analysis.

¹⁹⁸ Ibid
¹⁹⁹ Ibid
²⁰⁰ Ibid

Table B.14 Landscape scale change disaggregated to landscape type across 6 time epochs, 1990–2015²⁰¹

Landscape name	1990		1995		2000		2005		2010		2015	
	ha	%										
Built-up	10,180	100	10,975	108	11,562	114	12,336	121	13,452	132	13,089	129
Disturbed Ground	25,555	100	25,756	101	23,558	92	25,900	101	28,381	111	25,353	99
Dryland Cropping	4,382,138	100	4,673,019	107	4,793,679	109	4,978,979	114	5,035,536	115	5,145,877	117
Exotic Woody	77,317	100	74,668	97	95,930	124	91,825	119	88,649	115	109,837	142
Hardwood Plantation	51,084	100	66,513	130	73,400	144	164,109	321	201,594	395	243,609	477
Irrigated Horticulture	460,525	100	574,821	125	463,421	101	444,881	97	405,604	88	585,312	127
Mangrove	5,887	100	6,217	106	6,291	107	6,325	107	6,386	108	6,706	114
Native Grass Herb	2,282,992	100	2,083,245	91	1,944,463	85	2,124,330	93	2,222,795	97	1,820,093	80
Native Scattered Trees	542,210	100	454,371	84	492,556	91	467,682	86	446,289	82	393,147	73
Native Trees	7,822,316	100	7,935,448	101	7,912,706	101	7,916,538	101	7,917,106	101	8,000,382	102
Native Shrub	165,262	100	138,990	84	156,291	95	135,752	82	118,125	71	116,620	71
Natural Low Cover	101,448	100	92,462	91	90,162	89	98,925	98	97,689	96	96,063	95
Pasture Not Native	5,954,067	100	5,727,331	96	5,848,345	98	5,429,390	91	5,334,092	90	5,324,753	89
Pine Plantation	207,713	100	217,611	105	223,771	108	227,169	109	227,853	110	232,058	112
Saltmarsh	11,327	100	11,863	105	11,388	101	11,427	101	11,756	104	12,055	106
Urban	193,200	100	221,729	115	227,292	118	245,303	127	253,738	131	270,547	140
Water	1,527,070	100	1,526,788	100	1,509,181	99	1,504,251	99	1,500,232	98	1,506,213	99
Wetland Intermittent	47,286	100	47,869	101	40,191	85	41,851	89	34,265	72	42,133	89
Wetland Seasonal	418,611	100	397,106	95	361,999	86	359,225	86	342,651	82	342,955	82

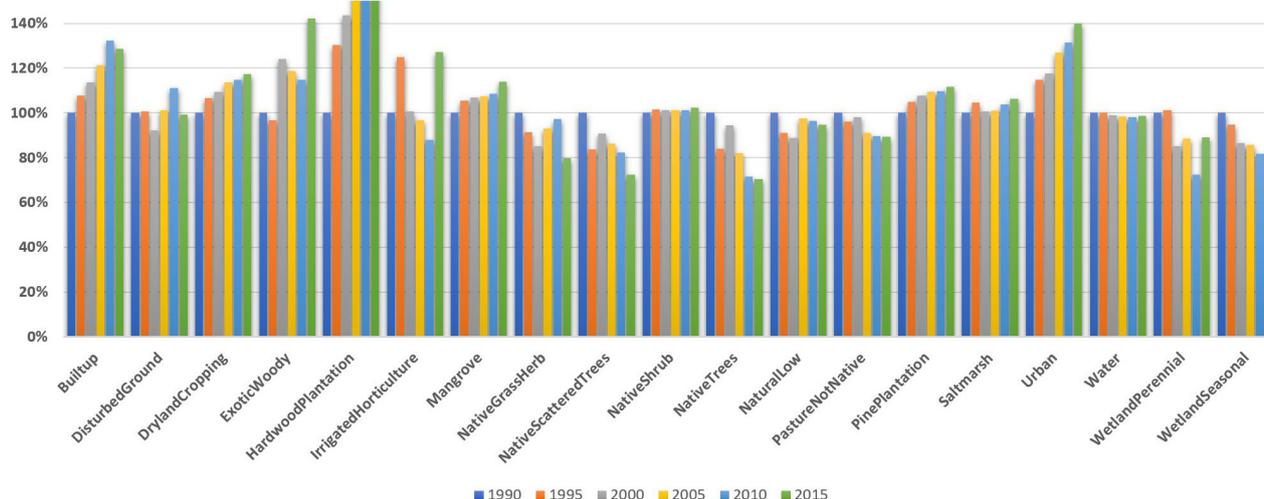


Figure B.10 Landscape Scale Change for each landscape type across 6 time epochs, 1990–2015²⁰²

201 DELWP 2018, Data Analysis.

202 Ibid

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:20 Change in Suitable Habitat						
Data custodian DELWP						Good

The previous Victorian SoE biodiversity indicator, Biodiversity Information, which assesses the comprehensiveness of biodiversity information required for effective management, is reported here under the new indicator title, Change in suitable habitat (CSH), which will be included in future SoE reporting.

CSH is the Victorian Government’s new key performance indicator (KPI) through which it will measure progress towards the targets in *Biodiversity 2037*. This indicator’s aim is to provide a practical measure for estimating net improvement in suitable habitat and the most effective options for improving the future of native species across the state under climate change.²⁰³ The indicator’s target is a 100% net positive change (on average) in suitable habitat for threatened species in 50 years.

The methodology considers the type, extent and configuration of habitat for a species and the factors that influence how much a species can make use of this habitat. This measure allows comparisons to be made between species, places and actions and is a shift from considering threatened species individually to securing the greatest overall benefit for all threatened and native species, taking account of cost-effectiveness. It compares the relative benefits that can be expected for different species from diverse management interventions. CSH can be calculated for one species and can be combined across many species.

Biodiversity 2037 states that achieving the 100% change (on average) in suitable habitat target will require the establishment and maintenance of management actions and associated targets identified in the Strategic Management Prospects (SMP) tool. The contributing management actions and targets identify priority areas that need to achieve the CSH, as soon as possible, and its maintenance over the life of the management plan. If effort slows or stops, for even a short time, the gains made over the preceding years of management effort could be lost. The faster the management actions are implemented and sustained to deliver their contributing targets, the more likely the statewide target, 100% net positive change (on average) in suitable habitat for threatened species in 50 years, can be achieved. The contributing management actions and targets will be reviewed every five years to ensure they are contributing to the statewide target.

To track and identify each management plan’s actions and efforts in meeting this indicator’s statewide target, DELWP has established five-yearly milestone targets for each management plan. Milestone targets identify whether the expected management actions and efforts in priority locations, from existing and proposed activities, align with the management plan’s target and the statewide target. Milestone targets will also consider that some management actions and efforts, such as deer control, are still subject to adaptive management approaches.

For each management plan, CSH measures the increase in the likelihood that a species will persist at a priority location at a future time (for example, in 50 years) in response to sustained management of relevant threats. It is expressed as the proportional increase (percentage) in hectares of suitable habitat a species has received under a sustained management regime, compared with no management.

203 DELWP 2017, ‘Protecting Victoria’s Environment – Biodiversity 2037’, Melbourne, Victoria.

The calculation for CSH is:

$$\text{CSH (for a species)} = (\text{action}^1 - \text{action}^0) \div \text{action}^0$$

where:

action⁰ is the likelihood of persistence of the species with no action in the analysis

action¹ is the likelihood of persistence of the species with actions, adjusted based on the standard of work applied.

Management actions at sites included in the analysis are based on the activity data (DELWP standard outputs) reported by organisations delivering on-ground works to control terrestrial pest plants and animals (Figure B.11). The current analysis includes on-ground management actions from 2015–16 and 2017–18, in addition to any permanent protection agreements.

Results found that the average percentage CSH in 50 years for all native species is 5.24% (Table B.15). For threatened species, the average percentage CSH in 50 years is 5.3%, based on the on-ground management actions taken. For some species, the percentage CSH was much higher than the average. For example:

- 6 species had CSH greater than 100%
- 89 species had a CSH greater than 20%
- 431 species had a CSH greater than 10%.

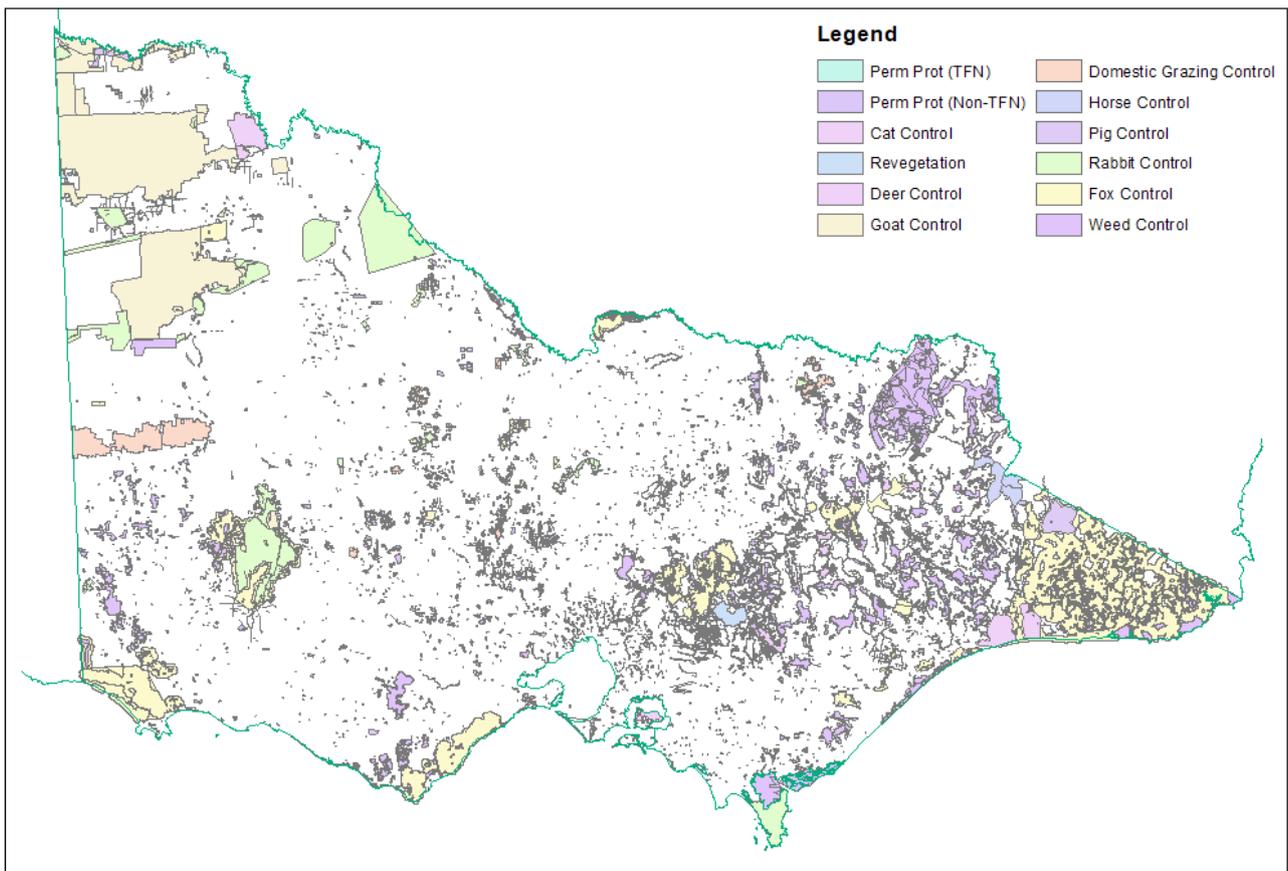


Figure B.11 Map of reported on-ground management actions across Victoria and applied to assess CSH assessment

(Source: DELWP 2018)

Table B.15 CSH for all native species in 50 years

Parameter	Target net positive CSH in 50 years for all species (%)	(on average) % net CSH in 50 years (%)
All species	(on average) 100	5.24
Birds		2.56
Frogs		3.45
Mammals		27.11
Plants		4.33
Reptiles		19.02
Threatened species	n/a	(on average) 5.3

(Data source: DELWP 2018)

A key assumption of these calculations is that the actions are continued for the next 50 years at the best practice standard. The relatively low predicted percentage net change (on average) in suitable habitat in 50 years may be due to the following factors:

- the short time frame over which reporting and recording of key management actions has occurred
- a lack of alignment of key management actions with priority locations
- evidence of only partial control of the threat due to the lack of a fully integrated management plan or implementation of partial treatments of a particular threat (Figure B.11). For example, management actions such as pest predator and herbivore controls in priority locations require an integrated approach to fully manage these threats. All pest herbivore species must be adequately controlled in a location for a beneficial management outcome. In practice, controlling all pest herbivore species is rarely done, and in many cases, only one or two species are targeted for control at a management location. While there is a large amount of pest herbivore control occurring in priority management locations across Victoria (Table B.16), analysis of management actions indicate that the benefits are not being fully realised in terms of percentage increase in suitable habitat as not all pest herbivore species are being adequately controlled in those priority locations (for example, there is a need for integrated feral horse, deer and pig control in the Victorian Alps).
- a relatively large number (over 100) of flora species that received negative benefits from predator control management actions, due to the increase of herbivore species (such as rabbits) from reductions in predation without the corresponding pest herbivore control, therefore increasing total grazing pressure. Such negative benefits could be avoided by an increase in integrated ecosystem management, such as considering the potential flow-on effects of predator control by restoring or mirroring the function of predators through other management.
- the need for further management action through increased investment
- missing spatial data for management actions completed or being undertaken that may impact on CSH, particularly for threatened species (for example, species-specific actions) or actions implemented by community groups, volunteers, conservation efforts on private land and gaps for individual CMAs and other organisations who manage environmental assets that have not been recorded and reported to DELWP.

Caveats and assumptions for implementing and measuring CSH include:

- The values provided here assume that the reported management actions were done to best practice, and that they will be sustained for 50 years. Any estimated benefits do not apply if a management action is not sustained for the 50-year time horizon. Therefore, when calculating benefits, management actions will be counted for a location if they are current (either newly established or continuing from previous years).
- The location across which management actions were implemented for each individual species targeted contributes to the overall management target, even when the location of the management action or the management action itself overlaps.
- The benefit and area data are calculated on the assumption that a management action is implemented across the full extent of the polygons reported, and therefore may be overestimated in some cases. Efforts were applied to refine polygons where better information was available, however, data for some actions (such as weed control) may still be an overestimate due to spatial data that overvalues the actual area of management action. Future reporting against these targets requires refinement of reporting data to reduce this uncertainty and associated overestimates.
- In instances, some polygons of reported management action did not intersect with action benefit models in the SMP tool. This was due to some threat models underestimating the true distribution of a threat, and therefore, locations where management action is required. This results in an optimistic CSH value.

- The figures detailed here apply to the information provided by the current (v1.2) SMP analysis. As the SMP develops and improves over time, and includes accurate data for effective treatment area and standard of works, the CSH values will vary. It will be possible in the future to back cast the SMP models and data to provide trend information through time.

Case Studies

Potoroos

The Long-footed Potoroo (*Potorous longipes*) and Long-nosed Potoroos (*Potorous tridactylus*) are both expected to have a net positive CSH of 127% and 98.6%, respectively, over the next 50 years under their reported management regimes. This is largely due to large-scale predator control programs (e.g. Southern Ark) operating in East Gippsland.

Anglesea Grevillea

The Anglesea Grevillea (*Grevillea infecunda*) will experience a positive CSH by approximately 4.1% over the next 50 years under the reported management plans. This positive change is due to weed control efforts across its distribution range. Important threats to the Anglesea Grevillea include: physical disturbance by humans and inappropriate fire regimes. Management of these threats are not captured in this assessment. Future inclusion of these management actions, and others, in this assessment might result in an increase in the expected positive CSH for Anglesea Grevillea.

Button Wrinklewort

The Button Wrinklewort (*Rutidosia leptorhyncoides*) is expected to have roughly a 1.3% positive CSH over the next 50 years under the reported management plans, due to weed control efforts. Other key management actions for this species including management of fire regimes and species' genetic diversity management across its distribution range, are not captured in this assessment. Increasing the coverage and inclusion of management actions specific to this endangered species, such as genetic rescue, might result in an increase in the expected positive CSH for Button Wrinklewort.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:21 Area of Management in Priority Locations						
Data custodian DELWP						

This indicator sets out targets for hectares of management in priority locations, including restoration of habitat, which includes:

- 4 million hectares of herbivore control in priority locations by 2037
- 1.5 million hectares of pest predator control by 2037
- 1.5 million hectares of weed control in priority locations by 2037
- 200,000 hectares of revegetation in priority areas for connectivity between habitats by 2037
- 200,000 hectares of new protected areas on private land by 2037

A priority location refers to areas identified within the top 20% cost-effective actions in the SMP. SMP helps to integrate and compare information on the expected benefits and indicative costs of conservation actions across species and locations. It allows us to compare management options, or the effectiveness of individual management actions in different places.

SMPs will help conservation managers make decisions across Victoria, including both investment in actions to strengthen biodiversity, and guidance in the application of statutory responsibilities and regulatory controls. SMP helps to integrate and compare information on the expected benefits and indicative costs of conservation actions across species and locations. It allows us to compare management options, or the effectiveness of individual management actions in different places.²⁰⁴

The SMP focuses on the benefit of action (representing best options for gains) and so contains a mix of values, noting some high-value areas may not be included because they may not have a relevant action in the analysis, the actions are not particularly cost-effective, or the needs of that species have been met by other actions in other places. Increasing the alignment of these actions to sit in the top 20% cost-effective actions, as indicated in the SMP analysis outputs,²⁰⁵ could yield greater biodiversity benefit per unit cost.

On-ground management works are progressing towards Victorian priority location *Biodiversity 2037* targets (Table B.16 and Figure B.12). Caveats and assumptions for implementing and measuring change in area of management in priority locations include:

- Measures include the effective treatment area over which the management action was undertaken. For example, herbivore control in an area with introduced herbivores such as, deer, rabbits, goats, horses and stock. Pigs were controlled by culling, other animals were removed or restricted, shot, trapped, excluded (seasonal or permanent) or a changed grazing regime was introduced. It recognises the area where the target species is located and treatment is applied. It does not include the search area.

204 DELWP 2018, 'Strategic Management Prospectus', Melbourne, Victoria <http://delwp.maps.arcgis.com/apps/MapJournal/index.html?appid=e0289e3fe12f436490ef63d4444a05df#> Accessed 2 October 2018.

205 Ibid

- This assessment assumes on-ground management actions were completed to an appropriate standard (such as DELWP's *Biodiversity 2037* Monitoring, Evaluation and Reporting Framework, DELWP Output Delivery Standards and Output Data Standard).²⁰⁶ A discount rate was applied where a lower level of standard has been applied to the work, where only a portion of the area has been treated or where there is insufficient information provided on the delivery standard. Given this dataset is preliminary in nature, any of these discount rate scenarios are likely to have occurred. Discount rates were 50% of the estimated total biodiversity benefit for the actions where the discount was applied. Weed control and revegetation had a 50% discount applied to each as both actions are rarely done to the standard that is the basis of the benefit estimate in SMP. The spatial data provided for weed control appeared to overestimate the area controlled (in areas such as Murray-Sunset, Grampians and East Gippsland). Weed control, for example, assumes that all high threat weeds are controlled in an area, not just a single or subset of species. Revegetation assumes that it is done to the ecological vegetation class standards, rather than just selected overstorey and understorey species.
 - Priority locations in the SMP contain a mix of area values, where some high value areas may not be included due to the following:
 - They lack a relevant management action in the analysis.
 - The management actions are not particularly cost-effective.
 or
 - The needs of that species have been met by management actions in other locations.
- Increasing the alignment of these management actions to the top 20% cost-effective management actions in the SMP could yield greater biodiversity benefit per unit cost.

²⁰⁶ Note: see Biodiversity 2037 Monitoring, Evaluation and Reporting Framework, DELWP Output Delivery Standards, DELWP Standard Outputs.

Table B.16 Measuring progress from on-ground management actions in achieving *Biodiversity 2037* targets for priority locations across Victoria applying DELWP's Standard Output Data

Management action	Contribution of actions to Biodiversity 2037 targets		Actions across the State
	Hectares of action in priority locations (ha)	Target hectares of actions in priority locations by 2037 (ha)	Total hectares of action in priority and other locations across the state (ha)
Herbivore control	1,572,725	4,000,000	6,979,935
Pest predator control	705,590	1,500,000	2,475,713
Weed control	1,916,350	1,500,000	4,223,328
Restoration	359	200,000	65,217
Hectares of newly protected area on private land	2,204 (a)	200,000	137,270 (b)

(a) Priority location does not apply to this management action.

(b) Total area of permanently protected area on private land in Victoria

(Data source: DELWP 2018)

Some management plans and projects may occur in locations where it would be beneficial to conduct a particular management action. However, each management action is competing with all other management actions across Victoria in the SMP Analysis. This means that not all locations where it is beneficial to conduct a particular management action will be in a 'priority location' within the SMP analysis or where that management action is the most cost-effective. Further progress towards targets could be made by increased alignment of management actions in priority locations (including a combination of actions) through increased funding.

Further progress towards targets could be made by increased alignment of management actions in priority locations (including a combination of management actions). An audit of management sites is planned to determine how management and data standards are being interpreted and applied in DELWP's Standard Output Data. This will feed into a review of the standards to ensure reporting accurately reflects on-ground management action and progress towards priority location targets.

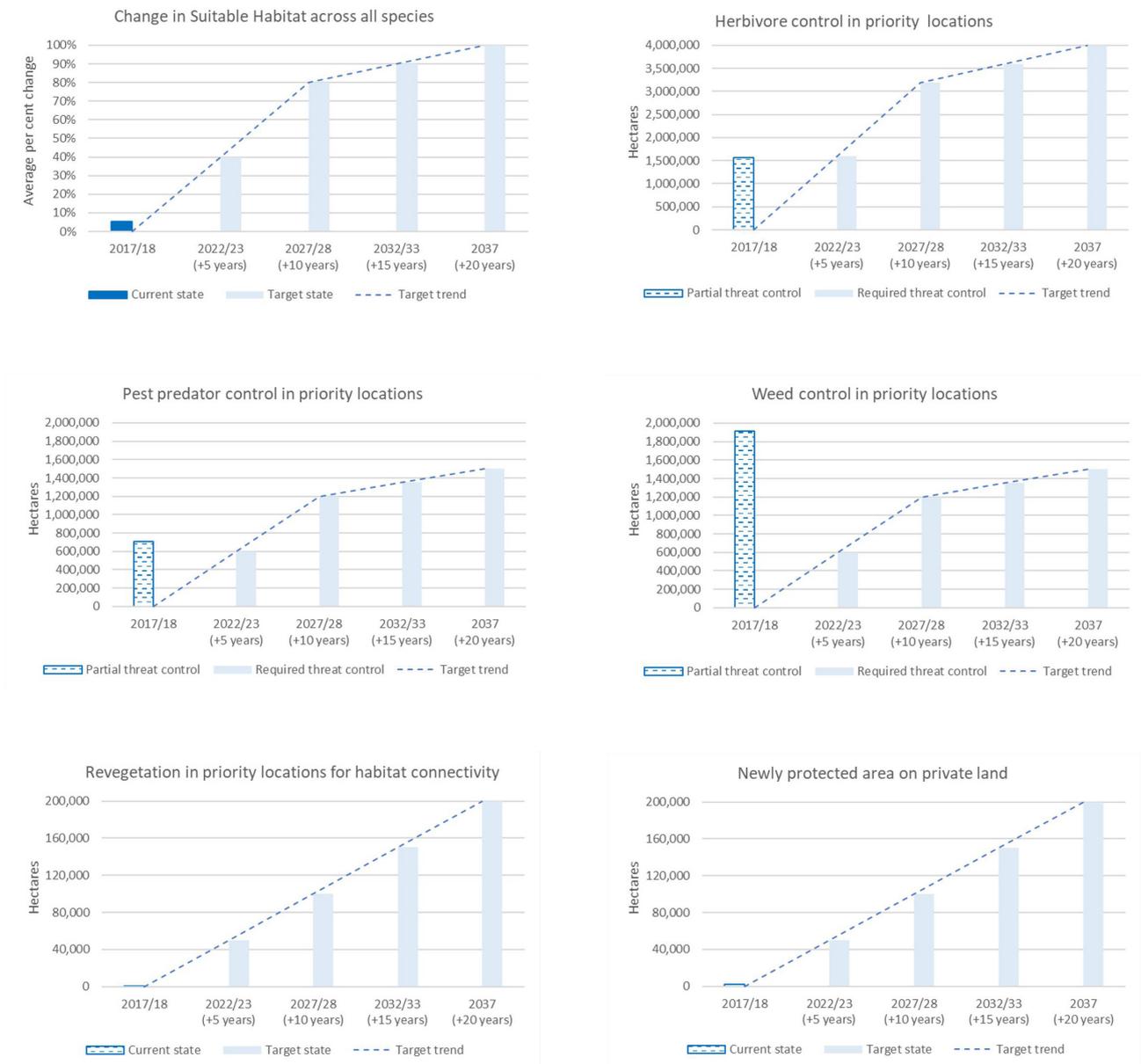


Figure B.12 Measuring progress from on-ground management actions in achieving Biodiversity 2037 targets for priority locations across Victoria

(Data source: DELWP 2018)

Indicator	Status	Trend	Data Quality
	UNKNOWN POOR FAIR GOOD		
B:22 Victorians value nature			
Data custodian DELWP, Parks Victoria, CMAs			Poor

There is an estimated number of 100,000 Victorians participating in environmental volunteering each year across diverse volunteer groups and mostly structured programs.²⁰⁷ These include citizen science programs, marine and coastal volunteers, water programs, Landcare, friends groups, parks volunteers, outdoor enthusiasts groups, Zoos Victoria, climate change and sustainability networks, gardening, wildlife programs, corporate volunteering, not-for-profits, and local government and government agency programs. The majority of environmental volunteer groups are based in regional and rural Victoria.²⁰⁸ There is a lack of culturally and linguistically diverse communities involved in environmental volunteering.²⁰⁹

‘Victorians value nature’ (VVN) is a key objective for the Victorian Government’s *Biodiversity 2037*. This objective aims to understand and assess how Victorians are connecting with the natural environment, how this improves their health and wellbeing and how people are protecting Victoria’s natural environment for current and future generations.²¹⁰ An underlying assumption here is that an increased connection with nature will lead to greater value placed on the environment and more Victorians acting to support biodiversity. This indicator describes the relationship between people’s interaction with nature (how they value it and act to protect or enhance biodiversity) and the ways they use it to improve their health and wellbeing. Targets for VVN include:

- all Victorians connecting with nature
- five million Victorians acting to protect the natural environment

- all Victorian Government organisations that manage environmental assets contributing to achieving the above two targets.

To meet these targets, DELWP has developed the Victorians Volunteering for Nature – Environmental Volunteering Plan. This plan has four key foci areas:

- sustain – to sustain existing environmental volunteering programs and networks
- expand – to regenerate environmental volunteering and encourage more Victorians to act for nature
- value – to value and recognise the contributions of environmental volunteers
- understand – to understand the diverse needs of the environmental volunteering sector.

To implement this plan, DELWP is currently developing the Victorians Valuing Nature Conceptual Framework, which includes the Victorians Valuing Nature Foundations Survey and Structured Decision Making Process for Victorians Valuing Nature. The Victorians Valuing Nature Conceptual Framework will assist in conceptualising the work and creating measures to meet the above targets to be included in the next iteration of the *Biodiversity 2037* Monitoring, Evaluation and Reporting Framework in mid-2019. This will include the development of KPIs and related outcomes for the VVN goal, together with a description of the outputs and the types of standard outputs data required for reporting. As a new *Biodiversity 2037* indicator, baseline figures to assess and inform future state and trend of how Victorians value nature and their experience with nature is currently being collated by DELWP.

207 DELWP 2018, ‘Victorians volunteering for nature environmental volunteering plan’, Melbourne, Victoria.

208 Ibid

209 Ibid

210 DELWP 2017, ‘Protecting Victoria’s Environment – Biodiversity 2037’, Melbourne, Victoria.

Parks Victoria visitor data can also contribute to understanding how Victorians value nature through visitor numbers. In 2013–14, approximately 4.3 million day trips were taken to natural areas by Victorian domestic nature-based visitors.²¹¹ During 2016–17, there were 449 licensed tour operators which increased to 494 licensed tour operators in 2017–18 with active licences working across Parks Estate, highlighting visitor interest.²¹² It is estimated that visits to parks saves Victoria between \$80 to \$200 million per year from avoidance of disease, mortality and lost productivity.²¹³ Aboriginal cultural tourism is also expanding to meet the growing demand for Aboriginal cultural experiences and products.²¹⁴ ParkConnect is Park Victoria’s online volunteer management system. The largest demographic registering to volunteer on ParkConnect is the 18 to 35-year old age group with the highest percentage indicating their employment status as ‘full-time’. The largest proportion of volunteer activities are focused on habitat restoration followed by environmental research, historic heritage conservation then gardening. Since the implementation of ParkConnect there has been a significant shift in demographics of new volunteers with the highest percentage of volunteers previously over 65.²¹⁵

Citizen Science Contribution to Understanding and Managing Victoria’s Biodiversity

Under VVN there is an opportunity for citizen science data to complement science research data for evidence-based biodiversity planning and management decisions. The following indicators can be considered for future reporting of citizen science data:

- the actual data, and its quality, that contribute to management decisions
- the number and types of citizen science programs contributing data for informing real-time on-ground management decisions
- the number of volunteers involved in citizen science programs and the economic value of volunteers’ time
- social benefits – for example social cohesion, level of environmental stewardship and health and wellbeing benefits – as outcomes from volunteers engaging in citizen science.

211 DELWP 2016, ‘Protecting Victoria’s Environment – Biodiversity 2036. Supporting technical supplement’, Melbourne, Victoria.

212 PV Data 2018.

213 PV 2015, ‘Valuing Victoria’s Parks. Accounting for ecosystems and valuing their benefits: Report of first phase findings’, Melbourne, Victoria <http://parkweb.vic.gov.au/about-us/news/valuing-victorias-parks> Accessed 27 July 2018.

214 Tourism Victoria 2014, ‘Aboriginal tourism: market profile year ending June 2014’, Melbourne, Victoria. <http://www.tourism.vic.gov.au/research/domestic-and-regional-research/product-segment-market-profiles.html> Accessed 27 July 2018.

215 PV Data 2018.

Indicator	Status				Trend	Data Quality
	UNKNOWN	POOR	FAIR	GOOD		
B:23 Number of Victorian Government organisations that manage environmental assets that contribute to DELWP Standard Output Data					?	 DATA QUALITY Poor
Data custodian DELWP						

This indicator's target is to have 100% of Victorian Government organisations that manage environmental assets contributing to DELWP Standard Output Data.

To date, 12% of Victorian Government organisations who manage Victoria's natural assets have contributed some data. In most cases this data is not complete and does not reflect all on-ground works those organisations have delivered or funded. Further work, funding and resourcing is needed to support all Victorian Government organisations who manage natural assets to contribute activity data, and ensure they include as requirement for programs including any grant agreements.

Future Focus

Improve Victoria's biodiversity outcomes on public land

As this report demonstrates, the data and science available to answer many of the critical questions about biodiversity condition and extent in Victoria, is inadequate. This fragmented evidence base is an impediment to adaptive management and improving biodiversity outcomes. This fragmentation has three overarching causes.

Firstly, various investment programs across multiple land management groups have created different and inconsistent data sources and terminologies for reporting on the state of biodiversity, land and forest assets in Victoria. These inefficiencies impact on the ability to present a coherent and integrated evidence base to improve management interventions and ultimately, biodiversity outcomes. Streamlining its approach to land-management to reduce inefficiencies will assist DELWP to deliver a well-coordinated and coherent approach.

Secondly, these measures will require complementary investment in improving data capability to routinely monitor progress towards biodiversity outcomes. This will result in improved accessibility and utility of data in more meaningful timeframes for biodiversity, land and water decision-making. Improved data capability has been recognised as an 'enabler' in DELWP's Science Statement for increasing connectivity and discoverability of science across the department, with partners, stakeholders and the community.

Finally, Victoria's biodiversity science and data capability, although underpinned by world-class scientists and research institutions (including DELWP's Arthur Rylah Institute), is diminished by a lack of coordination and strategy in approach to investing in critical research to enable better and more timely decision-making and policy interventions. This is a critical theme that links many of the recommendations presented in this report – and the broader narrative of addressing knowledge gaps and improving the evidence base for environmental management.

This report highlights the need for improved functionality of biodiversity science across the Victorian Government environment portfolio to improve the collection, coordination, curation and interpretation of biodiversity science. Perhaps most critical is the need to integrate biodiversity science to inform solutions to complex problems, cumulative threats (climate change, fire, drought, flood, heatwave, invasive pests, development) and cumulative challenges (forests, water, marine and coastal management).

A chief biodiversity scientist for Victoria would provide the leadership that is missing in Victoria to improve investment and coordination in biodiversity science and research. The chief biodiversity scientist would report directly to the Secretary of DELWP, complement the current roles of EPA Victoria's Chief Environmental Scientist, Parks Victoria's Chief Conservation Scientist and Victoria's Lead Scientist, and provide the DELWP Secretary and the Minister for Environment with esteemed counsel on biodiversity, threatened species and the impacts of climate change, invasive pests and extreme events on biodiversity values and assets. This science leadership role would also extend to advising on the development of the biodiversity targets that the Victorian Government has committed to establishing in *Biodiversity 2037*. A key function of this role would be to ensure that biodiversity research investment by the Victorian Government is targeted to management and policy priorities across the portfolio, and that the science is better curated, coordinated and tailored to improve the collective research impact of the investment on adaptive management.

The chief biodiversity scientist would be equipped with the authority to provide esteemed counsel on the Victorian Government's collective biodiversity research effort and on enhancing biodiversity outcomes consistent with the objectives of *Biodiversity 2037*.

Recommendation 5: That DELWP streamline the governance and coordination of investment in the science and data capability of all government biodiversity programs and improve the coherence and impact of the publicly-funded, scientific endeavour. Further, that DELWP establish the position of the chief biodiversity scientist to oversee this coordinated effort and provide esteemed counsel to the DELWP Secretary and the Minister for Environment to improve the impact of investment in biodiversity research across the Victorian environment portfolio.

Improve Victoria's biodiversity outcomes on private land

The rate of biodiversity loss on private land requires greater focus and effort by government. Victoria has nearly 23 million hectares of land: public land accounts for 37% and private land 63%.²¹⁶ Private land conservation through permanent protection has been increasing across the state. However, it occurs at a slower rate than biodiversity loss and needs to be addressed as a priority over the next decade.

The recommended chief biodiversity scientist would, in consultation with stakeholders across the portfolio, provide esteemed counsel to the DELWP Secretary and the Minister for Environment on the science that underpins private land conservation and on enhancing biodiversity outcomes on private land consistent with the objectives of *Biodiversity 2037*.

Recommendation 6: That DELWP improve biodiversity outcomes on private land by accelerating private land conservation. This will require resourcing permanent protection measures that focus on high-priority ecosystems and landscapes, and investing in local government capability to enforce the existing *Guidelines for the Removal, Destruction or Lopping of Native Vegetation and the Invasive Plants and Animals Policy Framework*.

²¹⁶ VEAC, 2016. Statewide Assessment of Public Land Discussion Paper. Victorian Environmental Assessment Council, East Melbourne, Victoria.

Accounting for the Environment

Biodiversity plays an essential role in supporting economic and social wellbeing through maintaining functioning ecosystems that produce ecosystem services. Environmental–economic accounting provides a framework to measure and link biodiversity and the ecosystem services it supports that underpin economic activity and wellbeing.

The impact of healthy or degraded biodiversity already appears to some extent in Victoria’s traditional economic accounts (the System of National Accounts (SNA)) that record goods and services such as tourism and agricultural production, which are often supported by biodiversity. However, traditional accounts do not identify the proportion of economic activity that can be attributed to biodiverse ecosystems. The System of Environmental–Economic Accounting (SEEA) extends the SNA by including environmental and ecosystem assets. For example, in 2015, Victorian parks were found to support \$1.4 billion per year in visitor expenditure and generate \$1 billion gross value added for the Victorian economy.²¹⁷ Biodiversity is a key part of the visitor experience attraction of parks.

Biodiversity accounts can help illustrate the relationship between biodiversity and economic activity and wellbeing by reporting data in a spatially explicit and consistent and comparable manner. By comparing trends in biodiversity against measures such as land use, energy use, or residual pollutants such as carbon emissions or nitrogen loads it may be possible to link key drivers and pressures contributing to biodiversity loss. Biodiversity accounts have the potential to play an important role in evaluating the efficiency and effectiveness of government and community management actions to protect and enhance Victoria’s biodiversity.

In experimental ecosystem accounting, biodiversity

is typically considered as a characteristic of ecosystems which can be strongly linked to the ecosystem services they provide. In this context, falling biodiversity (as measured, for example, by reductions in the number of species in a given area) will generally correspond to declining ecosystem condition. A measure of biodiversity could be a relevant condition metric for ecosystem assets discussed in other chapters of the SoE 2018, such as forests or marine and coastal environment.

Biodiversity accounting is a complex and evolving area of environmental–economic accounting. Its measurement is a specialist field, and different methods for assessing biodiversity provide varying levels of accuracy and precision. Biodiversity accounting is advancing but remains less defined than other areas of environmental–economic accounting such as land, water or carbon accounting.

Species Accounts

As a component of biodiversity, species form the biotic elements of ecosystems and have an important role in how ecosystems function and deliver ecosystem services that support economic activity and human wellbeing.

Specific species can also contribute directly to economic activity and wellbeing. For instance, some species are important for providing food or medicines used by local communities and in commercial activities. Others may contribute to wellbeing due to their charismatic and iconic nature – valued on the basis of aesthetics, characteristics and behaviour – or because of the cultural status given to them.

Species accounts may support the following analytical uses:

comparing trends in species status with information on economic activities and other drivers of species loss

- organising the information required to support trend analysis – for instance, via interpolation (new data points in an existing set) or forecasting

²¹⁷ Varcoe T, Betts O’Shea H, Contretas Z 2015, ‘Valuing Victoria’s parks: Accounting for ecosystems and valuing their benefits’, Melbourne, Victoria.

- organising information on species for aggregation and communication across all scales
 - communicating the relationships between species, ecosystems and the supply of ecosystem services
 - providing objective statistics to report on policies related to species and ecosystems
 - exploring future trade-offs by organising species information required to support scenario modelling
 - informing cost–benefit or ecological return on investment analyses
 - supporting expert judgement on species status and trends by organising available information on the observations of species.
3. snapshot of species focusing in classifying in a way to enable links between species and ecosystem condition and climate change (by identifying those which rely on habitats in the ACT to breed)
 4. account bringing together the information in points two and three above over two periods of time, showing 9 species added over 40 years.

Lessons learned from the butterfly accounts include that, while conservation status is important, a number of other classifications are useful for understanding the management needs of species, or strategies for conservation of species. In particular, classifications of species as specialists or generalists in terms of habitat needs as well as by area of distribution and movement is important. Having these classifications standardised in future will be useful. The ACT is also planning to compare measures of ecosystem condition from remote sensing data with the butterfly accounts.

The ACT is aiming to eventually use butterfly accounts covering species presence and abundance by habitat type and season each year and between two points in time, species area of distribution by habitat and a land cover account.

Australian Capital Territory Butterfly Accounts

Due to the complexities of biodiversity measurement, the focus is often placed on selected indicators of biodiversity rather than accounting for all aspects of biodiversity.

Butterflies can be used as indicators of environmental condition and change. The Australian Capital Territory (ACT) has recently prepared a set of novel SEEA butterfly accounts²¹⁸ aiming to use accounting for butterflies as a metric of ecosystem condition to identify problems and guide management of ecosystems. The ACT butterfly accounts include:

1. number of butterfly species at different scales (ACT, Australia and global) at one point in time
2. snapshot of species by family with breakdown by breeding category (endemic or introduced) and specialisation (generalists able to survive in a wide range of conditions or specialists that are more localised with specific needs for survival)

²¹⁸ Bond S, Vardon M 2018, 'Moonlight Jewels to Common Browns: Butterfly Accounts for the ACT, Canberra', Australian Bureau of Statistics and Australian National University. https://seea.un.org/sites/seea.un.org/files/g_24_d_16b.pdf Accessed September 2018.