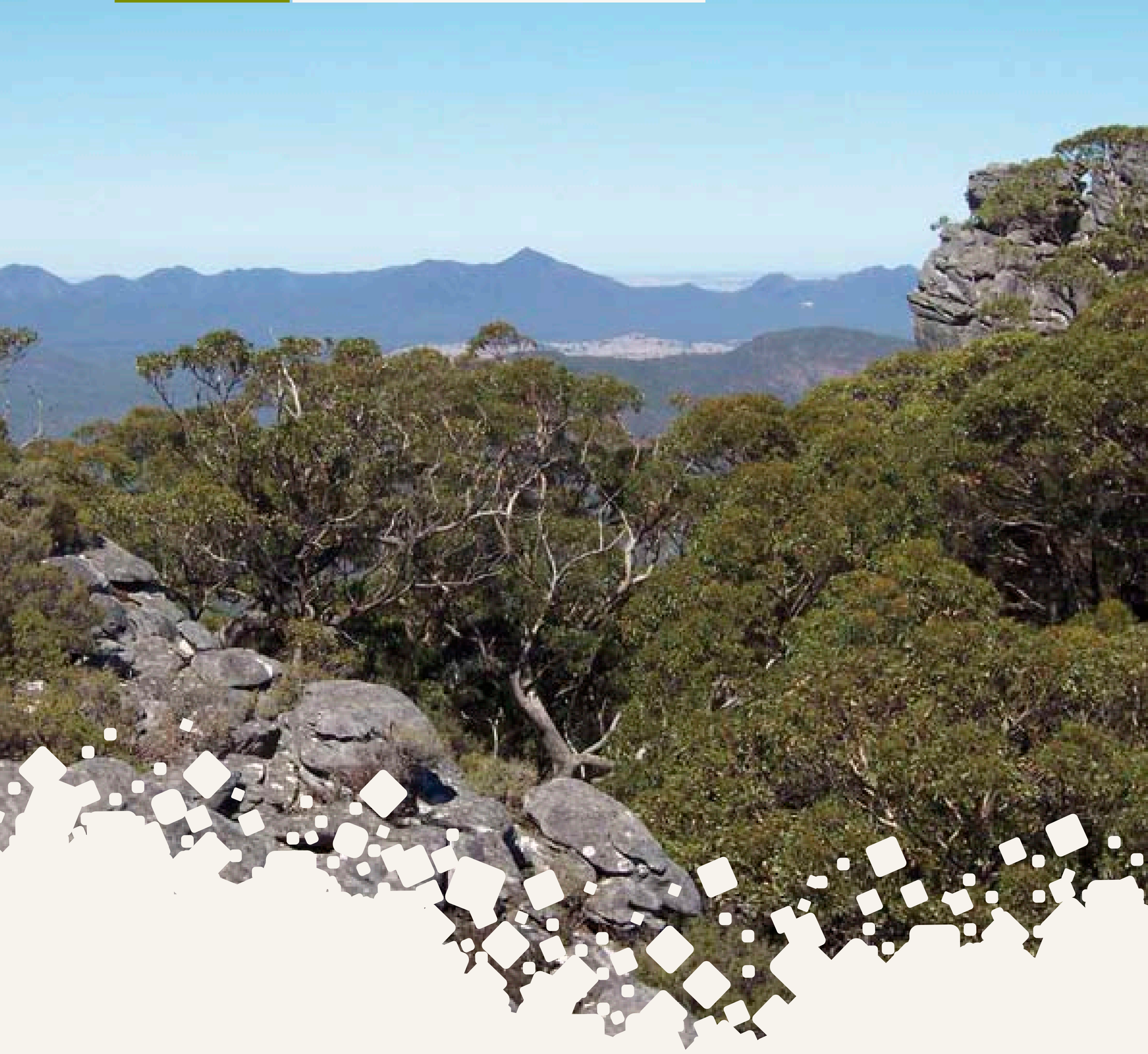


Land and Biodiversity

LB0 Introduction

Key Findings

- Despite improved understanding of environmental issues and processes, the policies and initiatives implemented in recent decades, and extensive investment in the environment, the condition of Victoria's land and biodiversity has continued to decline – Victoria has the highest proportion of sub-regions in Australia considered to be in poor condition. A lack of co-ordinated data collection and reporting arrangements limit the ability to report on individual land and biodiversity resources at a statewide level.
- The study of climate change impacts on Victorian land and biodiversity is in its infancy and there is a high level of uncertainty about both the nature of climate change and its likely effects on Victoria's flora and fauna. Natural ecosystems are highly vulnerable to 1.5–2°C of warming. Climate change is likely to drive changes in land use that will require political and managerial decisions about the relative values of terrestrial systems and uses of land.
- Victoria's historic use of land has left a legacy of highly cleared and fragmented native vegetation over much of the State. Good quality, relatively intact native vegetation only remains in areas that have not been extensively modified. Native grasslands are Victoria's most depleted and most endangered vegetation classes; however, Victorians continue to develop and modify grassland ecosystems. High levels of vegetation clearing may constitute the crossing of an ecological threshold, beyond which rapid change occurs and ecosystems may not recover.
- Human activities continue to cause declines in the condition of native flora and fauna. Future decisions will reflect the choices of Victorians about the attributes of land and biodiversity that they most value. Continuing population growth, urbanisation and consumption may hinder achievement of land and biodiversity management objectives. The high degree of urbanisation of the Victorian population means that the environmental impacts of societal lifestyle patterns may go largely unrecognised.
- A lack of co-ordinated data collection and reporting arrangements limits the ability to assess and report on the condition of Victoria's land and biodiversity at statewide level.
- Victoria's current legislative and institutional framework for land and biodiversity conservation has been developed over many years and is in need of reform and consolidation. However, Victoria has in place a range of structures and processes that will form the basis of future responses to land and biodiversity concerns.
- A range of policy options, including regulation and enforcement, market-based instruments, education and research, is needed to engage a broad spectrum of Victorians in management and protection of land and biodiversity resources.

Victorian land and biodiversity assets

Victoria, a land area of approximately 22.7 million ha with a coastline of 2,000 km[1], is a complex array of landforms produced over a period of 520 million years. The landscape has been substantially modified by human activities. Much of the recognisable shape of Victoria was formed during the last 150 million years. During this period the coastal hinterland was uplifted to form the Great Dividing Range, and the area to the north-east formed the Murray basin[2]. Most recently, volcanic eruptions have shaped the Victorian landscape. Within the last two million years, about 400 volcanoes produced extensive basalt flows over much of western Victoria[3].

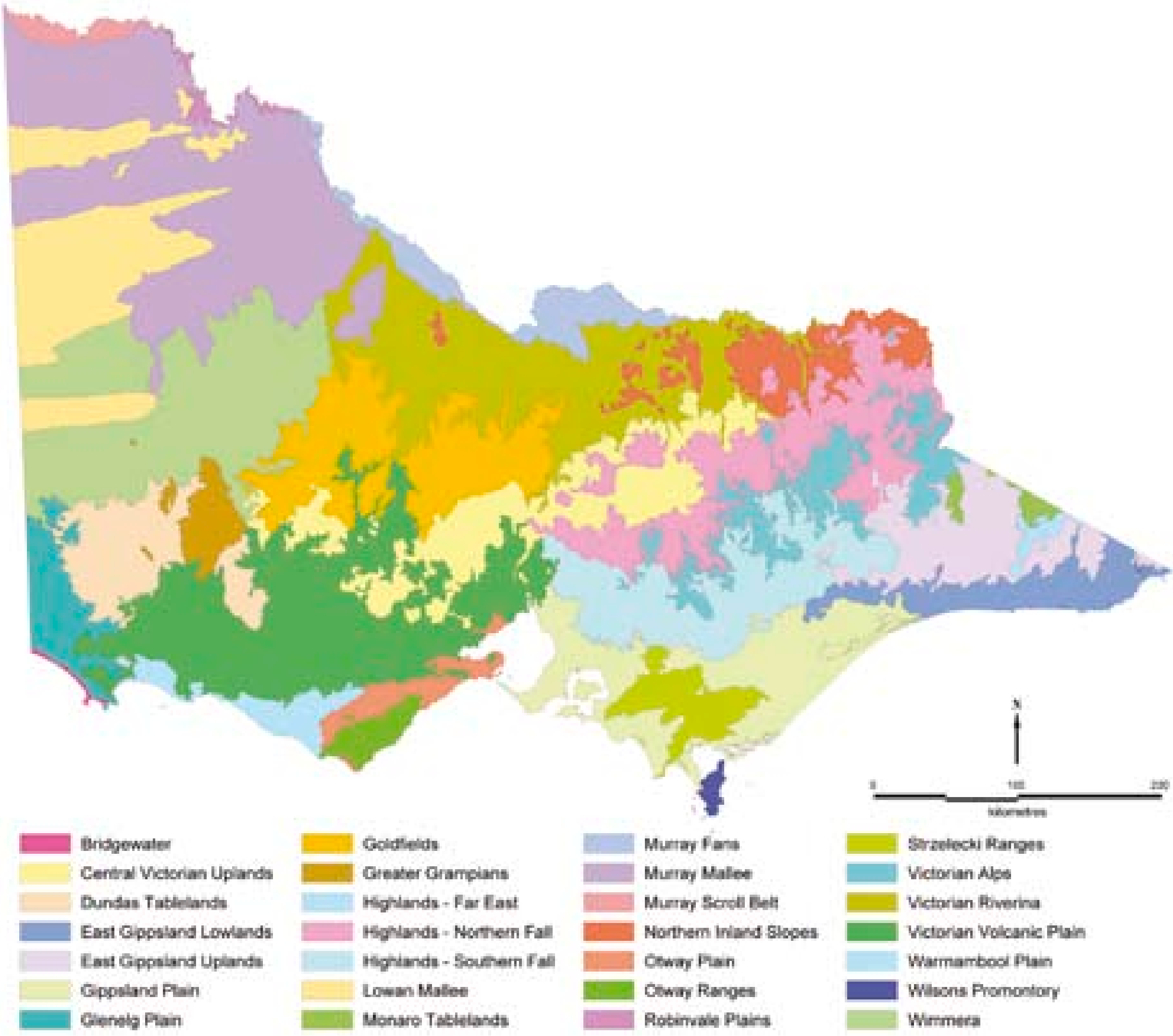
These physical characteristics underpin a diversity of landforms and soil types that allow Victoria's land area to support a greater range of broad ecosystem types than any other area of similar size in the rest of Australia[4]. These ecosystems range from alpine woodlands to dry Mallee grasslands and include inland waters, coastal environments, wetlands, heaths and grasslands.

Victoria is classified into 28 bioregions (see Figure LB0.1) that capture the patterns and ecological characteristics in the landscape. Bioregions are the broadscale mapping units for biodiversity planning and may extend over State boundaries. Many of Victoria's bioregions have been heavily cleared, leaving around 45% of Victoria's original vegetation cover. Four of Australia's five most cleared bioregions occur in Victoria[5].

Within these broad bioregions, Victoria has nearly 220 ecological vegetation classes (EVCs) with a further 424 EVC mosaics, complexes and aggregates. EVCs are a means of classifying native vegetation through a combination of species composition, life forms and ecological characteristics, and through an association with particular environmental attributes such as soil type and rainfall. EVCs may occur over more than one bioregion.

Victoria has a diverse indigenous terrestrial biodiversity including some 3,140 species of vascular plants, 900 lichens, 750 mosses and liverworts, 111 mammals, 447 birds, 133 reptiles and 33 amphibians. Victoria also has a large number of invertebrates, fungi and algae species, many of which are yet to be described.

Figure LB0.1 Victorian bioregions
Source: Department of Sustainability and Environment 2007



Terrestrial ecosystems provide important services to Victorians (see Part 1 Introduction for discussion of ecosystem services). Healthy ecosystems support production of food, fibre and timber, clean air and water, and a regulated climate. Healthy soils maintain fertility by cycling nutrients and decomposing wastes. Biodiversity is integral to ecosystem function and also provides resources for human use, such as compounds for pharmaceutical use. Healthy land and biodiversity are also important in their own right as places for relaxation and sources of cultural, spiritual and intellectual satisfaction[6]. Degradation of land and biodiversity resources limits delivery of these services. Thus, maintaining healthy ecosystems is essential for the continued provision of services on which all Victorians depend.

Ecosystem services are not specifically valued in the economy and are public goods, so there has been limited incentive to conserve the ecosystems that provide them. Recent development of markets for ecosystem services in Victoria now provides land owners with the opportunity to derive income from the provision of ecosystem services (see also Part 5 Living Well Within Our Environment).

The global cost of environmental damage and lost species has been estimated at US$2.1–4.8 trillion annually[7] (approximately A$2.2–5.1 trillion). The costs of repairing degraded ecosystems are difficult to estimate but are reflected in the economic values of the services provided by healthy ecosystems. The annual value of four key environmental services provided by native insects in the USA (dung burial, pollination, pest control and recreation, i.e. fishing, hunting, bird watching) has been conservatively estimated at US$57 billion[8] (approximately A$60 billion). Reduction in climate regulation services is adding to climate change from anthropogenic sources. The economic and social costs of climate change threaten a global economic crisis worse than that produced by the Depression of the 1930s[9].

Terrestrial ecosystems are intimately connected to the rivers and streams that flow over them, the coastal areas and the marine environment. The condition of terrestrial systems has implications for these aquatic systems, explored in Part 4.3 Inland Waters and Part 4.4 Coasts, Estuaries and the Sea.

Prior to European settlement Victoria was home to Aboriginal people who developed an intimate connection with the land over thousands of years. The land continues to hold great cultural significance for Victoria's indigenous people. Aboriginal people modified landscape to provide for their needs by practices such as 'firestick farming', or burning used to manipulate the plant and animal species composition of an area and facilitate hunting[10]. At the time of European settlement the connection of indigenous people to the land was not recognised and all land was declared as belonging to the Crown. Land was sold to settlers, becoming private property. Clearing of the land, which was considered to 'improve' it, was a condition of ownership.

Public land now occupies approximately 39% of Victoria[11] and is used for biodiversity conservation purposes, timber harvesting, recreation and water catchment. State forest accounts for approximately 14% of Victoria and is concentrated in the east of the State. Approximately 1.9 million ha of State forest (60% of total State forest area) is available for timber harvesting. Public land allocated to nature conservation occupies approximately 17% of Victoria, mostly in National and State Parks, Wilderness Areas and Nature Conservation Reserves[12] (see section LB2: Contemporary land use change).

The remaining 61% of Victorian land is privately owned and much of this is farmed. Agriculture is the predominant land use in Victoria, occupying 13.25 million ha or approximately 58% of the total area. It contributes $8.7 billion to the Victorian economy[13], accounting for 3.5% of Victoria's Gross State Product[14] and approximately 35% of Victoria's export income (see Part 3.2 Water Resources). The key agricultural products are beef, dairy, wool, grain crops, and fruit and vegetable crops. Agricultural production occurs mainly in the flatter and more accessible areas in western and northern Victoria (see section LB2: Contemporary land use change, Indicator LB9 Land use types in Victoria). Melbourne occupies less than 1% of Victoria's land area but about 75% of Victorians live in metropolitan Melbourne.

Victoria's agriculture was established initially on the most fertile soils and for the most part is rain fed. However, agricultural production is supported by ongoing additions of synthetic fertilisers and, in some areas, irrigation. Fertilisers, pesticides and the fossil fuels from which many of these are derived, have traditionally been low-cost inputs. However, the price of fertiliser has increased strongly during the past two years in response to global supply and demand factors as well as an increase in the price of fossil fuels. Nitrogenous fertilisers are also associated with emission of the greenhouse-intensive gas, nitrous oxide. Continued reliance on these inputs to support productivity gains in agriculture is becoming decreasingly sustainable, both environmentally and economically. Continued gains in agricultural productivity, supported by artificial soil fertilisation, appears to be masking ongoing and cumulative environmental degradation.

Objectives

- To maintain and enhance Victoria's land and biodiversity assets
- To increase the extent and improve the condition of Victoria's native vegetation
- To improve the conservation status of Victoria's native species
- To retain, or, where required, re-establish, robust landscapes that buffer against the impacts of climate change
- To ensure sustainable land management under a range of land uses
- To ensure that land use changes do not place further pressure on biodiversity and that changes produce a net positive impact on biodiversity

Overall Condition

Condition of land

There is no simple measure of the condition of land *per se*; however, Victoria has the highest proportion (48%) of sub-bioregions in Australia considered to be in poor landscape condition. This is assessed on the basis of the extent and condition of native vegetation, the associated increase in threatened species, and threats to ecological function such as salinity[15]. The areas of poor landscape condition correspond to areas of extensively cleared and fragmented native vegetation.

Native vegetation is fragmented over approximately two-thirds of Victoria and is under continuing pressure from intensification of agricultural production and urban expansion. Native vegetation management policy was substantially reformed in 2002, with the aim of achieving a 'Net Gain' of native vegetation through reduced clearing, better offsetting of permitted clearing, protection of existing vegetation and biodiverse revegetation activities. This goal has not yet been achieved. Although vegetation gains have exceeded losses on public land, native vegetation continues to be lost on private land. Victoria continues to lose native vegetation at a rate of approximately 4,000 ha per year[16].

Land use in Victoria varies markedly between public and private tenures. Public land is dominated by parks and State forests, while private land is dominated by agricultural and urban uses. Private land is changing towards a broader mix of uses in response to demographic change, and the intensity of agricultural production is increasing.

The susceptibility of Victorian soils to structural decline and erosion varies across the State with soil type and topography. The risk of water erosion is generally greater on steep, mountainous land in eastern Victoria, while wind erosion is associated with the flatter land and sandier soils of the Mallee and northern Wimmera in western Victoria. Management of soil to reduce erosion has been a feature of Victorian cropping systems over the past 20–30 years. Susceptibility to soil structural decline is widespread but the risk can be minimised by the management of soil for biological activity and organic matter accumulation.

Changed vegetation structure has altered the hydrology of Victorian landscapes, increasing drainage to groundwater and resulting in salinisation and acidification of soils in some regions. The extent of dryland salinity is considered to have peaked at around 240,000 ha due to a combination of improved land management and prolonged low rainfall. The extent of accelerated acidification, however, is unknown and potentially expanding.

Condition of biodiversity

Assessment of the condition of Victoria's biodiversity is set against the backdrop of a global crisis in biodiversity. The Victorian Government's recent Green Paper, *Land and biodiversity in a time of climate change* (p. 3), states that:

"There is increasing scientific evidence and consensus that the world is facing a biodiversity crisis.

The first Millennium Ecosystem Assessment unambiguously showed that humans have changed ecosystems over the past 50 years in a way unprecedented in any other period of human history. It concluded that nearly two-thirds of the critical services nature provides to humans are in decline, and warned we face even greater loss of biodiversity over the next 50 years.

In 2007, the United Nations Environment Program again highlighted the crisis in biodiversity. In its fourth Global Environment Outlook report it warned we are either on the cusp or have already entered a period of mass extinction the like of which has not been seen since the demise of the dinosaurs. It warns that climate change will lead to the first wave of mass extinctions caused by humans".

In some parts of Victoria, specifically the well-vegetated and mountainous eastern highlands and the Mallee country in the north-west, ecosystems remain relatively intact, with vegetation condition and quality considered to be high. However, even in the relatively intact landscapes managed by Parks Victoria, the condition of biodiversity is variable due to previous land use and disturbance such as logging and grazing as well as the impact of a range of current and ongoing threats from invasive species (weeds and pest animals), altered hydrology, inappropriate fire regimes, grazing pressure and fragmentation.

The bioregions most suitable for urban development and agriculture, including the Victorian Volcanic Plains and Riverina, have not only suffered the greatest loss of vegetation, but the quality of the remaining vegetation is amongst the lowest in the State. Furthermore, these regions are characterised by high levels of vegetation fragmentation and low connectivity, which, combined with the small size and irregular shapes of much of the remnant vegetation, further limits the ecological functionality of these landscapes. The extensive and ongoing clearing of the once-widespread native grasslands and grassy woodlands, in particular, has resulted in these ecosystems being classified as endangered.

Some 157 animal species are considered threatened in Victoria, while a further 24 have become extinct. In addition, 778 plant species are listed as threatened in Victoria, with 51 extinctions[17]. Some populations of threatened species continue to decline, while others appear to be recovering. There is a large number of species whose population trend is inconclusive, unclear or variable. These species require ongoing monitoring. Considerable re-establishment of habitat and restoration of environmental flows will be required to significantly improve the conservation status of many species and regional ecosystems[18].

Knowledge of the status of invertebrates is extremely poor, hampering assessments of conservation needs. Furthermore, surveys of flora and fauna distributions have declined over the past decade, limiting the ability to track increases or declines in species abundance or changes to distribution.

Pest species, particularly weeds, continue to establish in Victoria and pose a major threat to biodiversity, landscape function, primary production and landscape aesthetics.

Pressures on Victorian land and biodiversity

The choices that Victorians have made about land use have produced a modified landscape over much of Victoria. The extent of modification is least in the forested areas of eastern Victoria, although the use of these ecosystems for timber production and recreation certainly creates disturbance. The greatest modification has occurred in urban areas, where topography is altered to accommodate roads and buildings, and land surfaces are paved to control run-off and drainage and to facilitate transport. Victoria's agricultural land has also been modified to suit the production of food and fibre for the domestic and international market.

All of Victoria's ecosystems provide services for nature and society; however, the modifications made to ecosystems when land is used for various purposes affect the primary service provided. For example, forests in protected catchments to Melbourne's east are managed specifically to provide clean water for Melbourne. They also provide habitat for native species and contribute to the supply of clean air.

Land used for agriculture may be less effective in filtering water and providing habitat for native species, depending on management practice, but provides far more food and fibre than could be produced from a less modified landscape. Provision of food and fibre from land used for agriculture and forestry is a critical service, but it is important to acknowledge that these uses of land can compromise the delivery of other services that are best provided by less modified ecosystems. While the optimal management of land for agricultural production can produce land that is 'healthy' for that purpose, agriculture is essentially a simplified ecosystem supported by regular inputs of nutrients. The requirements of more complex native ecosystems are different, and land that is healthy for agriculture does not necessarily support the full range of ecological processes that underpin retention and restoration of native biodiversity.

Society must make decisions about the trade-offs it is willing to accept between these services, acknowledging that it is difficult and sometimes impossible to restore the provision of ecosystem services from degraded ecosystems.

Although many of Victoria's land and biodiversity concerns are focused on extensively cleared private land, management of Victoria's public land has also been criticised (for example, see the ENRC report on the Inquiry into the impact of public land management practices on bushfires in Victoria[19]). Management of fire, weeds and pest animals remains a significant problem on public land. Improved management of land and biodiversity is required on public and private land, but the dominant issues vary with land use.

Clearing of native vegetation to make way for agriculture was actively encouraged by Victorian Governments until well into the 20th century. Clearing was particularly intense during the gold rush period in the mid-19th century and during the settlement schemes that occurred after both the World Wars in the first half of the 20th century. The broadscale clearing of native vegetation has changed Victorian landscape functions in ways that are now presenting major challenges to land managers by accelerating erosion and acidification of land and mobilising salt stored deep in the soil for thousands of years. Victorian farmers have been instrumental in developing and adopting innovative farming systems aimed at combating these effects. Farmed land can, with appropriate management, provide ecosystem services and biodiversity benefits in addition to primary production.

Historic broadscale clearing of native vegetation in many Victorian landscapes has resulted in widespread loss and fragmentation of habitat and decline in species populations. Clearing of Victoria's most threatened grassland ecosystems is still continuing in Victoria. Ongoing vegetation clearing, combined with degradation of land and habitat resulting from inappropriate land use and climate change, exacerbates the pressures on biodiversity associated with the impacts of historic clearing. High levels of vegetation clearing may constitute the crossing of ecological thresholds, or points beyond which rapid ecosystem change occurs and from which ecosystems may not recover[20,21].

Greater Melbourne occupies a relatively small area of Victoria (approximately 210,000 ha[22]), but urbanisation places extreme pressure on ecosystem services because of the intensity of landscape modification and use of resources by the population concentrated in these areas. Much of the remnant native vegetation in the Port Phillip region occurs at the fringes of the Melbourne urban area, including the Green Wedges, while inner urban Melbourne retains only 5% of its native vegetation[23]. Development into outer urban, Green Wedge and peri-urban areas threatens remnant native vegetation and has the potential to further fragment native fauna habitats that are already under significant pressure.

Climate change is introducing significant new pressures that will combine with the existing pressures from population growth and urbanisation to extend the risks to Victoria's biodiversity. Natural systems have limited capacity to adapt to climate change, which is occurring faster than predicted and is very likely to exceed rates of evolutionary adaptation in many species[24]. Vulnerability of natural ecosystems to climate change, even if adaptive capacity is realised, becomes significant at 1.5–2.0°C of warming. This degree of warming is possible for Victoria by 2070, even under the International Panel on Climate Change's (IPCC) low-emissions scenario[25] (see also Part 4.1 Atmosphere: Climate Change). Climate change is likely to threaten animal species with limited ranges and those restricted to fragmented landscapes where the ability to disperse is limited. Similarly, climate change is also likely to affect a range of plant species, such as those that tolerate only narrow ranges of temperature and rainfall. In forested areas climate change is likely to make wildfires more frequent and severe, threatening the regenerative capacity of vegetation in Victoria's relatively intact ecosystems.

Agricultural land uses are expected to change substantially[26]. Reduced rainfall and increased evapotranspiration are likely to increase the frequency and severity of drought, and permanently reduce the availability of water, increasing pressure on Victoria's already stressed freshwater systems and irrigation industries (see also Part 3.2 Water Resources, Part 4.3 Inland Waters).

Management responses

There is a broad and complex array of responses aimed at managing land and biodiversity issues in Victoria. These responses involve all levels of Government, Catchment Management Authorities (CMAs), the non-government sector, industry, the community and individual land owners. Responses take the form of legislation, strategy and policy, institutions and structures, and processes and functions. Responses from all sectors interact to direct natural resource management (NRM) in Victoria and it is difficult to evaluate any response in isolation from its policy and institutional context. A range of policy options is needed to address natural resource management and biodiversity concerns and to engage a broad spectrum of Victorians in that task of finding solutions to these problems. Depending on the distribution of public and private benefits from management interventions, responses—including legislation and regulation, economic incentives, technology development, and education and extension—may be effective[27]. Objective analysis of public and private costs and benefits is necessary to develop cost-effective investment strategies.

The Victorian Government's main objective for land and biodiversity management is 'to maximise the value of the services the land produces to ensure its long term health'[28]. One of the key roles of Government is to develop and implement mechanisms that address market failures that under-value the services produced by land and biodiversity.

The role of Government in management of land and biodiversity differs between public and private land. The Victorian Government, along with a range of statutory authorities such as Parks Victoria, the CMAs and Coastal Boards, is directly responsible for managing public land, including National Parks, State forests, conservation reserves and other publicly owned land and water assets. On private land, the Government seeks to influence land management decisions that affect the broader community; for example, by creating incentives to produce public goods for which no-one would otherwise pay. The Government also has a role to play in providing information to the market and to individual land managers on the impacts and benefits of various land management practices[29]. The collection, integration and interpretation of information relating to land and biodiversity are thus important functions of Government and necessary for sound policy decisions.

Private landholders and managers also have a duty of care for land and biodiversity resources, as defined in the *Catchment and Land Protection Act 1994*. The duty of care of private landholders helps to define the limits of landholders' responsibilities. Activities that are within the duty of care should be funded by the landholder. Activities considered beyond the landholder's duty of care, however, are candidates for support by government incentives. The concept of environmental stewardship is developing in Victoria and new market-based instruments are being implemented to reward good stewardship (see section LB1 Vegetation loss and modification).

Response name
Catchment and Land Protection Act 1994

Responsible authority
Department of Sustainability and Environment

Response type
Legislation

The *Catchment and Land Protection Act 1994* (CaLP) is the primary instrument for protecting land condition on private land in Victoria and seeks to engage Victorians in the management of land and water resources. It established a framework for integrated and co-ordinated management of catchments with the aims of maintaining and enhancing long-term land productivity while also conserving the environment and ensuring the quality of the State's land and water resources and associated plant and animal life are maintained and enhanced. The key achievement of this legislation has been the establishment of the CMAs and the development by CMAs of Regional Catchment Strategies and associated management plans for native vegetation, biodiversity and other assets by CMAs (see Response: Catchment Management Authorities; see also section LB2: Contemporary Land Use Change). The current structure of CMAs and the Victorian Catchment Management Council was preceded by a system of Catchment and Land Protection Authorities and a Catchment and Land Protection Council, also set up under the auspices of the CaLP Act. These bodies had responsibilities similar to those of the current CMAs.

The CaLP Act also sets out private landholders' duty of care. It states that, 'in relation to his or her land a land owner must take all reasonable steps to:

- Avoid causing or contributing to land degradation which causes or may cause damage to another land owner
- Conserve soil
- Protect water resources
- Prevent the growth and spread of regionally controlled weeds
- Prevent the spread of and as far as possible eradicate established pest animals.'

The effectiveness of the CaLP Act is limited by the absence of defined standards for natural resource management and by a lack of agreement on the implementation of land management practices best suited to specific environments. While the CaLP Act prescribes the obligations of the CMAs and individual landholders, these obligations are not supported by required resource condition outcomes. For example, New South Wales has Natural Resource Condition Standards, which provide mandatory outcomes and guidance on achieving these standards. The lack of consistent monitoring of natural resource condition against defined targets is a recurring theme in Victoria and makes it difficult to accurately assess the effectiveness of institutional arrangements and investment programs.

A further limitation on the effectiveness of the CaLP Act is the overlap of responsibilities and jurisdictions between agencies. For example, aspects of the Yarra catchment fall under the Port Phillip and Westernport CMA, Melbourne Water, Southern Rural Water, the EPA and several local authorities. This division of responsibilities is a barrier to integrated management.

The CaLP Act is the key instrument regulating weed control in Victoria and places obligations on land owners to prevent the growth and spread of weeds and pest animals. A range of activities, including the sale and purchase of noxious weeds, is prohibited in Victoria. If land owners do not comply with their obligations under the CaLP Act, the Secretary of DSE may give directions to reduce the impacts of their poor management, including the issue of a Land Management Notice. Failure to comply with such a notice attracts a penalty.

A limitation of the CaLP Act in relation to weed control is that actions to control weeds are required only for designated noxious weeds. Noxious weed lists in Victoria are being reviewed for the first time since 1974 (see section LB4: Pest plants and animals). The lack of review over more than 30 years means that there has been no enforceable regulation for many important weed species on private land.

Response name
Land and biodiversity in a time of climate change Green Paper/White Paper

Responsible authority
Department of Sustainability and Environment

Response type
Policy/strategy

The White Paper is designed to guide environmental policy and investment in Victoria for the next 50 years. This process has begun with a round of public consultation to identify the issues for consideration and the release of a Green Paper identifying key themes. The White Paper is due for publication in early 2009. The process will consider how management of the environment and natural resources is affecting biodiversity and environmental health, and ensure that policy and investment strategies are responsive to emerging environmental threats and opportunities. The Green Paper outlines the principles that will be used to guide future investment and management decisions. Decisions should:

- allow ecological processes and functions to continue
- preference the maintenance of species in natural habitats over relocation or ***ex situ*** conservation programs
- protect what currently exists and enhance its condition before restoring what has been lost
- consider the complexity of natural systems, recognising that changes in one part of a system may affect another part
- be based on the best available knowledge and models
- not be avoided solely due to lack of scientific certainty.[30]

The Green Paper also outlines a range of possible approaches promoting private sector investment, using carbon markets to achieve biodiversity gains, improving catchment management and vegetation connectivity, supporting climate change adaptation and managing fire, weeds and pest animals. These initiatives are valuable; however, they present several risks that should be assessed and addressed. For example, the Green Paper focuses on attracting public sector and philanthropic investment to generate a proportion of the resources needed to protect and enhance Victoria's land and biodiversity resources. Unless private sector investment is leveraged by sufficient government investment, there is a risk of underinvestment by the private sector. Community groups are also identified as a source of conservation activity, but the Green Paper does not indicate how these activities will be resourced.

The Green Paper also focuses strongly on the use of market-based instruments (MBIs). While MBIs are useful tools for addressing market failure, there is a risk of producing unforeseen or perverse outcomes if schemes are not well designed. For example, the opportunity to invest in plantations as carbon offsets may create a proliferation of monoculture plantations with limited biodiversity benefits and risks for surface water run-off. It will be important to define what it is that the market is intended to achieve and to plan methods of overcoming any shortfall between what the market is intended to achieve and the desired outcome. MBIs will require adequate testing and modelling before implementation and should form part of a range of policy options.

Finally, the Green Paper considers a trade-off approach to the prioritisation of investment, acknowledging that resources are limited. While pragmatic and preferable to an ***ad hoc*** allocation of investment, the risk of incremental decline in the condition of species and ecosystems will need to be addressed. As resources are focused on the most valued assets, there is a risk that others will slowly decline to the point where they may not be considered worth further investment. This approach also seems to imply acceptance of a certain level of species loss.

The funding to be allocated to policies developed from the White Paper is unknown at this stage, but given the broad scope of the White Paper, the long timeframe over which it is intended to influence Victorian policy, and the scale of past losses and current threats, substantial funding will be required. As an indication, the *Our Water, Our Future* White Paper released in 2004 committed $225 million to water reform over the first four years of the initiative.

Response name
Victorian Biodiversity Strategy

Responsible authority
Department of Sustainability and Environment

Response type
Policy/strategy

The *Victorian Biodiversity Strategy* was released in late 1997 to complement the *National Biodiversity Strategy*. It is supported by the *Flora and Fauna Guarantee Act 1988* and the *Wildlife Act 1975*, and expresses the intent of the FFG Act as practical environmental goals. The *Victorian Biodiversity Strategy* provides the overarching direction for biodiversity conservation and management in Victoria and emphasises the role of all Victorians in contributing to biodiversity conservation.

The Strategy outlined the biodiversity conservation challenges for Victorian ecosystems at the end of the 20th century. It emphasised the importance of actions by individuals and organisations for conserving biodiversity and encourages the adoption of Environmental Management Systems, Codes of Practice and environmental auditing. Furthermore, it emphasised the important concepts of accounting for biodiversity through markets and assigning values to services derived from natural systems (ecosystem services). These concepts form a major part of the market-based policy instruments that are currently being trialled and adopted by Victoria, such as BushTender, BushBroker and other ecoMarket tools. The Strategy was also instrumental in developing the concepts that form the basis of Victoria's current approaches to biodiversity conservation such as Net Gain, environmental assets and bioregions. A number of tools currently in use in Victoria, such as the Native Vegetation Management Framework, the Habitat Hectares method for assessing native vegetation and Ecological Vegetation Class mapping (see LB1: Vegetation loss and modification), and the Actions for Biodiversity Conservation database (see LB3: Threatened species) originated from the *Victorian Biodiversity Strategy*. The Strategy also precipitated the development of biodiversity plans within the Regional Catchment Strategies of Victoria's 10 CMA regions and influenced biodiversity strategies developed by VicRoads and the Country Fire Authority (CFA)[31].

The *Victorian Biodiversity Strategy* provides detailed information, including management directions and priorities, for each of Victoria's 28 terrestrial and six marine bioregions. The Strategy includes a reporting framework and takes an adaptive management approach to evaluating biodiversity outcomes, emphasising reporting of effectiveness. These approaches are preferable to reporting of inputs, activities and outputs, because they can be used to evaluate whether or not the activities and investments have been effective in achieving improved biodiversity outcomes.

Despite the comprehensiveness of the *Victorian Biodiversity Strategy*, biodiversity throughout Victoria is under increasing pressure, with declines in condition of threatened ecosystems, increasing numbers of threatened species and increasing establishment of exotic plant species. Recent evaluation of the Strategy suggested that its limitations include: a lack of targets, indicators and mechanisms for assessing progress; a lack of additional funding for implementation; and inadequate coverage of certain themes, such as marine biodiversity, grasslands, fire regimes, climate change, peri-urban development, threat management and indigenous engagement[32].

The *Victorian Biodiversity Strategy* is currently under review after 10 years of operation. Areas covered in the review include threatened species protection and recovery, linking fragmented land, public land management and the coastal interface. Part of the review process is to identify current problems and propose solutions that may be acted on in the next five years. The draft strategy is expected to be released for public comment at the end of 2008.

Response name
Catchment Management Framework/ Integrated Catchment Management

Responsible authority
Catchment Management Authorities

Response type
Structure

Victoria is divided into 10 Catchment Management Authority (CMA) regions for the purpose of natural resource management on both private and public land (see Part 4.3 Inland Waters). The CMAs were established in 1997 under the *Catchment and Land Protection Act 1994*. The CMA structure is described in detail in the *Victorian Catchment Management Council's Catchment Condition Report 2007*[33]. Briefly, the role of each CMA is to facilitate and co-ordinate integrated catchment management relating to land, biodiversity and water resources within the CMA region.

Community engagement is a strong feature of the CMA structure. CMAs prepare the Regional Catchment Strategies in consultation with regional communities. Regional Catchment Strategies are supported by a range of action plans relating to specific issues such as native vegetation, soil health, biodiversity and weeds. Regional Catchment Strategies are comprehensive documents identifying priorities and targets for managing each region's natural assets. They form the framework for regional investment and CMA activities.

The outputs of investment through CMA processes are recorded in the Catchment Activities Management System (CAMS), a computer program that has been developed to improve the recording and reporting of catchment activity information. CAMS captures information about on-ground activities and expenditure of funds for catchment activities and facilitates Catchment Condition and project reporting.

The CMAs are the vehicle through which Commonwealth natural resource management funding is distributed to the states. Until 2008, CMAs have had direct and guaranteed access to Commonwealth funding through the Natural Heritage Trust and National Action Plan for Salinity and Water Quality, but a review of Commonwealth funding released in early 2008 has resulted in changes to this arrangement. It is of concern that Commonwealth investment priorities will no longer be matched to State and local priorities. Rather, the Commonwealth Government will determine its own investment priorities, making it difficult for CMAs to match funding opportunities with regional priorities. Although the regional delivery model will be retained, CMAs will have to compete with other research and natural resource management (NRM) providers such as universities and State Government agencies for funding. This new funding arrangement is likely to reduce Commonwealth funding to the CMAs and may reduce their capacity to carry out NRM activities unless alternative funding can be attracted.

Evaluation of responses to land and biodiversity issues

Although Victoria is committed to an integrated approach to catchment and biodiversity management and is working towards this aim, the fundamental difficulties seem to be the complexity of governance over land and biodiversity issues, and the difficulty in achieving integration between levels of governance and between public and private land. The result has been an extensive and complex range of regulations and legal requirements for land managers[i], and variable compliance with and enforcement of these obligations further limits the effectiveness of Victoria's management responses for land and biodiversity.

In addition to the complex and sometimes fragmented structural and institutional arrangements in place, shortcomings in existing procedures have also been identified. These include a lack of measurable resource condition targets and indicators in strategies and plans, a lack of verified and scientific data on which to base targets and plans, a focus on project outputs rather than on environmental outcomes, a lack of monitoring and evaluation of outcomes, and inconsistencies in data collection and reporting between regions, which precludes the assembly and analysis of statewide data sets[34]. There is also a nationwide lack of consistent monitoring of environmental trends for land and biodiversity[35]. This limits the capacity of the Government to develop sound policy informed by the most accurate and up-to-date data.

i An entire website - www.rurallaw.org.au – has been developed to help Victorian landowners understand their legal obligations and rights.

The Victorian Government's recent Green Paper on land and biodiversity has identified similar issues as barriers to effective management of land and biodiversity in Victoria. Specifically, poor integration of natural resource management between public and private land, and across catchments and administrative boundaries, along with inadequate collection and management of information, and a lack of responsiveness of Victoria's planning systems to rapid land use and demographic change are highlighted as issues for Victoria to address[36]. The Victorian Government's key metropolitan planning policy document, *Melbourne 2030*[37], identifies the integration of land use planning and natural resource management as being a critical issue. Green Wedge Management Plans, in preparation by local government, will identify appropriate land uses and actions for the sustainable management of Green Wedge land.

Achievement of land and biodiversity management objectives in Victoria may be hindered by continuing rapid population growth and consumption as well as continued urbanisation. The unexpectedly rapid growth in Victoria's population (see Part 2 Driving Forces) and the accompanying consumption (see Part 3.3 Materials) and urban development exert strong pressures on Victorian land and biodiversity resources. There is no indication in the Land and Biodiversity Green Paper of how the Government intends to alleviate the pressure of population growth on land and biodiversity resources. This population-induced pressure will be exacerbated by climate change, for which Victoria is preparing, but about which there is little scientific certainty on which to base government policies.

The forthcoming White Paper, *Land and Biodiversity in a Time of Climate Change*, provides the opportunity to review and unify Victoria's management of land and biodiversity issues. New markets for carbon are likely to provide opportunities to improve vegetation and biodiversity outcomes in Victoria. The Victorian Government is assisting this process with the development of more targeted market-based instruments, such as BushTender, BushBroker and EcoTender, to encourage beneficial management of native vegetation by offering an alternative income stream to landholders.

The recent focus of DSE and the broader Victorian natural resource management community on asset-based prioritisation of investment to achieve multiple environmental outcomes from natural resource management projects may provide integration at the landscape scale and offers the potential for greater community engagement (see section LB6: Salinity, Management responses). It is hoped that these changes in approach provide Victoria with the tools to overcome some of the barriers that have limited environmental gains to date.

For further information

Catchment management: www.dse.vic.gov.au/DSE/nrenlwm.nsf/childdocs/-E9B6826F3AB828F64A2567D7000B1BA6-82A6DD30CA52A8C0CA256E69002F506C?open

Land use planning: www.dse.vic.gov.au/dse/nrenpl.nsf/Home+Page/DSE+Planning~Home+Page?open

Land and biodiversity in a time of climate change: www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/2270213701D9AE6DCA2574350015F8F9554FC9C681B6CAB6CA2572C600036DB1

Victorian Biodiversity Strategy: www.dse.vic.gov.au/DSE/nrence.nsf/childdocs/-8946409900BAC6344A256B260015D4AF-F20C24316259FF3FCA256EE700077CB3?open

Our Environment, Our Future: www.dse.vic.gov.au/ourenvironment-ourfuture/

Recommendations

LB0.1 The Victorian Government should prioritise investment in incentives for enhanced vegetation and biodiversity management on private land. For example, the Government should allocate funding for priority development and expansion of the ecoMarkets programs, which encourage multiple environmental outcomes from improved vegetation management and deliver a reliable alternative income stream to landholders for provision of vegetation management services. Future expansions of ecoMarkets programs should be targeted to threatened ecosystems such as grassy plains ecosystems and to sites identified as having priority for revegetation or natural regeneration and with the ability to improve connectivity at the landscape scale.

LB0.2 Through the Land and Biodiversity in a Time of Climate Change White Paper, the Victorian Government should develop an overarching institutional and legislative framework for management, protection, restoration and enhancement of the environment to integrate existing legislation and clarify institutional responsibilities. Investment should be articulated in the Land and biodiversity White Paper process.

LB0.3 The setting, monitoring and reporting of short-, medium- and long-term resource condition targets should form an integral component of management of natural resources, biodiversity and threatened species in Victoria.

LB0.4 Transparency of policy decisions and accountability of management should be improved by implementing a program of independent auditing and monitoring of land and biodiversity management across tenures; for example, in a way similar to auditing of forest management by the EPA.

LB0.5 The Victorian Government should work with the Commonwealth Government to ensure maximum alignment between Commonwealth, State and regional investment priorities under the new Commonwealth natural resource management investment program, Caring for our Country.

LB0.6 The Victorian Government should work with the other States and Territories and the Commonwealth to develop a nationwide program of environmental monitoring focusing on biodiversity, the carbon cycle and water resources, for example by adopting reporting against agreed National Land and Water Resources Audit indicators.

LB1 Vegetation loss and modification

Key findings

- At least half of Victoria's native vegetation has been cleared, including 80% of the original vegetation cover on private land, whereas public land retains over 80% of its original vegetation cover. Victoria is losing native vegetation at a rate of approximately 4,000 ha per year, mostly from endangered grasslands.
- Victoria has developed a native vegetation accounting approach to monitoring gains and losses of native vegetation which provides the basis for assessment of progress towards the State's goal of a Net Gain of native vegetation. On public land, vegetation losses have been offset by gains but on private land, gains have been outweighed by losses.
- Victorian native vegetation is fragmented over much of the State and is declining in quality. Loss of quality is now a key driver of native vegetation decline in Victoria, especially on agricultural and urban land, which has been the most severely impacted through incremental clearing, and suffers significant ongoing threats.
- Twelve per cent of Victoria's remaining native vegetation is on private land; of this vegetation, 60% is of a threatened vegetation type. Native vegetation on private land supports 30% of Victoria's threatened species populations.
- Ongoing clearing and conversion to cropping is still the major pressure for native grasslands and Victoria's native grasslands retain less than 1% of their original extent in good condition.
- Climate change is likely to compound existing pressures on native vegetation due to greater incidence of drought and fire and increased competition from weeds and pathogens. Climate change is also likely to threaten the adequacy of Victoria's current reserve system.
- The ecosystems and biodiversity attributes of cleared vegetation are not necessarily reconstructed in revegetated offset areas and are not provided on the same timescale due to the lag between clearing of remnant vegetation and the establishment and maturation of planted offset vegetation.
- Victoria's undisturbed native forests store much more carbon in forest biomass and soil than estimated by the IPCC, meaning that the importance of undisturbed native forests in mitigating climate change may be greater than previously thought.
- Restructuring of the Victorian timber harvesting industry in response to a review of its sustainability in 2001 has resulted in substantial reductions in the area logged and volume of sawlogs harvested.

Description

Approximately half of Victoria's native vegetation has been cleared, including 80% of the original cover on private land. The decline of native vegetation was greatest during the expansionary phase of settlement, when large areas of land were alienated from the Crown for private ownership and were cleared, mostly for agriculture[38]. Land clearing was encouraged by Victorian governments until the mid-20th century and was a feature of the settlement schemes that followed World Wars I and II. Vegetation has also been extensively cleared from urban land. Clearing of native grasslands continues in urban and peri-urban areas with high population growth to the west of Melbourne (see Figure LB1.7; see also Part 2: Driving Forces).

A total of about 2 million ha of woody vegetation remains on private land in Victoria[39] and about 60% of the remaining vegetation on private land is of threatened vegetation types[40]. Native vegetation retention regulations were introduced to Victoria in 1989 to prevent broadscale clearing on private land; since then, the annual rate of clearing of woody vegetation on private land has declined to approximately 1,600 ha per year[41]. Prior to 1989 clearing rates were estimated to be 15,392 ha per year[ii,42]. Native vegetation remnants on private land are often small, isolated and subject to disturbance and degradation arising from human activities (see Indicator LB4 Quality, condition and fragmentation of vegetation) but nevertheless this vegetation supports 30% of Victoria's threatened species populations[43].

Native vegetation in landscapes dominated by public land (such as National Parks and State forests) has not been extensively cleared and is more intact than native vegetation on private land. Differences in land-use history between Victoria's public and private land have produced two contrasting but overlapping landscapes with respect to native vegetation in Victoria (Figure LB1.1)[44]:

- 'Largely intact' landscapes, where natural or semi-natural dynamics are the dominant drivers.
- 'Fragmented' landscapes, and areas affected by invasive processes within largely intact landscapes, where degradation and recovery from degradation are the dominant characteristics.

In the largely intact landscapes, which correspond closely with Victoria's parks and State forests, natural disturbances such as fire, drought or flood, as well as timber harvesting, produce a complex of different vegetation structures. In these regions the underlying stock of vegetation is generally considered to be 'stable' (i.e. it is resilient and expected to recover from such disturbances without active management intervention. Some management may be required during regeneration to prevent undesirable outcomes such as weed infestation, particularly in the case of disturbance by fire).

In landscapes with fragmented native vegetation, the underlying stock of native vegetation is declining or at risk of decline in extent, quality and regenerative capacity. Declining vegetation quality is now a key driver of vegetation loss in many parts of Victoria, rather than broadscale clearing; however, clearing remains the main cause of loss of native grasslands. Both the legacy of historic clearing and incremental vegetation decline due to land degradation are greatest in areas of fragmented vegetation. Consequently, the impacts of vegetation and habitat loss are greatest in these landscapes. Nevertheless, remnant native vegetation in Victoria's agricultural regions, although not necessarily of highest quality, constitutes an important natural asset and, with appropriate management, may contribute to both biodiversity conservation and agricultural production[45].

ii These figures are based on woody vegetation only.

Native vegetation provides numerous ecosystem services such as provision of habitat; protection of soil from erosion; regulation of surface and groundwater movement; protection of water quality; provision of genetic resources; and sequestration of carbon, in addition to its own inherent value. For this reason, declining extent and quality of native vegetation has profound biological implications, and vegetation clearing is considered the single greatest threat to terrestrial biodiversity in Australia[46].

Victoria has developed a range of policy initiatives and monitoring methodologies in recognition of the importance of native vegetation retention and restoration. Native vegetation policy in Victoria emphasises the avoidance of vegetation clearing as a priority and aims to engage landholders in native vegetation management. Victoria's native vegetation accounting framework provides an opportunity for Victoria to detect and evaluate future changes in native vegetation.

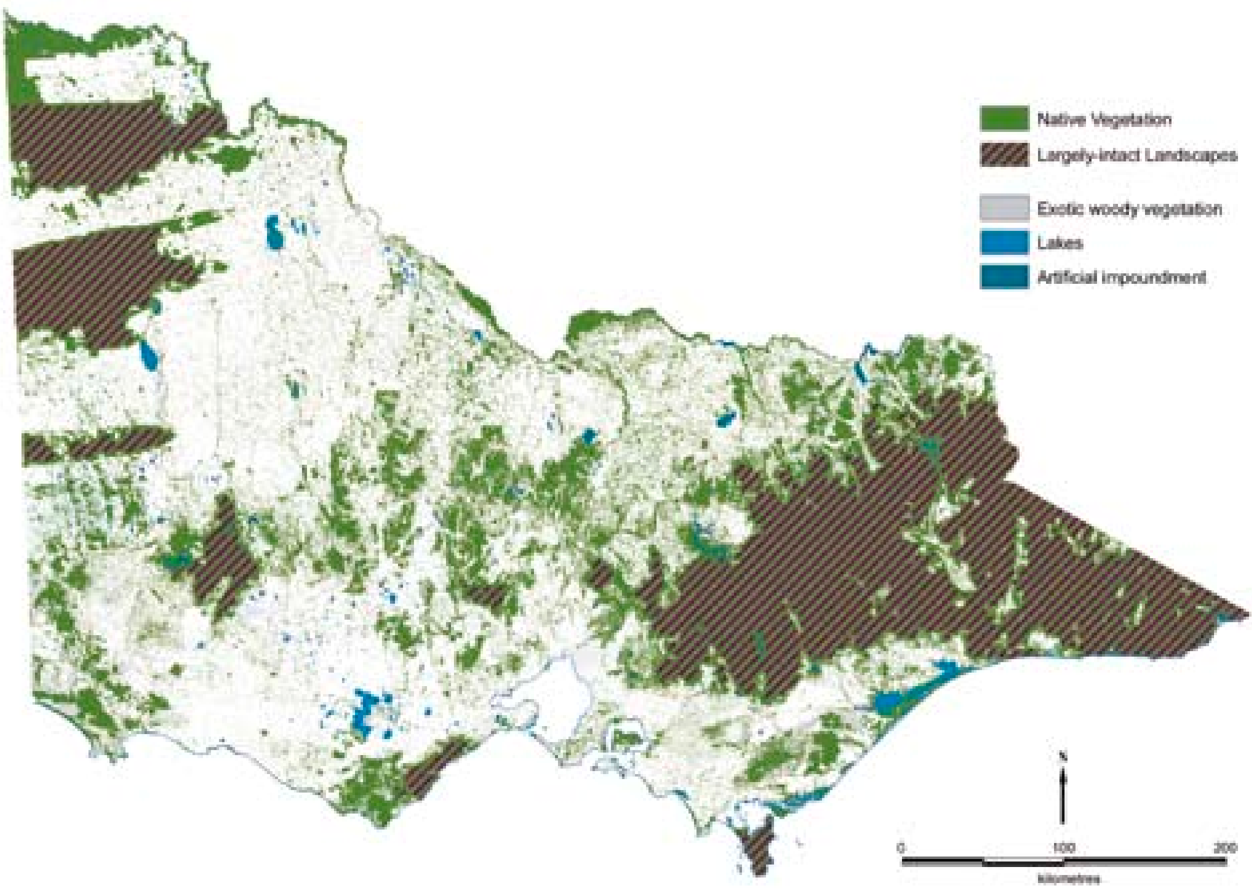
Objectives

- Achieve a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation, leading to a Net Gain
- Avoid or minimise further vegetation losses through clearing
- Offset unavoidable losses with improvement of vegetation quality or protection of remnant vegetation elsewhere
- Improve the viability of remnant vegetation and landscape connectivity in highly cleared landscapes

Links

See also: Part 3 Materials; Part 4.2 Land and Biodiversity: Contemporary land use change, Soil structure and erosion, Salinity, Threatened species, Pest plants and animals, Fire in the Victorian environment, Impacts of climate change on land and biodiversity.

Figure LB1.1 Native vegetation and areas considered largely-intact landscapes for the purposes of Net Gain Accounting
Source: Department of Sustainability and Environment, Native Vegetation Net Gain Accounting: First Approximation Report 2008.



State

Indicator LB1 Extent of Victoria's native vegetation

Based on satellite imagery analysed by the Department of Sustainability and Environment[47], the current extent of native vegetation in Victoria is approximately 10.3 million ha[iii] (see Figure LB1.2), of which 7.3 million ha are on public land and 3 million ha are on private land[48]. Public land covers approximately 39% of Victoria and retains over 80% of its vegetation cover. However, private land covers approximately 61% of Victoria and retains only 20% of its original vegetation cover.

Temporary changes in woody native vegetation cover (for example, recent fire scars, post-fire recovery and timber harvesting or regeneration) were treated in the vegetation accounting analysis as changes in condition rather than extent. Areas of native grassy vegetation are more difficult to detect than woody vegetation and are modelled using additional datasets and further analysis of satellite data[49]. A further category, 'possibly native vegetation', is shown in Figure LB1.2 but this is not counted in extent analyses as it reflects areas of uncertainty in interpretation of satellite imagery.

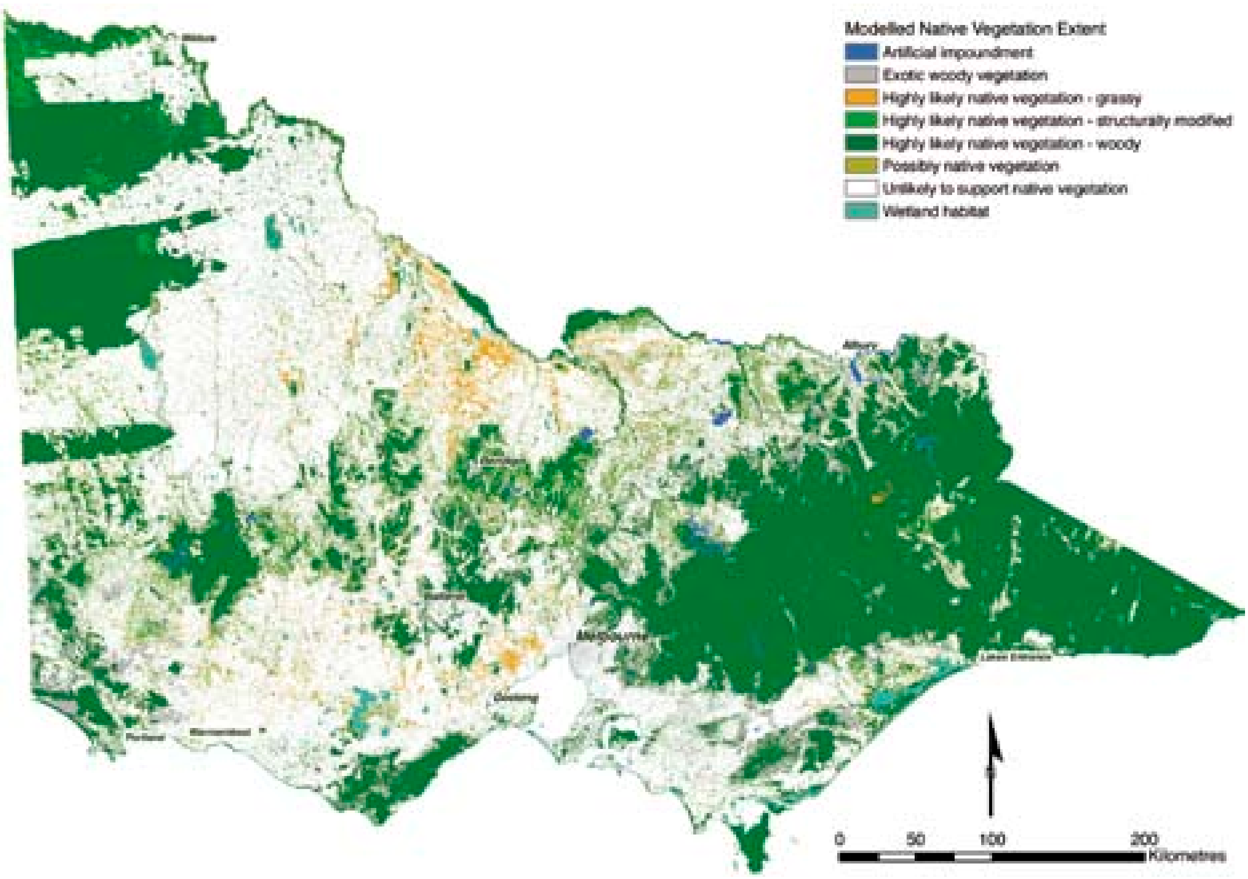
Recent improvements in detection of native vegetation from satellite data have meant that the estimate of native vegetation extent is greater than previously reported (10.3 million ha vs 8.3 million ha). However, this increase represents improved detection rather than new occurrences of vegetation, especially of areas believed to be native grasslands. The rate of clearing of grassy vegetation has been assessed for the first time with this new methodology.

Comparison of satellite data from the periods 1989–1995 and 1998–2005 showed that the rate of gain of woody vegetation has been approximately 400 ha per year, while the rate of loss has been 1,200 ha per year. In addition, grassland was lost at the rate of approximately 3,200 ha per year, mostly because of conversion from native pasture grazing to more intensive forms of agriculture (see also Box LB1.1). No long-term gains of native grassy vegetation have been recorded. In total over the period analysed, Victoria lost native vegetation at the rate of approximately 4,000 ha per year[50].

Indicator LB2 Depletion of native vegetation by bioregion

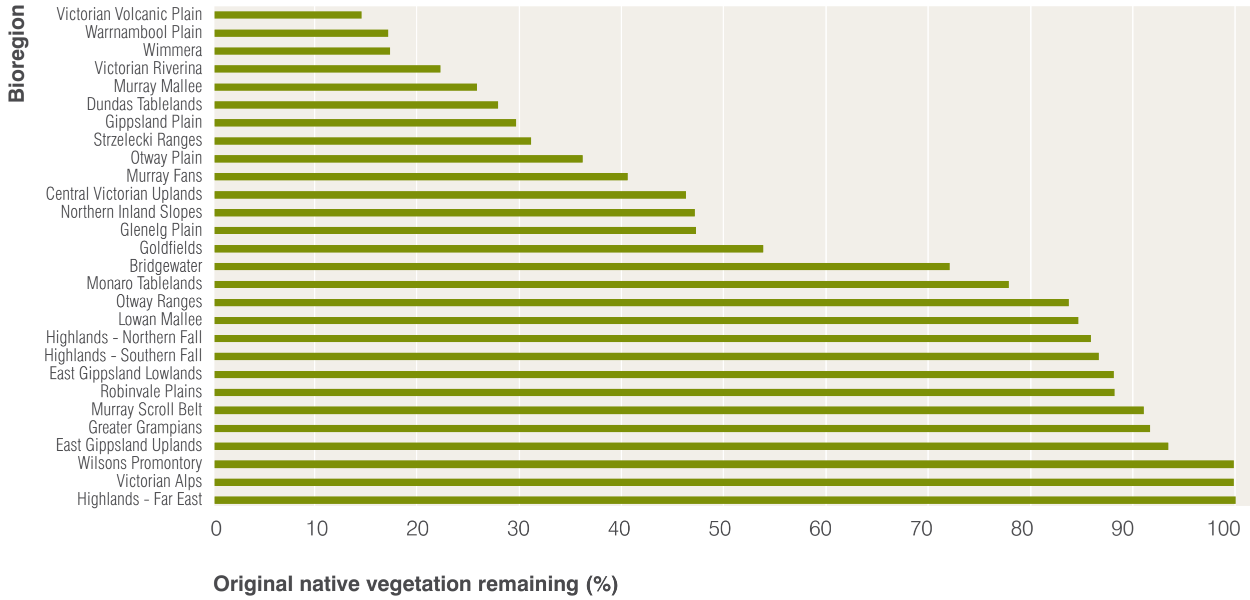
The loss of native vegetation has not occurred uniformly throughout Victorian bioregions. Some bioregions have been more heavily depleted than others (see LB0 Introduction, Figure LB0.1 for location of Victorian bioregions). Those relatively flat, agriculturally productive bioregions in western Victoria have been most heavily cleared, with less than 20% of native vegetation remaining in the Victorian Volcanic Plain, Warrnambool Plain and Wimmera, while only 20–30% of the Victorian Riverina, Murray Mallee, Dundas Tablelands and Gippsland Plain retain native vegetation (see Figure LB1.3). In contrast, of the 12 bioregions with greater than 80% of their native vegetation remaining, nine are in mountainous regions of the State. The other three well-vegetated bioregions occur in the desert (Lowan Mallee) and floodplain (Murray Scroll Belt, Robinvale Plains) of the northwest of the State.

Figure LB1.2 Extent of native vegetation in Victoria
Source: Department of Sustainability and Environment, Native Vegetation Net Gain Accounting: First Approximation Report 2008.



iii Excluding approximately 270,000 ha of wetland habitats.

Figure LB1.3 Extent of native vegetation remaining in Victorian bioregions
Source: Department of Sustainability and Environment, unpublished data, 2008.



Indicator LB3 Depletion of native vegetation by EVC broad groupings

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

EVCs occurring in areas most suitable for agriculture have been most heavily affected by clearing and degradation of quality (see Figures LB1.4, LB1.5). In particular, Plains Grasslands and Chenopod Shrublands, and Plains Woodlands or Forests have been reduced to less than 20% of their original extent, and ongoing loss, particularly of grasslands, continues from illegal clearing and decline in condition (see Figure LB1.6; see also Box LB1.1). In contrast, montane and subalpine ecosystems, rainforests and rocky outcrops or escarpment scrublands retain over 90% of their original extent. Some EVC groups, such as Mallee and Riverine Grassy Woodlands or Forests, occur in areas that are both suitable for agriculture (which have largely been cleared) and areas not suitable due to soil type or flooding (which have largely retained vegetation).

Figure LB1.4 Distribution of EVC groups in Victoria prior to 1750
Source: Department of Sustainability and Environment

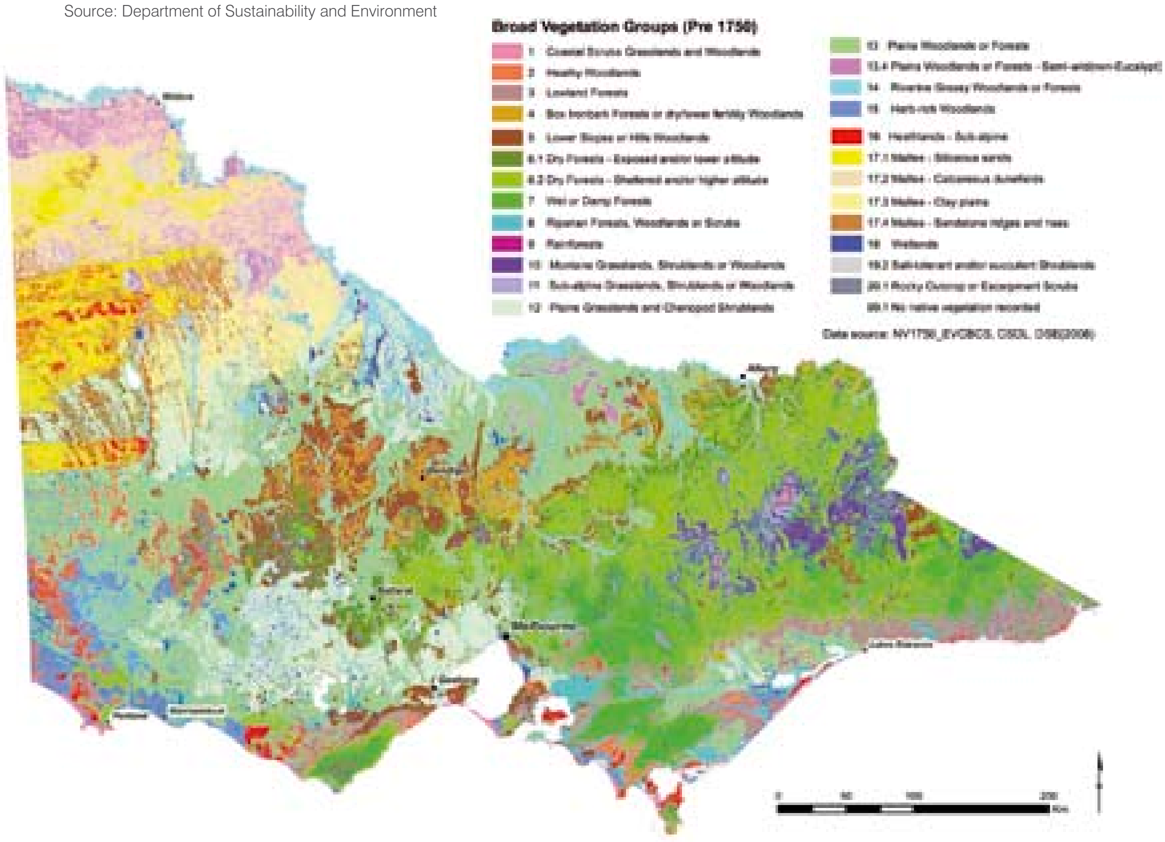


Figure LB1.5 Current distribution of EVC groups in Victoria
Source: Department of Sustainability and Environment

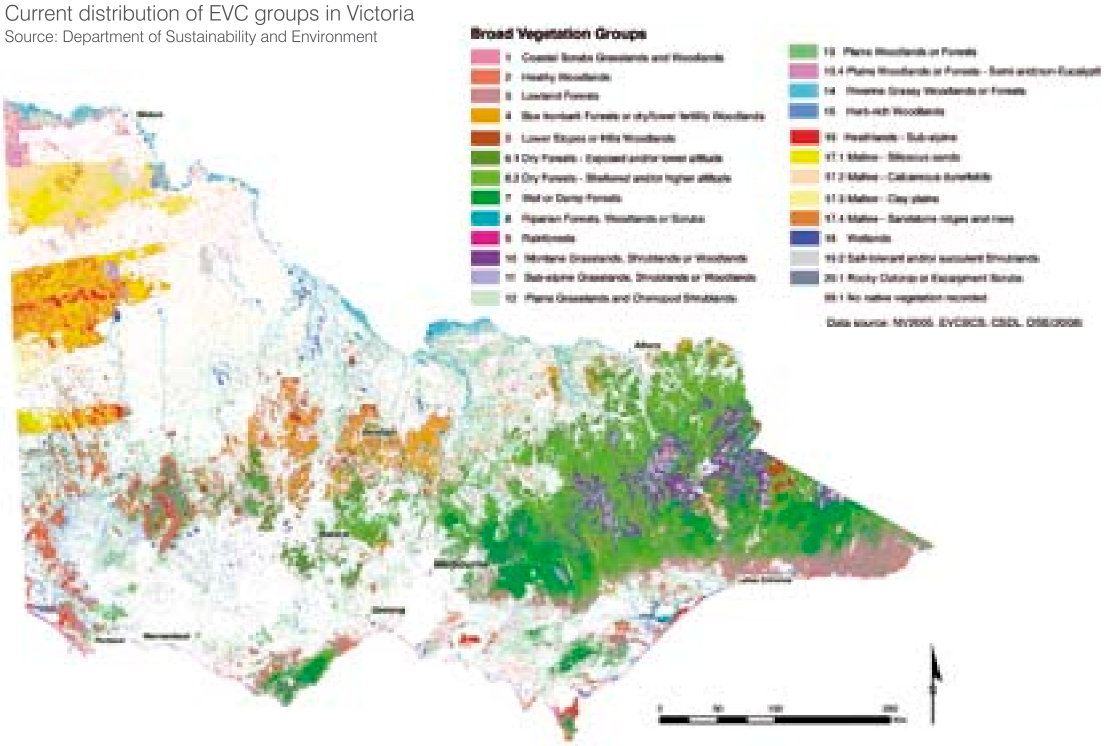
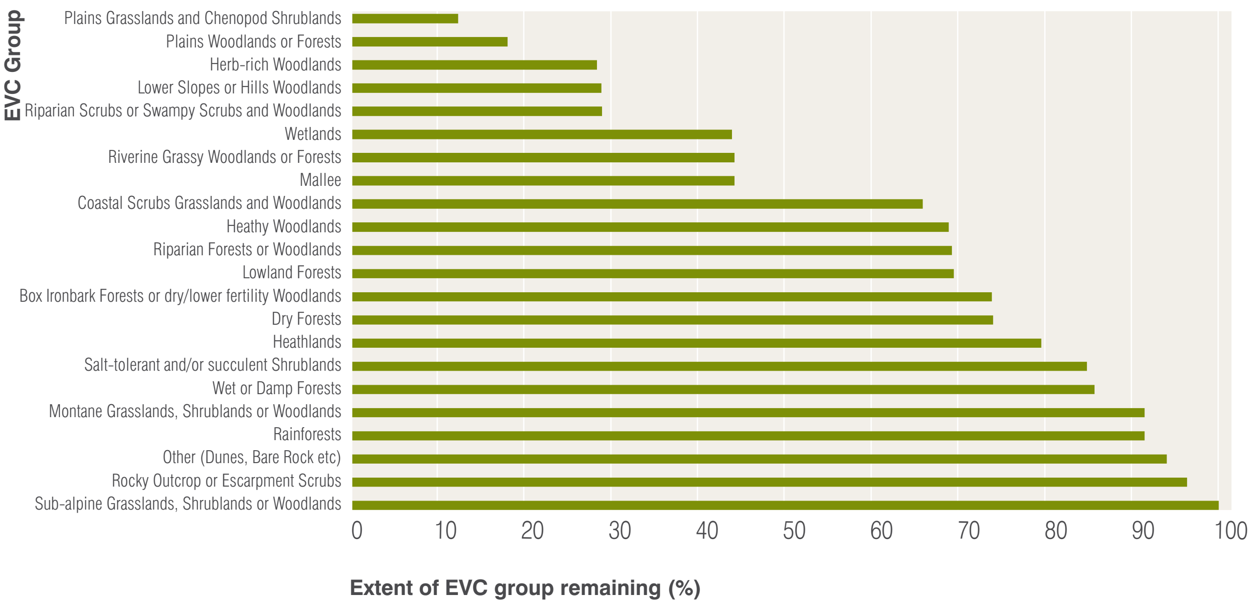


Figure LB1.6 Extent of Ecological Vegetation Class groups remaining in Victoria
Source: Department of Sustainability and Environment, unpublished data, 2008.



Box LB1.1 Ongoing loss of native grasslands in Victoria

Native grasslands are amongst Victoria's most heavily cleared ecosystems and all Plains Grasslands and related grassy ecosystems are considered endangered in Victoria. Plains Grassland in the Victorian Volcanic Plain, which once covered around 870,000 ha, now has as little as 1,000 ha (0.1%) of high quality grassland remaining[51]. Of the 530,000 ha of grassland which was present in the Victorian Riverina bioregion prior to settlement, less than 1% of high quality grasslands remain[52]. However, in both regions recent modelling suggests that there are more extensive areas of low quality grassland and native pastures than previously recognised[53].

Despite this loss, and legal protection through the *Flora and Fauna Guarantee Act 1988* and native vegetation clearing regulations, legal and illegal clearing of grasslands continues to occur. Much of this is due to conversion from native pasture grazing to more intensive forms of agriculture. However, native grasslands are also threatened by urban expansion (see also section LB2 Contemporary land use change). Of the 7,230 ha of native grassland present to the west of Melbourne in 1985, 1,670 ha (23%) were destroyed by development and 1,469 ha (21%) were degraded to non-native grassland by 2000[54] (see also Figure LB1.7). The Department of Sustainability and Environment has estimated the losses of grasslands to be mostly in areas of lower quality[55]. Recent research in the Victorian Riverina bioregion indicates that losses, particularly of high quality sites, are likely to be more extensive than those portrayed in Figure LB1.8[56].

Figure LB1.7 Clearing of native grasslands the decade 1989/1995 to 1998/2005 on the Victorian Volcanic Plains to the west of Melbourne
Source: Department of Sustainability and Environment, Native Vegetation Net Gain Accounting: First Approximation Report 2008.

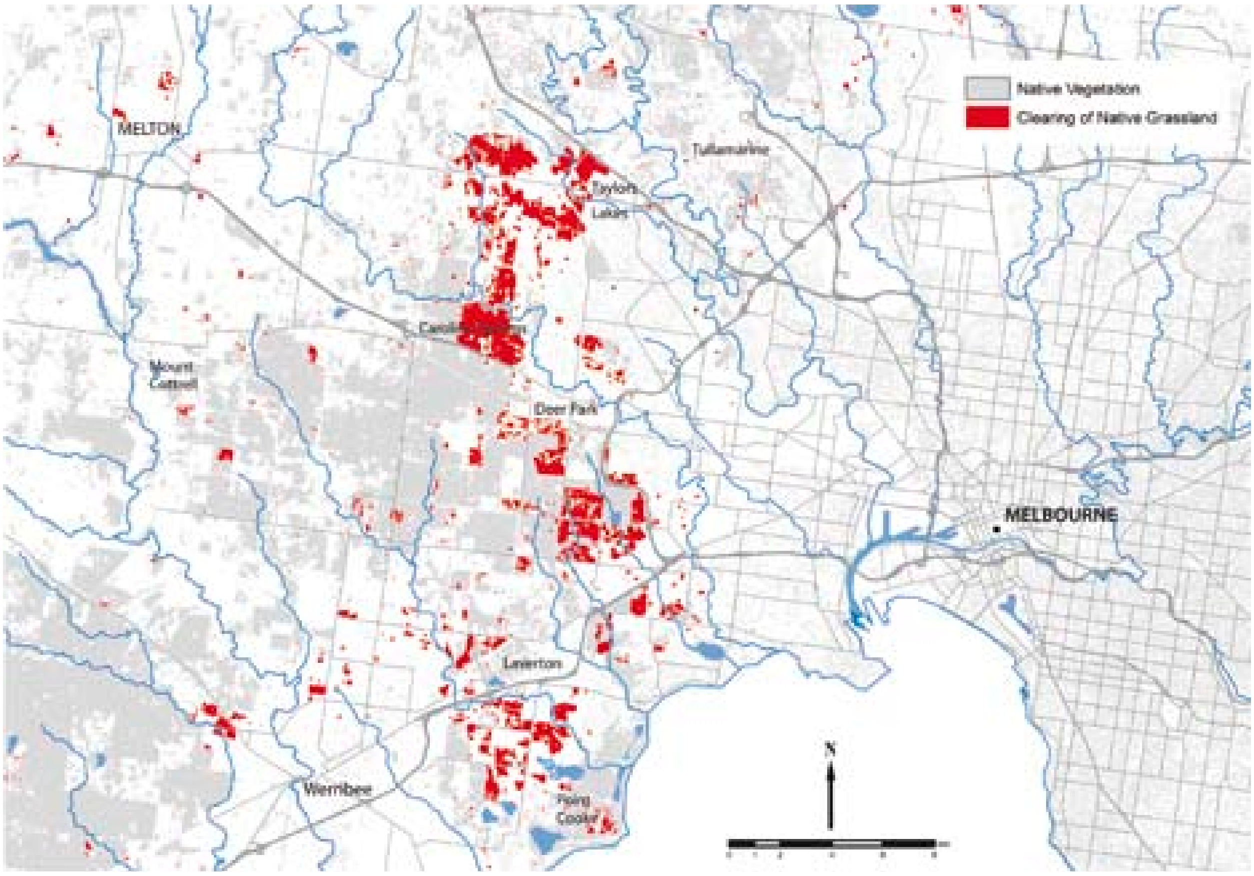
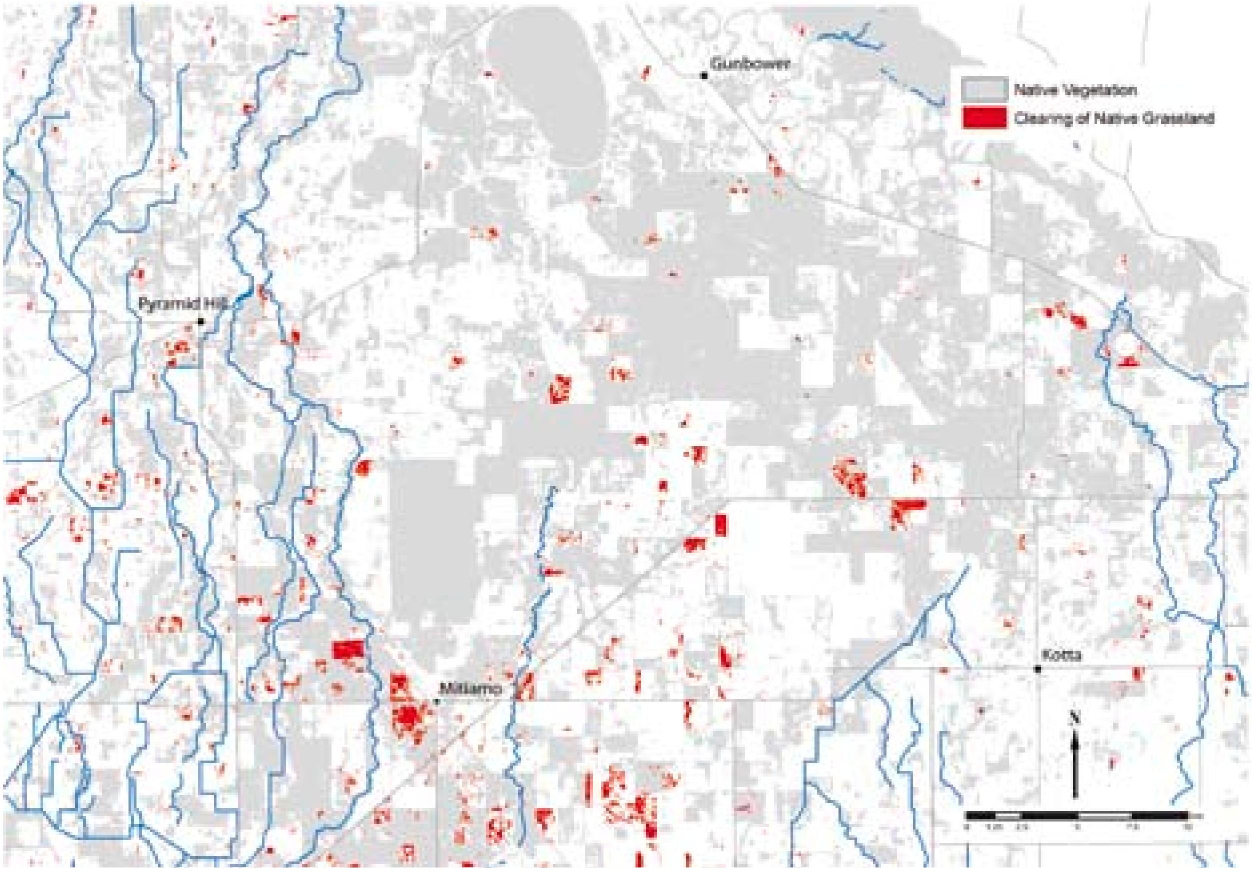


Figure LB1.8 Clearing of native grasslands during the decade 1989/1995 to 1998/2005 in the Patho Plains district, northern Victoria
Source: Department of Sustainability and Environment, Native Vegetation Net Gain Accounting: First Approximation Report 2008.



Recommendations

LB1.1 The Victorian Government should give greater recognition to the threats to grassy ecosystems and ensure that the Native Vegetation Management Framework is enforced in relation to these ecosystems.

LB1.2 The Victorian Government should ensure that future expansions of BushTender and related programs are targeted towards threatened ecosystems, such as grassy plains ecosystems, and should investigate options for encouraging stewardship of grassy plains ecosystems on private land.

Indicator LB4 Quality, condition and fragmentation of Victoria's native vegetation

Gradual loss of vegetation quality, rather than broadscale clearing, is now a major driver of vegetation loss in Victoria[57]. Assessments of vegetation quality are modelled at a landscape scale across Victoria based on assessment of biophysical components of the site (site condition)and the size of a patch of remnant native vegetation and its proximity to adjacent patches of remnant native vegetation (landscape context). Both of these components contribute to the habitat score used in the habitat hectare approach to measuring native vegetation (see Box LB1.2); changes in either component can drive changes in vegetation quality.

Figure LB1.9 shows that the quality of Victoria's remaining fragmented vegetation is generally low, while vegetation quality in the largely intact landscapes is generally high. For example, the Victorian Riverina, Murray Fans and Goldfields bioregions had more than 90% of remaining vegetation in medium and low quality classes (see Figure LB1.10). In contrast, the Victorian Alps, Wilsons Promontory, Highlands – Far East and East Gippsland Lowlands had more than 90% of their remaining vegetation in the higher quality classes.

The Department of Sustainability and Environment has estimated rates of gain and loss of native vegetation quality measured in habitat hectares[58]. On public land, the Department of Sustainability and Environment estimates that losses of 2,860 habitat hectares per year have been offset by gains of 8,760 habitat hectares per year for a net gain of 5,900 habitat hectares per year[59]. The gain on public land is driven by active management of conservation reserves, although ongoing losses of quality are likely as a result of weed invasions and inappropriate grazing regimes. On private land, the Department of Sustainability and Environment estimates that gains of 4,560 habitat hectares per year have been negated by losses of 14,550 habitat hectares per year, resulting in a net loss of 9,990 habitat hectares per year. Statewide, this represents a loss of vegetation quality of approximately 4,090 habitat hectares per year[iv,60].

On private land, gains have occurred through active management and increased security of native vegetation resulting from programs such as BushTender and Trust for Nature. However, these are outweighed by losses in quality resulting from the ongoing impacts of pest plants and animals, inappropriate grazing and removal of firewood, combined with reductions in vegetation extent resulting from illegal clearing and clearing that is exempt from regulations.

Landscape context, which incorporates patch size, patch shape, landscape connectivity and proximity to other patches of native vegetation, provides a surrogate for vegetation fragmentation. The Victorian Riverina, Warrnambool Plain, Victorian Volcanic Plain, Wimmera, Dundas Tablelands and Strzelecki Ranges bioregions had the highest proportion of remaining vegetation falling within the lowest landscape context classes and thus are amongst the most fragmented of Victorian bioregions (see Figures LB1.11, LB1.12).

As site condition is a major contributor to vegetation quality, many of the trends in vegetation quality reflect trends in site condition (see Figures LB1.13, LB1.14). An exception is the Lowan Mallee bioregion, where site condition falls mainly in the mid-range with virtually no vegetation in the higher categories. However, the overall vegetation quality in this bioregion is higher than indicated by its site condition due to the connectivity of vegetation in this bioregion.

Box LB1.2 Native vegetation accounting

Native Vegetation Quality

The modelled dataset of Native Vegetation Quality is based on habitat hectare assessment data. It consists of the combination of two datasets which are described below - a 'Site Condition' model (comprising 75% of the habitat score) and a 'Patch-based Landscape Context' assessment dataset (the remaining 25% of the overall Habitat score)[61].

Site Condition model

The Site Condition model is based on statistical relationships between many sample sites with known vegetation condition and a suite of biophysical data such as soil type, tree density, satellite imagery and climatic and topographic variables, which can be mapped. These relationships are then applied to the interplay of these same mapped biophysical data to predict the condition of native vegetation[62].

Patch-based Landscape Context model

Remnant native vegetation is assigned a rating of 0–20 based on measures of patch size, patch shape, landscape connectivity and proximity to other patches. A further five points are assigned if the native vegetation is considered 'intact' on a statewide or regional scale[63].

Habitat Hectares approach to measuring native vegetation quality

The Habitat Hectare metric has been developed as an objective way of assessing the quality of native vegetation per unit area across variable sites[64]. A patch of vegetation is assigned a habitat score based on its quality relative to an undisturbed EVC benchmark, as determined by the Site Condition and Patch-based Landscape Context models. Components of site condition include: the presence of large trees (for woody vegetation); canopy cover; understorey growth; presence of logs and absence of weeds. Landscape context incorporates the size of the patch of remnant vegetation and distance to neighbouring patches.

Habitat scores range from 1 (complete retention of natural quality relative to the benchmark) to 0 (complete loss of natural quality). The habitat score is multiplied by the area of the patch to derive the habitat hectare estimate.

Habitat Hectares = habitat score x area (in hectares)

Although the Habitat Hectares approach has gained common usage in Victoria for assessing vegetation condition and extent for the purposes of the Native Vegetation Management Framework, there are some concerns about how repeatable such assessments might be when performed by different assessors[65,66].

iv Due to considerable uncertainties, particularly about the amount of vegetation in each of the gains and losses categories, these figures may be under- or over-estimates, by possibly up to 20% (DSE, 2008. *Net Gain Accounting Report – First Approximation*).

Figure LB1.9 Modelled quality of Victoria's native vegetation
Source: Department of Sustainability and Environment, Native Vegetation Net Gain Accounting: First Approximation Report 2008.

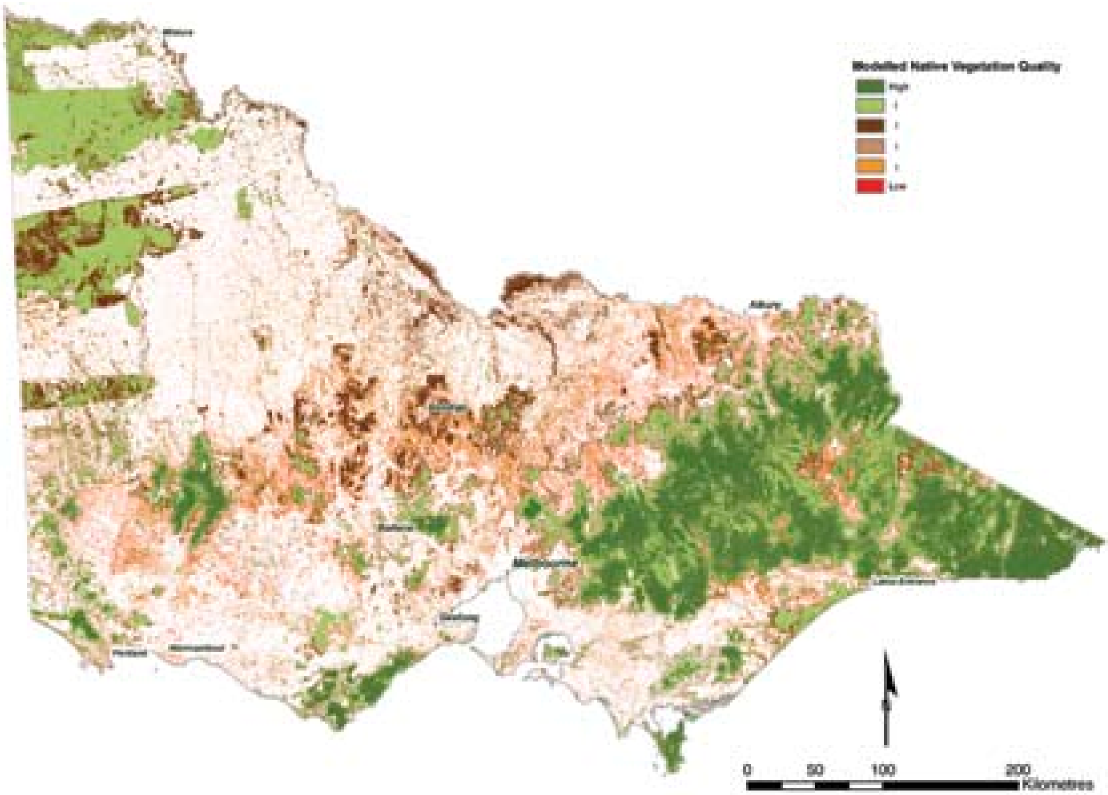


Figure LB1.10 Percentage of current vegetation in Victorian bioregions falling within various vegetation quality ranges (Low=1–30, Medium=31–60, High=61–100 (cleared land scores 0 and is not included here)). Does not include wetland habitat.
Source: Department of Sustainability and Environment, unpublished data, 2008.

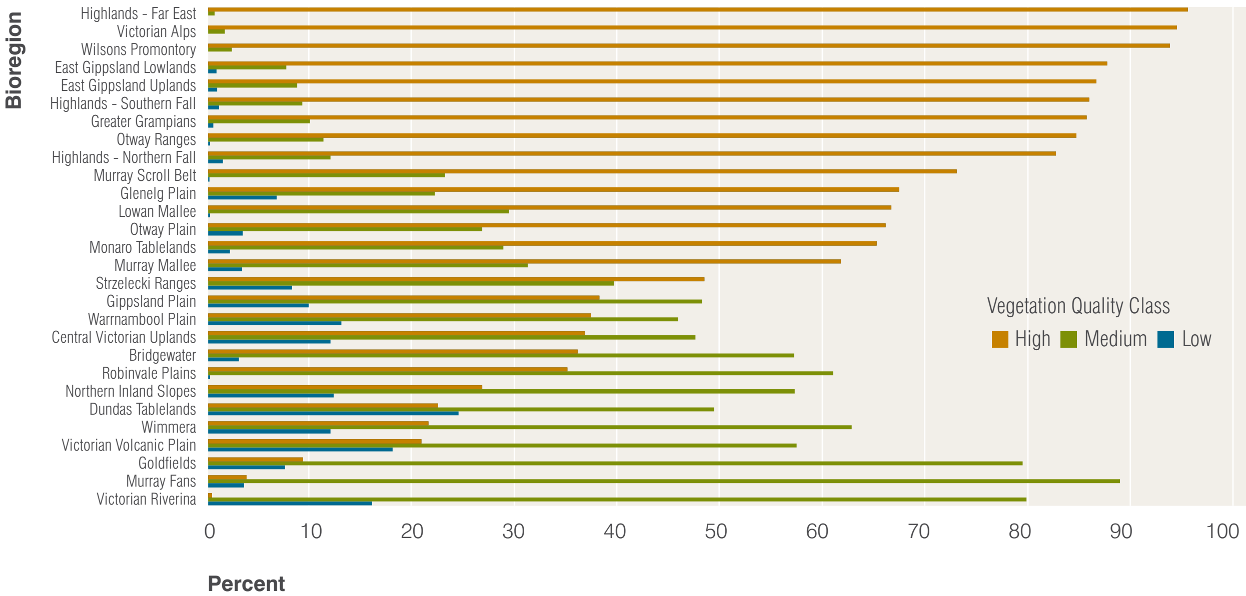


Figure LB1.11 Modelled landscape context component of native vegetation quality in Victoria (where 1=lowest and 20=highest)
Source: Department of Sustainability and Environment, unpublished data, 2008.

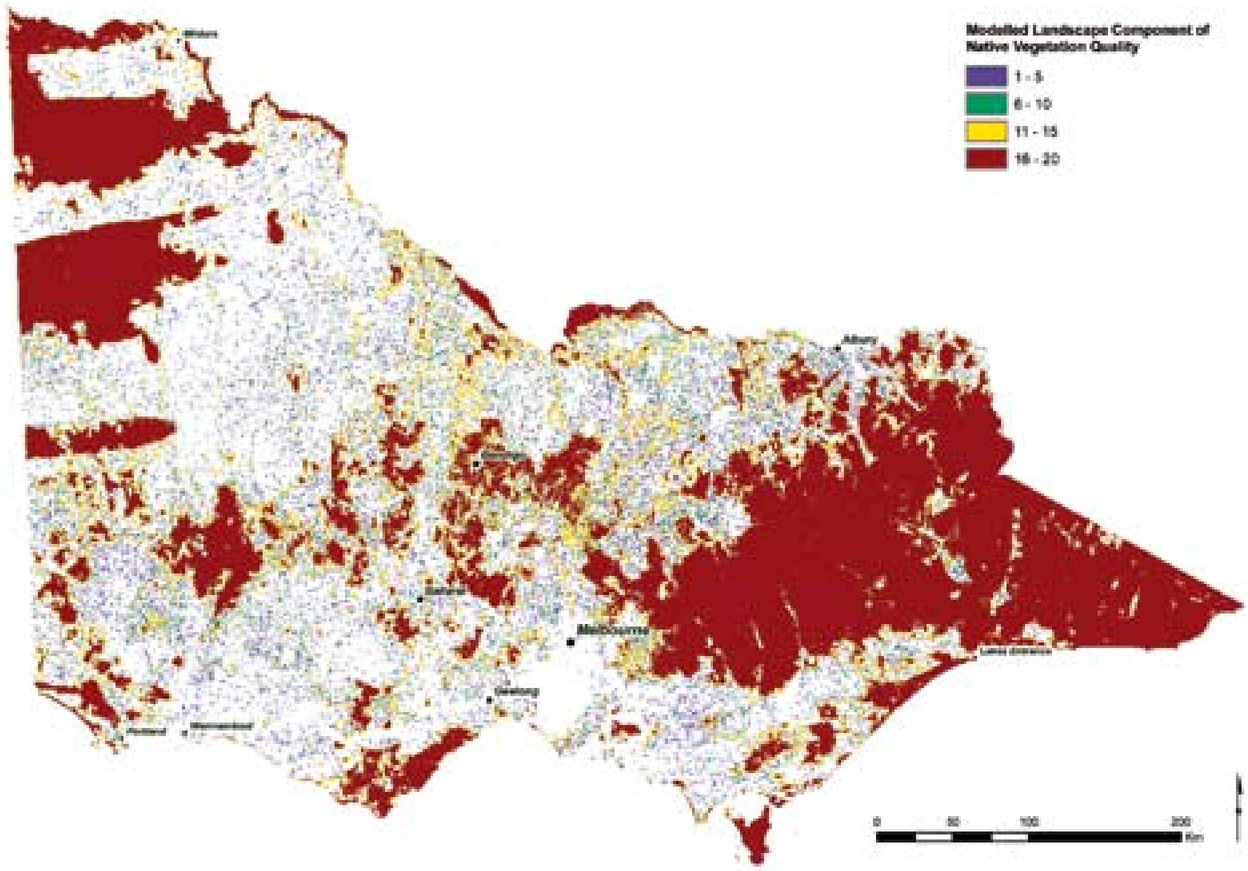


Figure LB1.12 Percentage of native vegetation in Victorian bioregions falling within various landscape context class ranges (Low=1-10, Medium=11-15, High=16-20). Does not include wetland habitat
Source: Department of Sustainability and Environment, unpublished data, 2008.

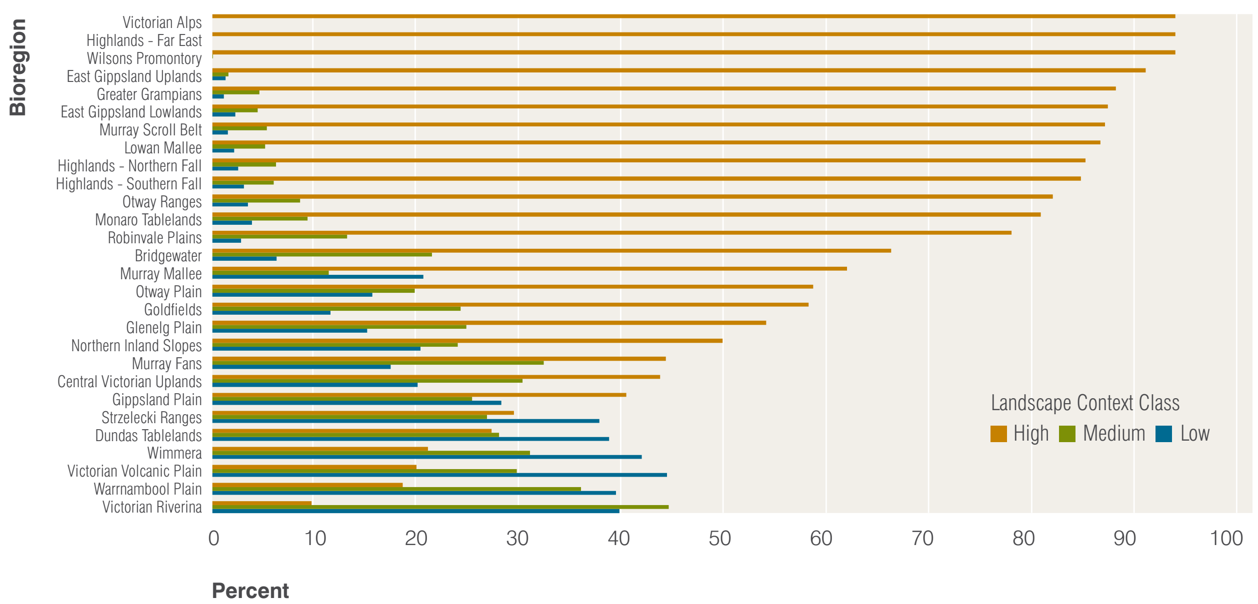


Figure LB1.13 Modelled site condition component of native vegetation quality in Victoria (where 1=lowest and 75=highest)
Source: Department of Sustainability and Environment, unpublished data, 2008.

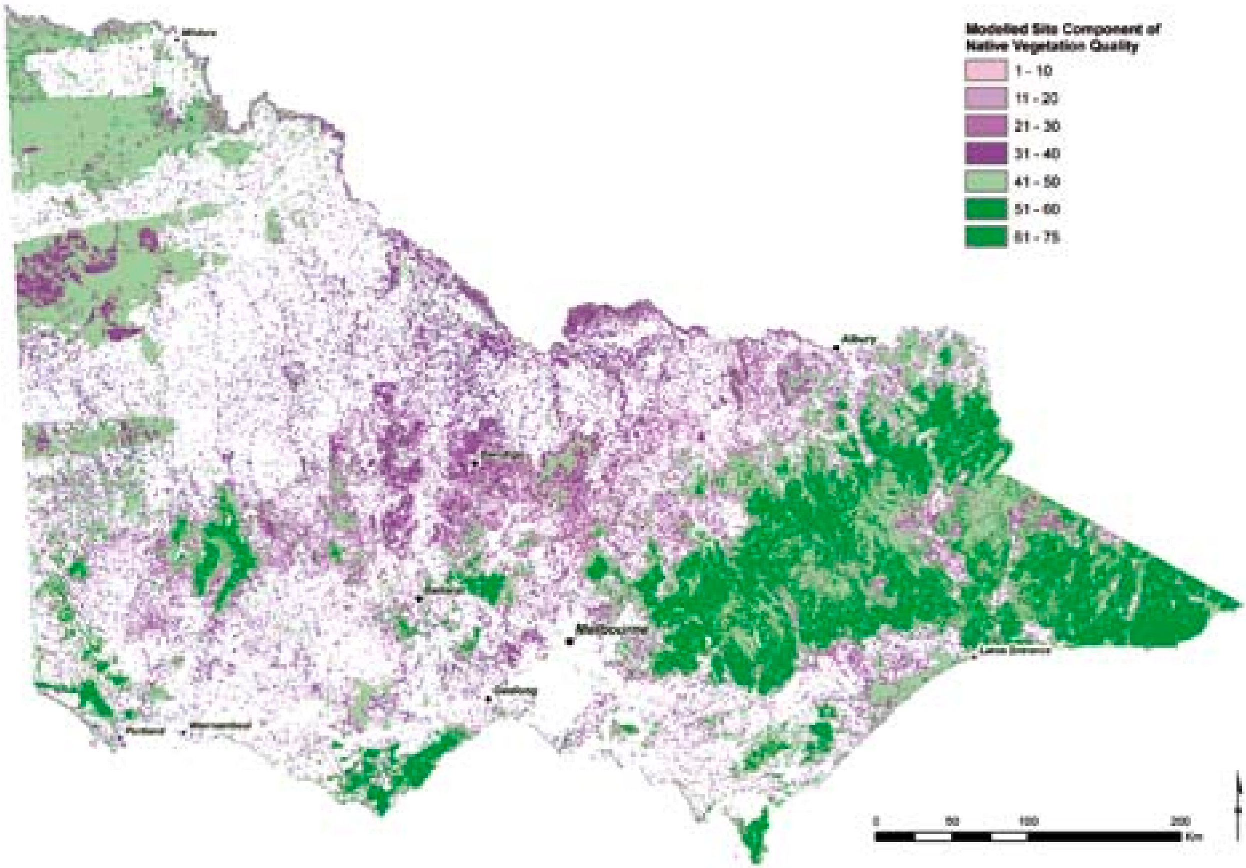
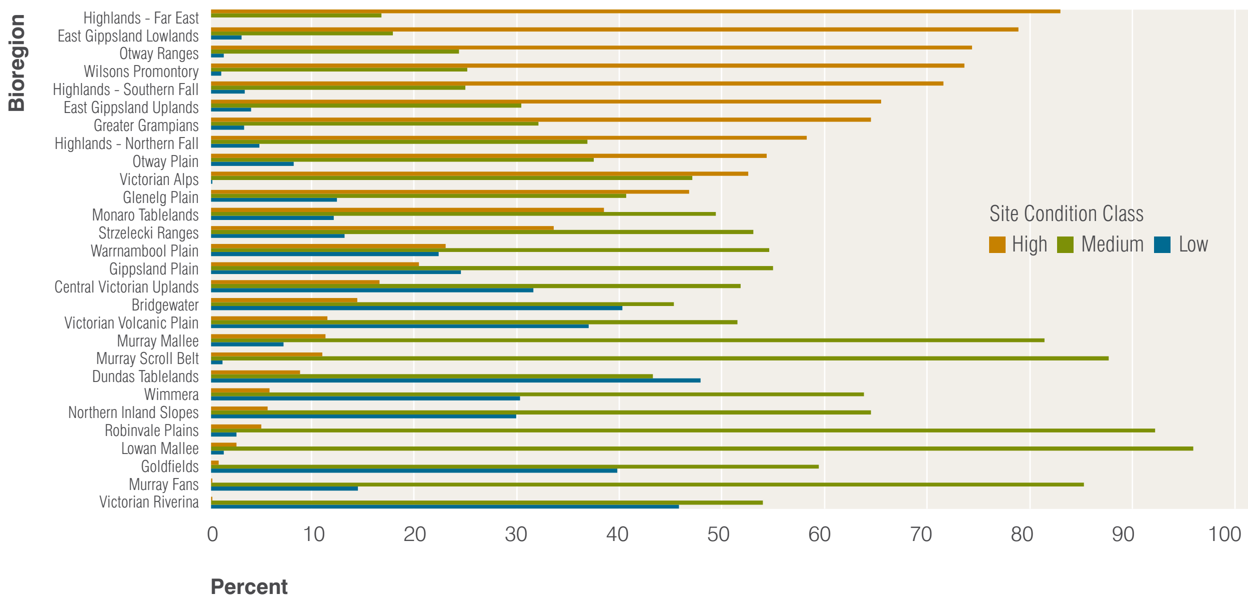


Figure LB1.14 Percentage of native vegetation in Victorian bioregions falling within various site condition class ranges (Low=1–30, Medium=31–50, High=51–75). Does not include wetland habitat
Source: Department of Sustainability and Environment, unpublished data, 2008.



Indicator LB5 Area of native forest harvested

Timber harvesting in Victoria is carried out in native forests (State forests), on public land and in plantations of native and exotic species, which are mostly on private land. State forests occupy approximately 3.18 million ha[67], or about 41% of the public land in Victoria, while plantations occupy about 411,876 ha[68]. The proportion of State forest harvested for timber each year is small: between 2002/03 and 2005/06, 8,000–10,000 ha per year were harvested (0.25%–0.3% of State forest area), while in 2006/07 only 6,223 ha were harvested (see Figure LB1.15). The majority of State forest harvested for timber lies within Ash, Red Gum and mixed species forests.

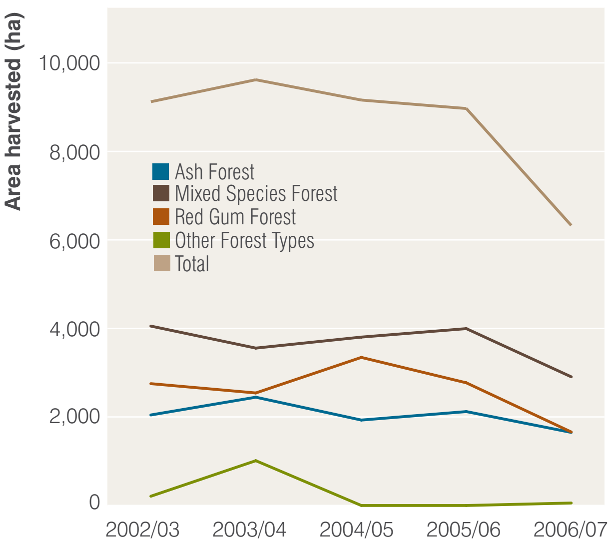
Different logging systems are used to harvest the different forest types across the State, depending on the regeneration requirements of the forest. The data shown in Figure LB1.15 indicate the total area harvested, irrespective of the logging system used. The logging systems include single tree selection, seedtree retention and clearfelling. These systems determine the area harvested; for example, single tree selection is less intensive but utilises larger areas. This explains the large harvest areas for Red Gum forests and mixed species forests, where the less intensive single tree selection method is used.

There are no obvious trends in the area of State forest harvested from 2002/03 to 2005/06 (see Figure LB1.15); however, there was a substantial decline in the area harvested in 2006/2007. This decline is attributed to a reduction in market demand for timber products, restricted availability of harvesting contractors during the 2006/2007 Great Divide Fires, and a focus on salvage operations yielding lower volumes of sawlogs.

The volume of sawlogs harvested from native forest has decreased to meet the reduced, sustainable harvest levels (See Indicator LB6 Annual production of wood products from State forest compared to sustainable harvest levels), but there has been little variation in the area harvested between 2002/03 and 2005/06 due to a number of factors, including:

- the impacts of fire resulting in large areas of salvage harvesting for 2003/04, 2004/05 and 2005/06
- the extent of single-tree-selection logging systems (larger areas, less intensive harvesting), particularly in mixed species and Red Gum forests
- the commitment of the Victorian Government to meet remaining sawlog licences until they expire
- natural variation in site productivity.

Figure LB1.15 Area of native forest (State forest) harvested. Other forest types includes harvests from freehold land and areas of native forest within softwood plantations, in agreement with landholders[v,vi]
Source: Department of Sustainability and Environment 2008



v This figure indicates the total area harvested, irrespective of silvicultural system. While Ash forest is generally clearfelled, harvesting of Red Gum forests and much of the Mixed species forests is by the single tree selection method. This method is less intensive but utilises larger areas.

vi The total area harvested in 2005/06 was 9,470 ha. This includes the area harvested outside the allocated area (forest stands described in the Allocation to VicForests Order 2004). This is not available by forest type and so is not represented in the graph.

Indicator LB6 Annual production of sawlogs from State forest compared with sustainable yield

Sustainable harvest levels and yield regulation are based on sawlog production. With the exception of 2002/03, volumes of sawlogs harvested from State forest between 2001/02 and 2005/06 were at or below the volume determined to be sustainable at the time (see Figure LB1.16).

The sustainability of timber harvesting in Victoria was reviewed in 2001 and timber yields were found to be unsustainable. As a result, the industry was significantly restructured and the sustainable harvest level was substantially reduced (see Figure LB1.16). The policy statement resulting from the review, *Our Forests, Our Future*, made significant changes to the way timber harvesting was managed, leading to a reduction in the number of licences available and a shift to sustainable forest management under a new Act, the *Sustainable Forests (Timber) Act 2004*.

The amount of timber harvested during 2002/03 significantly exceeded the reduced sustainable harvest levels set for that year. This resulted from a 39% reduction in sustainable sawlog harvesting levels between 2001/02 and 2002/03, identified as part of *Our Forests, Our Future*. The Department of Sustainability and Environment offered a Voluntary Licence Reduction Program to reduce volume commitments. Where there were insufficient voluntary reductions, the Government agreed to meet remaining licence commitments with transitional arrangements implemented by VicForests in 2005. This resulted in the volume of timber harvested in the first year of the new arrangement exceeding the designated sustainable yield. Some of these licences do not expire until late in the current decade[69], contributing to continued higher harvest levels in some areas.

Fire salvage operations in 2003/04–2006/07 were conducted in some of the fire-killed areas resulting from the 2003 Alpine Fires, which burnt just under 1 million ha of public land, including 438,000 ha of State forest (see section LB8 Fire in the Victorian environment). On a statewide basis, normal timber harvesting combined with salvage harvesting of fire-killed timber resulted in total harvest levels equal to, or slightly higher than, the volume determined to be sustainable (see Table LB 1.1); however, salvage harvesting is not representative of the area that would usually be harvested.

Table LB1.1 Actual and sustainable timber harvest from State forest 1992–93 to 2006–07. Sustainable yields are expressed as net volume (gross volume minus allowances for defects) until 2004–05. Until 1995–96, sustainable yield figures did not include low quality sawlogs. Figures from 1996–97 onwards include low quality sawlogs

Source: Department of Sustainability and Environment 2008

	Actual harvest (m^3)		
Year	Normal harvest	Fire salvage harvest	Allowed sustainable harvest
1992–93	632,000	–	743,000
1993–94	660,000	–	743,000
1994–95	664,000	–	743,000
1995–96	589,000	–	743,000
1996–97	729,000	–	921,000
1997–98	804,000	–	921,000
1998–99	821,000	–	921,000
1999–00	820,000	–	921,000
2000–01	667,000	–	921,000
2001–02	682,000	–	921,000
2002–03	638,000	–	559,000
2003–04	412,000	118,000	526,000
2004–05	533,000[A]	50,000[A]	580,000[B]
2005–06	470,000[A]	27,000[A]	580,000[B]
2006–07	336,000[A]	74,000[A]	547,000[A]

A. Gross sawlog volume
B. Gross sawlog volume equivalent to 526,000 m^3 net sawlog volume

Pressures

Many of the pressures on native vegetation in Victoria are explored in more detail in subsequent sections (see sections LB2 Contemporary land use change, LB8 Fire in the Victorian Environment, LB9 Impacts of climate change on land and biodiversity).

Historic clearing

Extensive clearing of Victorian land occurred during the expansionary phase of settlement, when freehold title was established over much of Victoria. Continued clearing was encouraged by State governments to facilitate the expansion and productivity of rural industries in Victoria. Major clearing also occurred after World War II on marginally productive areas of the northern Mallee for soldier settlements, although these blocks proved to be unviable and farming was not pursued. Extensive clearing has occurred in urban areas.

Primary industries on cleared land have played, and continue to play, a key role in Victoria's rural economy and export earnings. Clearing has been most extensive in areas with the greatest capability for agriculture, such as the fertile Victorian Volcanic Plains in western Victoria and the Riverina in northern Victoria, which each retain less than 25% of their original native vegetation cover (in reality, much less, as most of that cover is low-quality native grassland; see Box LB1.1). The extensive historic clearing of Victoria has produced a legacy of highly fragmented native vegetation throughout the agricultural areas of the State. These native vegetation remnants are vulnerable to natural disturbance events such as drought, fire and flood, as well as those arising from use of the land for agriculture and residential purposes.

Land degradation

Degradation of land as a result of historic vegetation clearing continues to exert pressure on existing vegetation remnants. Replacement of woody and perennial vegetation with cultivated annual plant species has disrupted the hydrological balance of Victorian landscapes, producing dryland salinity over parts of western Victoria such as south-west of the Grampians. Salinity is also a problem in Victoria's northern irrigation areas – as much as 72% of the Kerang district is considered to be susceptible to salinity[70].

Exchange of perennial native vegetation for more ephemeral vegetation (annual crops and pastures) also contributes to erosion, rising groundwater and salinity. The emergence of saline groundwater further threatens existing native vegetation (see sections LB5 Soil structure and erosion, LB6 Salinity). These processes degrade the soil that supports plant growth, contributing to a gradual decline in quality of Victoria's native vegetation and limiting future opportunities for revegetation.

Weeds adapted to disturbed environments readily invade degraded land and compete with native vegetation. Grazing by introduced pest animals such as rabbits, overabundant native animals (for example, kangaroos), and livestock also threatens the quality and persistence of native vegetation (see section LB4 Pest plants and animals).

Land use change

Change in the use of rural land in Victoria from largely agricultural production to a more diverse range of activities and enterprises can exert pressure on native vegetation (see section LB2 Contemporary land use change). Subdivision of large properties into smaller blocks has the potential to further fragment existing vegetation, increasing the susceptibility of smaller vegetation patches to future degrading processes. Conversely, small rural blocks are often managed for biodiversity values such as revegetation and habitat creation, which can contribute to gains of native vegetation.

Allowable land uses are regulated by the Victorian Planning Provisions and planning schemes. These planning schemes, used by local governments to plan development and land use, may not provide adequate protection for significant vegetation remnants (see section LB2 Contemporary land use change). A major issue is the inability of the planning system to adequately address the cumulative impacts of development. For example, a single development on its own may have only a small impact on native vegetation but successive developments approved in isolation may have a much bigger impact. Thus, there is a risk of threats to remnant vegetation from inappropriate land development in both rural and urban areas[71].

Timber harvesting

Timber harvesting, while more benign than historic broadscale vegetation clearing and land degradation, nonetheless does affect the vegetation structure and species composition of Victoria's forests and woodlands, as well as the landscape mosaic. These effects do not mimic those of natural disturbances such as bushfire[72]. The tree size distributions of harvested areas are skewed towards high densities of small trees, resulting from the systematic removal of large trees[73]. The length of harvest rotation, which is usually shorter than the normal lifespan of the trees, further disrupts forest vegetation structure[74] and prevents the natural succession of wet eucalypt forest to cool temperate rainforest.

Timber harvesting is regulated by the *Code of Practice for Timber Production*, which prescribes regeneration activities that must accompany harvesting. Regeneration is monitored and assisted where necessary. Timber harvesting does, however, produce a temporary loss of habitat during the regeneration period. There are also potential longer-term changes in forest structure associated with regeneration, which has implications for biodiversity and habitat availability.

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

Fire regimes

Fire is a necessary component of the Victorian environment; however, frequencies and intensities of fire that are inappropriate for a vegetation type can exert pressure (see section LB8 Fire in the Victorian environment). Forests in relatively undisturbed, largely intact landscapes are generally able to regenerate without loss of condition after fire; however, fragmented vegetation is more vulnerable to fire. Loss of regeneration potential of fragmented vegetation following fire may occur due to a smaller seed bank, an increased likelihood of soil degradation affecting regeneration potential and increased susceptibility to weed invasion. The complete absence of fire also has detrimental effects on some plant species reliant on fire for regeneration and on fauna reliant on the forest structure and composition created by regular fire; for example, the Southern Brown Bandicoot (*Isoodon obesulus*)[75].

Altered flow regimes

Many floodplain ecosystems require regular flooding to maintain high vegetation quality. Altered hydrological regimes, primarily resulting from river regulation (see Part 4.3 Inland Waters), have reduced the size and frequency of flood events, resulting in severe stress on floodplain vegetation types. For example, the Murray River now receives only 27% of original flows[76] and flooding events have been significantly reduced, threatening the health of River Red Gum (*Eucalyptus camaldulensis*) and Black Box (*Eucalyptus largiflorens*) forests along this river[77]. This situation is exacerbated by the current dry conditions and will become an increasing problem as a result of climate change, which is expected to reduce runoff by a further 20% by 2030 and more than 50% by 2070 in the Upper Murray catchment[78].

Climate change

Many species of Victorian native plants are highly sensitive to variation in climate. Some *Eucalyptus* species currently occupy ranges spanning less than 3°C in temperature and their likelihood of survival outside this range is uncertain[79]. Native plant species distributions are also often constrained by soil type and position in the landscape and many species are unlikely to adapt their ranges to new climate zones but, rather, are expected to contract within their existing ranges[80]. Higher temperatures resulting from climate change are also likely to increase the susceptibility of native vegetation to more frequent and higher intensity fire events. The implications of climate change for native vegetation are discussed in detail in section LB9 Impacts of climate change on land and biodiversity.

Implications

Ecological implications of loss and fragmentation of native vegetation

Historic broadscale clearing of native vegetation in many Victorian landscapes has resulted in widespread loss and fragmentation of habitat and decline in species populations. Fragmentation of habitat has severe implications for native fauna and flora. Lack of continuity between habitat fragments may prevent or limit the movement of animal populations, limiting opportunities for mating and dispersal of young, and potentially creating genetic isolation. Vegetation fragmentation, therefore, is likely to exacerbate the impacts of land use change and climate change by restricting opportunities for fauna to migrate or adapt.

Increasing fragmentation also creates smaller patches with higher edge:interior ratio. These edges, which are subject to increased weed invasion, nutrient input, solar insulation and predation, can further reduce the suitability of remnant vegetation for species reliant on more extensive, less disturbed habitat. Negative consequences for a range of fauna species and groups are evident in Victoria, such as reptiles in the Box–Ironbark forests[81], and forest-dependent birds on the Mornington Peninsula[82].

Although of lower quality than patches of high-quality remnant native vegetation, native vegetation that is integrated into agricultural production systems makes a contribution to biodiversity conservation at the broad scale. For example, native pastures on steep hill country have been partially cleared and modified by grazing but, with appropriate management, can support biodiversity in the agricultural landscape as well as providing a profitable basis for grazing[83].

The extensive clearing and habitat modification in some Victorian bioregions and vegetation types presents a danger of crossing an ecological threshold – a level beyond which there is a disproportionately rapid change in the status of species or ecological processes, and from which the ecosystem may not recover. For example, species richness of woodland birds in northern Victoria is correlated to habitat cover – below 10% cover in the landscape there is a rapid loss of woodland-dependent birds as tree cover decreases[84]. In this instance, a goal well in excess of 10% tree cover is required to prevent the collapse of the woodland-dependent bird communities[85]. High rates of vegetation loss have resulted in many of the species relying on those habitats now being considered threatened (see section LB3 Threatened species).

Some fauna groups have benefited from recent revegetation efforts in Victoria[86], but there are significant time lags in vegetation maturation and the consequent development of habitat resources (such as large boughs, tree hollows and fallen timber loads) that are essential for many birds and arboreal and scansorial mammals[87,88]. For example, small tree hollows can take up to 100 years to develop, and 200–400 years for larger hollows[89,90]. Species that depend on tree hollows for nesting, such as the woodland Superb Parrot (Polytelis swainsonii) and the forest-dwelling Leadbeater's Possum (*Gymnobelidius leadbeateri*), are threatened by a critical shortage of nesting sites during the period between loss of existing vegetation and maturation of new vegetation.

The continuing declines in extent and condition of Victoria's plains grasslands, which are amongst the most vulnerable vegetation types, have implications for the survival of both the grasslands vegetation community itself and the animals that inhabit this vegetation, such as the Striped Legless Lizard (*Delmar impar*). Very small proportions of high quality native grasslands remain, and the continuing loss of this vegetation type means that grasslands and the species they support are at risk of extinction in Victoria.

Functional implications of vegetation fragmentation

Native vegetation plays a central role in the regulation of water movement and prevention of erosion. Loss of fertile topsoil due to erosion limits the capacity of soil to support vegetation growth and exposes sub-soil layers, which are often hostile for seed germination and plant establishment.

The status of Victoria's native vegetation is reflected by the condition of the State's rivers, assessed by the Index of Stream Condition. Most of the rivers considered to be in good condition are located in eastern Victoria, where native vegetation is extensive and generally of high quality. In central and western Victoria, where vegetation is generally much more fragmented, rivers were in moderate to poor condition (see Part 4.3 Inland Waters), emphasising the link between the presence of high-quality native vegetation and the condition of the broader environment.

Native vegetation also plays a key role in regulating climate by storing carbon in plant tissues. Historic and contemporary losses of native vegetation can be expected to contribute to the impacts of climate change (see section LB9 Impacts of climate change on land and biodiversity) and its associated social, economic and environmental pressures.

It has recently been shown that Victoria's native forests store much more carbon in forest biomass and soil than estimated by the IPCC (an average of 640 tonnes of carbon per hectare, but as much as 2000 tonnes of carbon per ha compared with the IPCC default value of 217 tonnes carbon per ha), provided the forest remains undisturbed[91]. This underscores the importance of retention of natural forests in mitigating climate change. Under emissions trading, native forests may be of higher value for the carbon they store and the emissions they prevent than for timber products.

Recommendation

LB1.3 The Victorian Government should re-state the role of natural forests in climate change mitigation in light of recent findings that undisturbed forests are more efficient in carbon sequestration than harvested forests, and encourage the conservation of undisturbed forests. Production of timber products from Victoria's maturing plantation estate should also be encouraged.

Implications of disturbances for largely intact vegetation

Vegetation stocks in Victoria's largely intact landscapes are considered stable and capable of recovery from disturbance without significant human intervention. Disturbance in these landscapes is not currently likely to produce immediate and irretrievable loss of vegetation. However, even Victoria's largely intact native vegetation is subject to pressures that might degrade its quality and resilience to disturbance in the future; for example, weed invasion, overgrazing, timber harvesting and land use change. The condition of biodiversity in Victoria's parks is variable due to past land use and disturbance such as logging and grazing, as well as the impact of a range of current and ongoing threats from weeds and pest animals, altered hydrology, inappropriate fire regimes, grazing pressure and fragmentation.

Some types of disturbances that affect regions of largely intact vegetation, such as fire and drought, are mostly naturally occurring but are likely to increase in frequency, severity and scale with climate change (see Part 4.1 Atmosphere: Climate Change; section LB9 Impacts of climate change on land and biodiversity). The resilience of forest vegetation to an increase in natural disturbance of the scale predicted under climate change is not known. Ongoing management of Victoria's largely intact native vegetation is likely to be required to maintain its high quality under increasing pressures from climatic events.

Human-induced disturbances also affect parts of these largely intact landscapes. Many large blocks of vegetation on public lands have been managed mainly for timber extraction. The tree size distributions of these blocks are skewed towards high densities of small trees, resulting from the systematic removal of large trees[92]. Differences between burned and clearfelled forests are evident in vegetation structure, plant species composition and landscape patchiness. These changes can ultimately have significant negative impacts for many forest-dependent vertebrates[93].

Management responses

Current government responses to vegetation loss and modification need to address the legacy of historic vegetation clearing (highly fragmented rural landscapes), the ongoing low-level clearing of native vegetation and the current decline in quality of remnant vegetation. Victoria has traditionally employed a mix of regulatory activities and investment in information and education programs to target improved native vegetation management. Victoria has recently investigated and implemented market-based approaches to the protection and enhancement of native vegetation and other environmental goods and services in order to address market failures with respect to vegetation management and to engage a broader spectrum of the community. Both traditional methods and any alternative responses to native vegetation management must address a key objective: *to improve the extent and quality of Victoria's native vegetation*.

Victoria's responses to the loss of native vegetation and habitat fall against a background of global and national concerns about conservation of biodiversity (see section LB0 Introduction) and there is an extensive national policy context that provides direction on the retention and restoration of native vegetation. Victoria has a range of policies that articulate goals for native vegetation management in this State, supported by a comprehensive set of regional plans.

Response name

Victorian Native Vegetation Management – A Framework for Action

Responsible authority

Department of Sustainability and Environment

Response type

Policy/strategy

Victoria's *Native Vegetation Management Framework* underpins the approach to management of native vegetation across Victoria and addresses native vegetation management from a whole-catchment perspective. This framework is implemented by incorporation of endorsed Regional Vegetation Plans into the Victorian Planning Provisions (Clause 52.17) but is not supported by specific legislation. The Regional Vegetation Plans articulate State and regional Net Gain targets and specify particular vegetation assets as priorities for retention or management.

Applications for permits to clear native vegetation are initially assessed by local governments as part of the planning process and, if necessary, are referred to DSE for approval. The threshold for referral of clearing applications for consideration by DSE has recently been lowered, so most applications are now assessed by DSE[94]. However, illegal removal of native vegetation remains a source of vegetation loss. Because of the small fines involved and a lack of resources, such breaches are rarely prosecuted by local governments[95]. The current fines for illegal clearing of native vegetation appear to be an inadequate deterrent.

The primary focus of the *Native Vegetation Management Framework* is on private land, where the impacts of previous clearing are greatest. The aim of the Framework is to achieve *'A reversal, across the entire landscape, of the long-term decline in extent and quality of native vegetation, leading to a Net Gain'*. That is, native vegetation should be managed such that overall gains exceed overall losses. It is clear, however, that private landholders will not be required to meet the costs of reparation of past losses required for the delivery of the Government's Net Gain objective[96]. It is intended that these costs will be met through government and voluntary activities such as *BushTender*.

The first principle of the *Native Vegetation Management Framework* is that clearing should be avoided where possible. Where clearing cannot be avoided or the impacts minimised, revegetation or improved management of existing native vegetation is required to offset the losses. This approach to native vegetation management represents a major cultural shift in Victoria where, until 1989, clearing of native vegetation on private land was permitted 'as of right'.

The *Native Vegetation Management Framework* was adopted in 2002 and was reviewed in 2007. Although the rate of clearance of native vegetation in Victoria has been reduced from approximately 15,000 ha per year during the 1970s and 1980s to approximately 4,000 ha per year, vegetation clearing is still occurring in Victoria, particularly in endangered grassy ecosystems. Lack of enforcement of the Framework and prosecution of breaches in relation to grassy ecosystems has been one of the major limitations of the Framework to date. In addition, within the Victorian Planning Provisions (Clause 52.17.6), there is an extensive list of situations where clearing of native vegetation is exempt from the need to obtain a permit. This legal but permit-exempt clearing means that small-scale losses of native vegetation go undocumented in Victoria.

Despite the local revegetation efforts of many individuals and groups, the 2007 review of the *Native Vegetation Management Framework* indicated that the rate of loss of native vegetation exceeds the rate of gain on private land[97]. The *Native Vegetation Management Framework* does not specify a timeframe within which gains of native vegetation should exceed losses.

A limitation of the vegetation offset approach is the ecosystem and habitat value of revegetated areas. The ecosystems and biodiversity attributes of cleared patches are not necessarily reconstructed in revegetated offset areas; nor are they provided on the same timescale, as there is typically a lag between clearing of vegetation and the establishment and maturation of planted vegetation[98]. Where relocation of fauna between the cleared vegetation and the offset vegetation is not possible, offsets cannot be successfully used to replace habitat. Victoria's *Native Vegetation Management Framework* acknowledges these limitations and clearly indicates that avoiding clearing is the first priority and that the provision of offsets should only be considered when impacts of clearing cannot be avoided or minimised. The Framework also sets out specific criteria for quality and quantity of vegetation provided as offsets, depending on the significance of the vegetation to be cleared.

From June 2008, the Framework is supported by a native vegetation tracking (NVT) tool, which allows DSE to record and map the extent of clearing that has been allowed, the clearing that has been avoided and the offsets that have been provided. The NVT will provide an accessible electronic tool that will assist with monitoring the delivery and management of offsets and prevent permission being granted for clearing in areas designated as offsets. The lack of such a tracking tool has previously hampered DSE's capacity to monitor and, where necessary, enforce the delivery and ongoing management of offset areas. It would be beneficial if permit-exempt clearing was also registered in the NVT.

The need to maintain the current extent and high quality of native vegetation in the largely intact landscapes should not be neglected in future policy development.

Recommendations

LB1.4 The Victorian Government should urge improved implementation of the *Native Vegetation Management Framework* at the local government level. This could be achieved by supporting training for local government vegetation officers and ensuring that DSE has adequate resources to assess the additional vegetation clearing permit applications being referred by local governments.

LB1.5 All vegetation clearing activities should be recorded and monitored – not just those for which permits are required. This could be achieved by expanding the Native Vegetation Tracking tool to accommodate a register of permit-exempt clearing and encouraging voluntary registration of exempt clearing by landholders.

LB1.6 The Victorian Government should specify interim targets for the achievement of Net Gain of native vegetation on private land and allocate adequate funding to achieve the desired targets. This could be achieved by expansion of BushTender and other programs intended to encourage improved management of native vegetation.

LB1.7 The Victorian Government should allocate funds for and undertake five-yearly estimates of native vegetation cover in Victoria, based on high quality aerial photography or satellite imagery, with the aim of publicly reporting on progress towards the achievement of Net Gain of native vegetation.

Response Name

National Reserve System – Establishment of a Comprehensive, Adequate and Representative Reserve System.

Responsible Authorities

Department of Environment, Water, Heritage and the Arts; Department of Sustainability and Environment (Victorian Environmental Assessment Council)

Response Type

Strategy/policy

Victoria's reserve system today is largely the result of recommendations on the use and categorisation of public land by the Victorian Environmental Assessment Council (and its predecessors, the Land Conservation Council (LCC) and Environment Conservation Council (ECC)). Since the implementation of the National Reserve System (NRS) in 1992, all Australian States and Territories have been working toward a more systematic development of a comprehensive, adequate and representative (CAR) system of protected areas. This was supplemented in the mid–late 1990s by the Regional Forest Agreement process, which designated a large number of informal reserves in State forests. Since the mid-1990s, the Department of Sustainability and Environment's Conservation Land Purchase Program, with assistance from the Commonwealth Government's National Reserve System Program (NRSP), has focused on purchasing properties with ecosystems of high conservation significance which are under-represented in the reserve system, namely grasslands, grassy woodlands and wetlands. The NRSP has also assisted the Trust for Nature in securing a number of endangered grassland properties, including the 30,000-ha Ned's Corner Station in north-west Victoria.

The proportion of ecosystems meeting nationally agreed reservation targets is outlined in detail under Response Indicator LB7 Proportion of bioregional ecosystems meeting nationally agreed reservation targets. In general, the least reserved bioregions are those encompassing high proportions of private land and areas where vegetation loss is already extensive. The contribution of private conservation lands is outlined in Response Indicator LB8: Area and numbers of properties involved in private land conservation mechanisms.

Victoria's reserve system is considered to be more advanced than those in many other parts of Australia. However, there are still gaps in the system, including the south-west, Strzelecki Ranges, Gippsland Plain, Victorian Volcanic Plain and Riverina. The robustness of the Victorian reserve system also needs to be examined in light of the potential future impacts of climate change[99] and efforts to restore vegetation connectivity to the landscape. While improved connectivity is generally considered to assist biodiversity protection, it might threaten some protected areas which benefit from isolation, for example, by facilitating the movement of pests and predators into isolated reserves[100].

The announcement by the Commonwealth Government in March 2008 of the provision of $180 million for building the National Reserve System over the next five years[101] provides opportunities for addressing some of these gaps in areas where private land predominates. However, funding for land acquisition remains low in Victoria and opportunities to purchase ecologically significant properties to address gaps in Victoria's reserve system are being lost as a result.

Victoria's public reserve system is complemented by a growing private reserve system comprised of environmentally significant properties purchased and managed through funds operated by organisations such as Bush Heritage and the Trust for Nature, as well as the participation of individual landowners in government and private vegetation conservation programs (see Response indicator LB8 Area and number of properties involved in private vegetation conservation mechanisms).

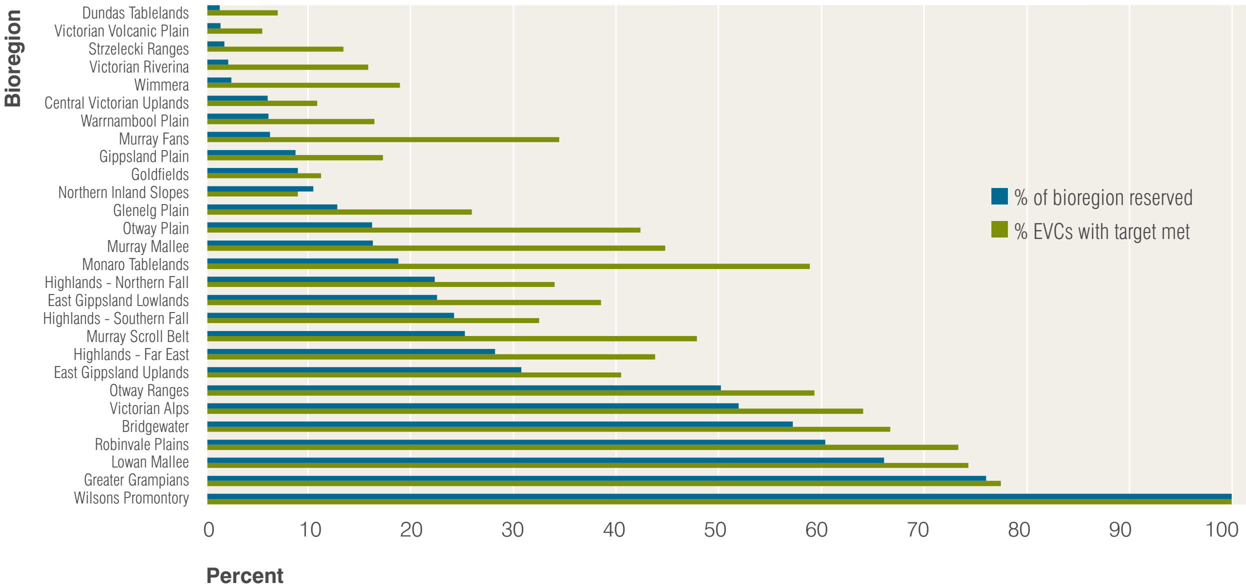
Response Indicator LB7 Proportion of ecosystems meeting nationally agreed reservation targets

The Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System of Forests in Australia (commonly known as the 'JANIS criteria'[102]) was developed for the Regional Forest Agreement process but is used in other reserve establishment processes for all ecosystems[vii]. The JANIS criteria set targets for the amount of each ecosystem that should be reserved in each bioregion (namely 15% of the pre-European extent, or 60% of the current extent for vulnerable ecosystems, and 100% of the current extent for rare and endangered ecosystems), although there is debate about the adequacy of current reserve criteria[103].

The proportion of bioregional EVCs meeting the 'JANIS criteria' and the percentage of the bioregion reserved is presented in Figure LB1.16. For 10 of Victoria's 28 bioregions, less than 20% of EVCs had met the reservation target. This in part reflects the high proportion of private land in these bioregions, the extent of vegetation loss and the consequent difficulties in reserve establishment. However, of these bioregions, the Strzelecki Ranges, Wimmera, Central Victoria Uplands and Goldfields all have significant areas of vegetated public land not in the reserve system. Bioregions with high proportions of vegetated public land generally had a higher proportion of EVCs meeting the reservation targets. In recent years, improvements in both numbers of EVCs meeting reservation criteria and in bioregional area reserved have been made in the Otway Ranges and Otway Plain[104], while an increase in the area of grassy ecosystems protected within the reserve system has resulted from a strategic land acquisition process[105,106,107,108].

vii For example, the Victorian Government's Terms of Reference to VEAC for the River Red Gum Forests Investigation.

Figure LB1.16 Percentage of ecological vegetation classes meeting nationally agreed reservation targets and proportion of bioregion reserved (includes EVC complexes and mosaics)
Source: Department of Sustainability and Environment, unpublished 2008; CAPAD 2006.



Recommendations

LB1.8 There should be an increased allocation of funds for large scale, ongoing, active management of the existing public land estate for biodiversity conservation as the return on investment is significant when the range of services provided is considered.

LB1.9 The Victorian Government should review the applicability and adequacy of current reservation targets in light of the threats posed by climate change and explore ways of ensuring that Victoria's reserve system is as resilient as possible to climate change.

LB1.10 The Victorian Government should strongly support the Commonwealth Government's program to build the National Reserve System, with a focus on under-reserved Victorian bioregions and EVCs.

Response name
BushTender

Responsible authority
Department of Sustainability and Environment

Response type
Process

BushTender is an example of a market-based instrument providing an incentive for the management of native vegetation, complementing the Native Vegetation Management Framework. Market-based instruments provide landholders with opportunities to derive alternative income streams from the provision of ecosystem services that are otherwise unvalued in the economy. BushTender is a tender-based scheme that addresses a market failure in relation to the value of native vegetation. Ecosystem services provided by high quality native vegetation represent public goods and there is little financial incentive for landholders to retain or improve native vegetation on their properties. Under BushTender, landholders establish a price for managing native vegetation on their properties and those tenders representing the best value (greatest level of ecosystem service for investment) are identified. The landholders selected enter into a vegetation management agreement with the Department of Sustainability and Environment and receive payment for vegetation management and improvement services that exceed the landholder's duty of care under the CaLP Act (see LB0 Introduction).

A trial of the BushTender scheme was undertaken in 2001 and showed that the tender process can be successfully used to establish native vegetation management agreements. Under this trial and a subsequent trial in 2003, 4,800 ha of native vegetation was secured under vegetation management agreements[109]. The scheme has now been expanded to cover approximately 13,000 ha over 262 properties. Approximately $2.3 million was offered for landholder payments in the 2007 bidding round and $1 million for the 2008 round. BushTender has been shown to be a cost-effective and flexible means of securing native vegetation management services[110] and can be targeted to landscapes and vegetation types of high priority or conservation significance.

A study of BushTender participants in 2006[111] indicated that the scheme successfully engaged a wide range of landholders and motivated participants to carry out complementary vegetation management activities that were outside the scope of their agreements. Very high levels of compliance with agreements were observed in the trials, indicating strong engagement of participants with the process.

As yet, the majority of BushTender agreements have not expired; however, strategies to ensure the biodiversity benefits gained during the term of the agreement are maintained and secured after the agreement expires do not seem to be in place[112]. Landholders with short-term vegetation management contracts may have the opportunity to bid for further contracts but there is no guarantee that funding will be available or that contracts will be renewed. This concern is also true of all other forms of Government assistance or incentive in the natural resource management arena.

The BushTender scheme has provided a positive template for other auction-based natural resource management schemes targeting multiple environmental outcomes in Victoria. The ecoMarkets initiative, funded under the Victorian Government's *Our Environment, Our Future Environmental Sustainability Action Statement*, is modelled on the BushTender scheme. The Victorian Government will invest $14 million over a four-year period in the ecoMarkets initiative to design and test efficient markets for ecosystem services arising from private land[113]. Demonstration-scale projects are currently in progress for EcoTender, a market-based project aimed at achieving multiple environmental benefits, such as biodiversity conservation, salinity control, improved river health and carbon sequestration, through management and restoration of native vegetation.

Response name
Trust for Nature

Responsible authority
Non-Government sector

Response type
Civic

Trust for Nature is a non-government organisation established under the *Victorian Conservation Trust Act 1972*. Trust for Nature targets conservation of vegetation remnants on privately owned land through mechanisms including the purchase of significant properties and assisting land owners to place permanent protection covenants over titles of properties that encompass significant vegetation. Trust for Nature has contributed 63 properties to the National Reserve System and actively manages a further 50 properties.

Achievements of the Trust for Nature include:

- permanently protecting 878 private properties (36,619 ha) through conservation covenants with landholders
- providing ongoing land management support to participating landholders through a stewardship program
- purchase and conservation of more than 100 properties including historic sites such as Ned's Corner, near Mildura
- development of a revolving fund to buy at-risk properties which are then re-sold with conservation covenants. With a starting capital in 1994 of $1 million from Trust funds and a Commonwealth Government grant of $1.4 million in 2000, 45 properties have been purchased and protected in this way and on-sold at a value of $5.1 million

Although already providing protection for over 80,000 ha of native vegetation across Victoria, the Trust aims to protect the 1 million ha of remaining native vegetation on private land in Victoria. The 80,000 ha currently protected comprises only 8% of this target.

Trust for Nature supports land owners with covenanted properties through a land stewardship program funded in part by the Commonwealth Government's Natural Heritage Trust and delivered through the CMAs. Current changes to NHT funding arrangements may have long-term implications for the delivery of this program.

Response Indicator LB8 Area and number of properties involved in private vegetation conservation mechanisms

A variety of voluntary conservation mechanisms exist in Victoria to protect areas of vegetation on private land. These range from permanent protection binding on the title of the land (Trust for Nature conservation covenants), fixed-term management agreements linked to financial incentives and specific agreed management actions (BushTender and related market-based schemes) to non-binding agreements (Land for Wildlife). Some of these mechanisms are long established while others are in the establishment phase. There is also a range of grants and rebate schemes available to encourage biodiversity conservation on private land.

Both the number of Trust for Nature conservation covenants and the area protected have risen dramatically over the past decade, and now protect some 36,000 ha on 878 properties (see Figures LB1.17, LB1.20). There are still disproportionate numbers of properties to the east of Melbourne and around Bendigo and Ballarat, but in under-reserved regions such as the Wimmera, Gippsland Plain, Goulburn-Broken Plains, and around Omeo, which had few covenants in the late 1990s[114], the number of covenants and area protected have increased.

The Trust for Nature also contributes to private land conservation through the 51 properties it owns totalling some 35,000 ha. In addition, the Trust for Nature manages a revolving fund, which is used to purchase properties of conservation significance. These properties are on-sold with a conservation covenant attached to the title.

More than 161,000 ha (approximately 1% of private land in Victoria) of native vegetation or wildlife habitat on 5,700 properties are managed for conservation under the Land for Wildlife program (see Figure LB1.20). There do not appear to be any major changes in distribution of properties since the late 1990s[115], where large clusters of small properties occur to the east of Melbourne, the Mornington and Bellarine Peninsulas and regional centres such as Ballarat and Bendigo (see Figure LB1.18). Land for Wildlife agreements have been taken up over much of the State where there is private land, with the exception of the north-west.

BushTender is an auction-based approach to improving the management of native vegetation on private land. BushTender is not yet a statewide program and has operated in particular areas of the State that are considered a high priority for increased protection of native vegetation. As such, the distribution of properties is currently concentrated in the north-east, south-west of Bendigo and on the Gippsland Plain and Victorian Volcanic Plain (see Figure LB1.19).

In an effort to better integrate the management of public and private conservation lands across the landscape, a number of conservation management networks (CMNs) have been established in high-priority, fragmented landscapes[116,117]. CMNs are currently operating on the Gippsland Plains, East Gippsland Rainforest, Broken-Boosey, Northern Plains, Wedderburn, Mid-Loddon and Whroo, in central Victoria.

Figure LB1.17 Location of Trust for Nature Conservation properties in Victoria
Source: Trust for Nature 2008.

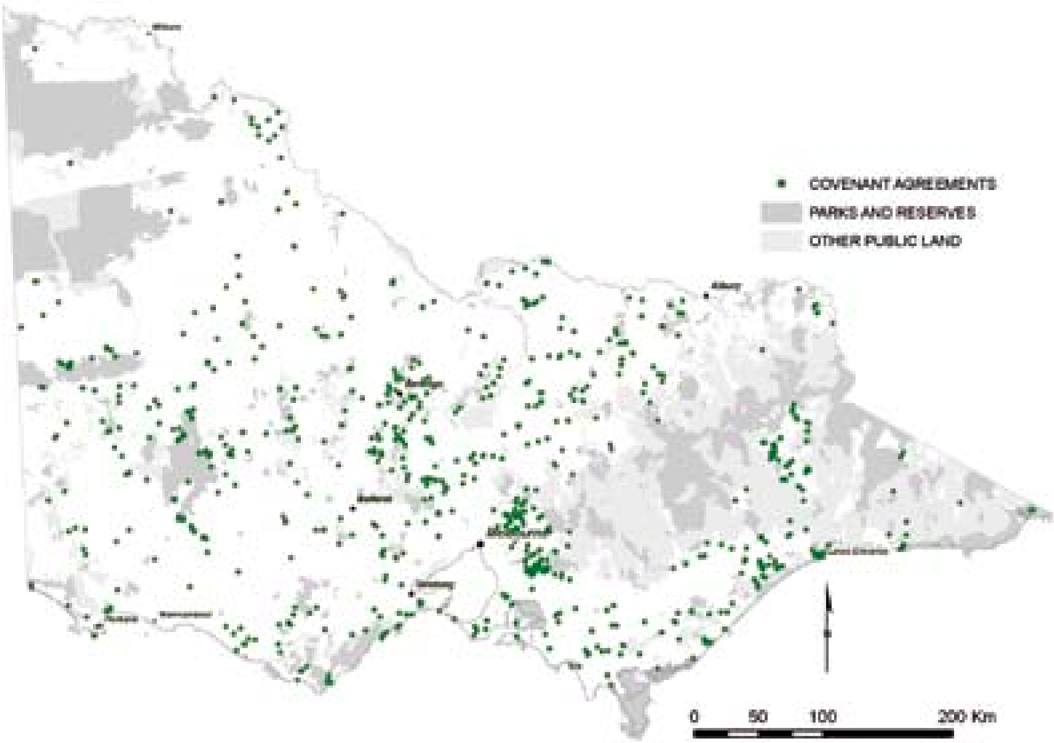
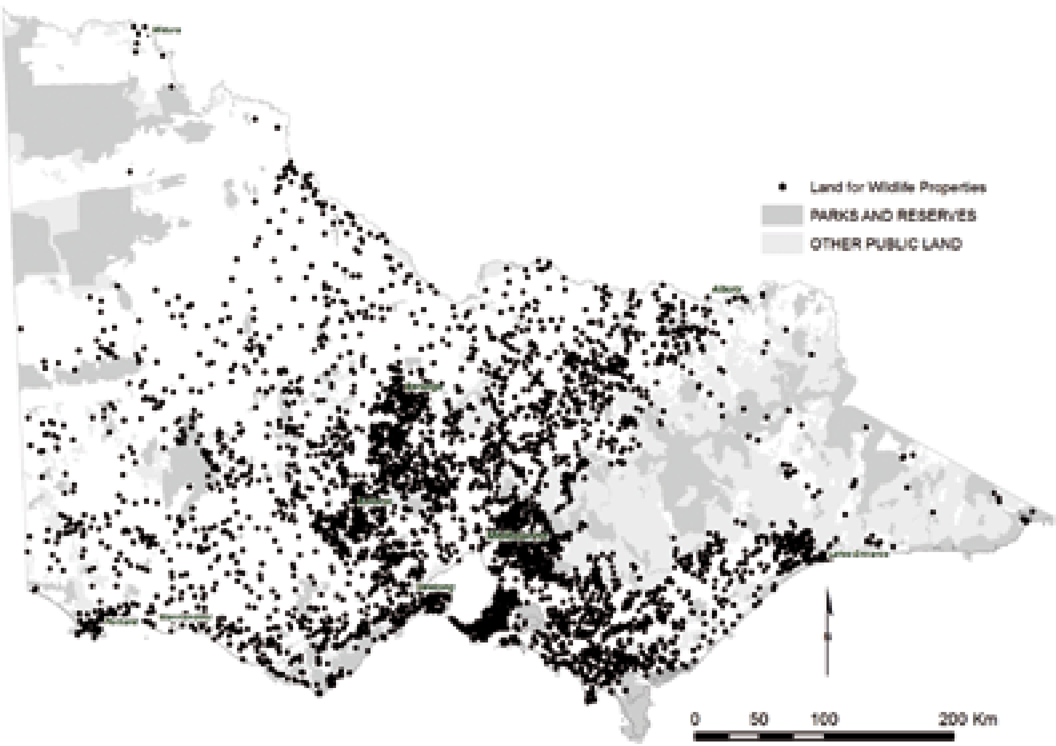


Figure LB1.18 Location of Land for Wildlife properties in Victoria[viii]
Source: Department of Sustainability and Environment 2007.



viii Land for Wildlife agreements cover 161,000 ha or approximately 1.1% of Victoria's private land.

Figure LB1.19 Location of BushTender properties in Victoria[ix]
Source: Department of Sustainability and Environment 2007.

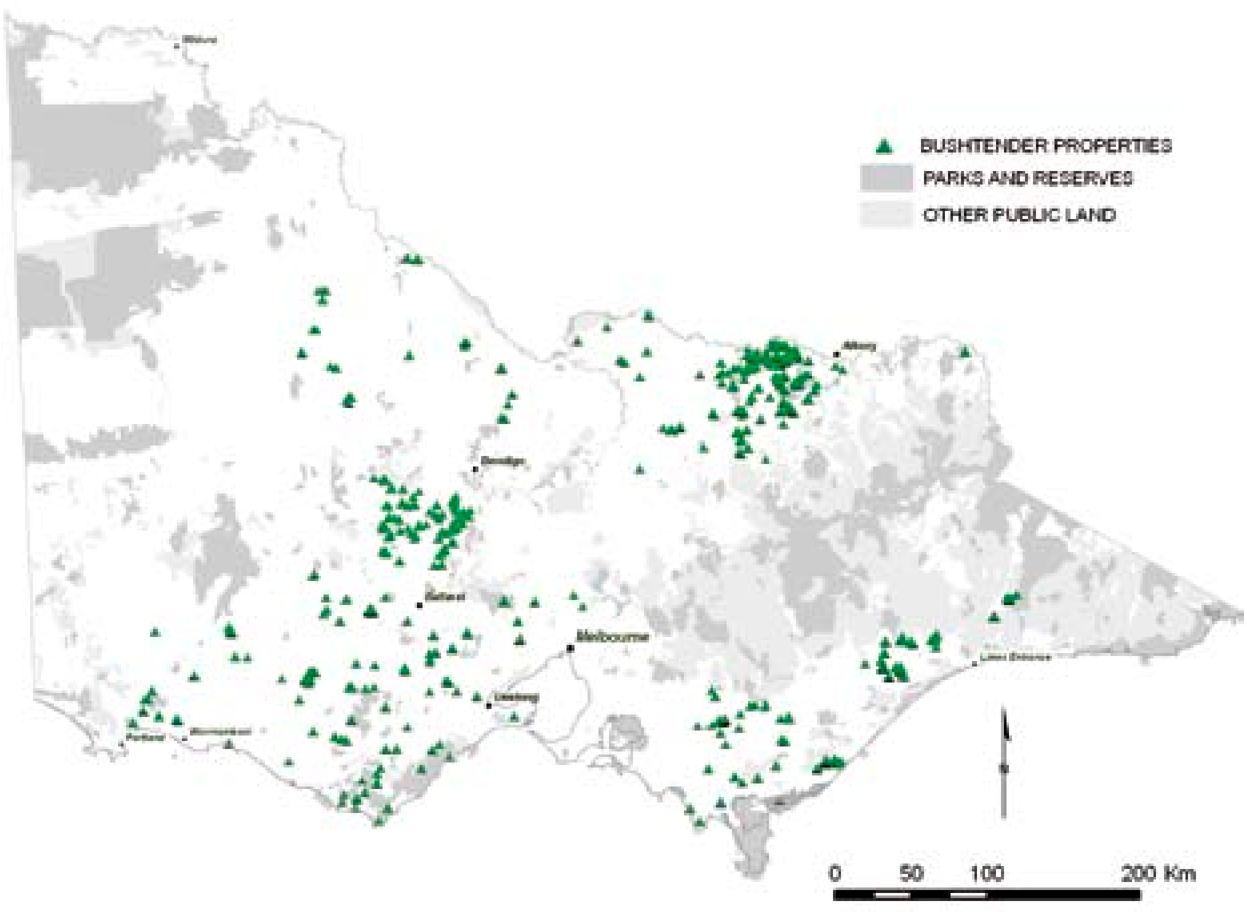
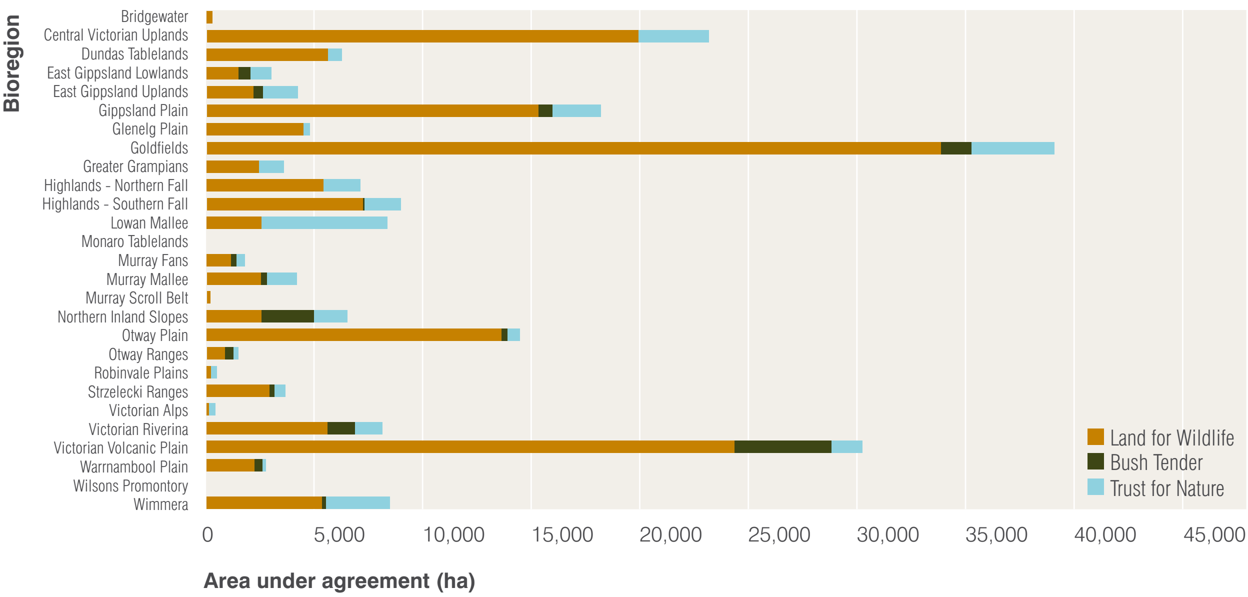


Figure LB1.20 Area of private land conservation agreements in Victoria
Source: Department of Sustainability and Environment 2007; Trust for Nature 2008.



ix The distribution of BushTender properties reflects the location of BushTender trials in north-east, north-central and southern Victoria.

Recommendations

LB1.11 There should be a significant increase in the allocation of funds for land acquisition to ensure that ecologically significant private land can be secured to address gaps in Victoria's reserve system. This could be achieved by making a contribution to the Trust for Nature's Revolving Fund. Funding should also be allocated for ongoing management of private land acquired for conservation purposes.

LB1.12 The Victorian Government should undertake a study evaluating the contributions of conservation on private land to biodiversity retention, and develop an integrated portfolio of strategies for improving the status of native vegetation and biodiversity on private land that targets a broad spectrum of private landholders. Such a portfolio could include: expansion of existing market-based instruments with mechanisms to ensure that vegetation remains protected beyond the life of management agreements; increased allocation of funding for acquisition and management of highly significant private land; and development of new tools to engage the full spectrum of landholders in native vegetation management, including Victoria's growing corporate farming sector.

Response Name
Our Forests, Our Future

Responsible Authority
Department of Sustainability and Environment

Response Type
Policy/strategy

The policy statement *Our Forests, Our Future* was announced in 2002 in response to a review of the sustainability of Victoria's forest industries and timber resources and produced a significant restructure of timber harvesting in Victoria.

Since implementation of the *Estimate of Sawlog Resources* and *Our Forests, Our Future* in 2002, the sustainable yield of timber has been reduced by approximately 40%, and a voluntary licence reduction program was implemented to reduce harvesting to the revised sustainable levels. New licensing arrangements have been implemented to increase flexibility and avoid over-commitment of timber resources. The Victorian Government provided $80 million to assist the timber industry and communities dependent on this industry to adjust to the lower volumes of timber available for harvest. Nevertheless, the commitment to honour existing licences meant that the revised sustainable yield was exceeded by almost 1 million cubic metres in 2002/2003.

A key component of *Our Forests, Our Future* was the establishment of VicForests as a State-owned entity responsible for commercial harvesting and supply of timber resources in order to separate the Government's previously conflicting roles of monopoly supplier of hardwood timber, regulator of forest industries and forest manager in Victoria.

Forest management outcomes are now reported every five years in the State of the Forests Report. The first State of the Forests Report was produced in 2003. The second report is due in 2008 and will assess progress against a set of criteria and indicators for sustainable forest management.

Evaluation of native vegetation responses

Victoria's approach to native vegetation has changed from broadscale clearing prior to the late 1980s to the widespread recognition of the value of native vegetation and an approach that encourages retention and restoration of native vegetation. Responses to the loss and degradation of native vegetation in Victoria in government and non-government sectors have succeeded in raising awareness of the issue and engaging a broad spectrum of Victorians in native vegetation management activities.

The *Native Vegetation Management Framework* introduced the concept of 'Net Gain' of vegetation and has led to innovations in vegetation monitoring and accounting. These procedural advances mean that Victoria should be well placed to identify and evaluate the responses of vegetation to future land management changes, as well as changes in vegetation resulting from climate change.

Despite the broad range of management responses and the wide coverage of voluntary conservation activities (see Response Indicator LB8 Area and number of properties involved in vegetation conservation), Victorian native vegetation remains highly fragmented over much of the State and is declining in quality. Native grasslands are of particular concern, as these are declining in both extent and quality.

For further information

Victoria's native vegetation management framework: www.dse.vic.gov.au/DSE/nrenlwm.nsf/LinkView/99ADB544789FE7D4CA2571270014671E49A37B2E66E4FD5E4A256DEA00250A3B

Native Vegetation Net Gain Accounting: First Approximation Report 2008: http://www.dse.vic.gov.au/DSE/nrence.nsf/LinkViewC9784DF5A0EEA928CA2574240018C12DB32D42FB223C7345CA25712B0007130A

Australia's National Reserve System: http://www.environment.gov.au/parks/nrs/index.html

Trust for nature: www.trustfornature.org.au

Land for Wildlife: www.dse.vic.gov.au/DSE/nrenpa.nsf/LinkView/34933B99F789EF0E4A25677800115944BA15AEEDADB3CA6C4A2567D600824A6C

ecoMarkets: www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/75AEDB6637D57294CA25739B000DAD857791A5F203C894104A2567CB00031088

Our Forests, Our Future: http://www.dse.vic.gov.au/dse/nrenfor.nsf/FID/-22A28C77A72588894A256B67000E0B85?OpenDocument

Photo: Kim Bege

LB2 Contemporary land use change

Key findings

- Victorian bioregions are under high levels of landscape stress and four of Australia's five most cleared bioregions occur in western Victoria. Climate change is producing and will continue to produce extreme pressure on land use and biodiversity.
- Victoria's land economy has traditionally been dominated by agriculture; however other land uses such as forestry and housing are driving change in some parts of Victoria. Water trading is driving the distribution of irrigation water towards highest value uses, which is producing significant land use change in irrigation areas. Land use change creates both threats and opportunities for biodiversity conservation.
- Victoria's population is expected to reach 6 million people by 2020, 10 years earlier than anticipated. The resulting growth of peri-urban and rural populations is driving land use changes and producing strong pressure on biodiversity.
- Housing density in Melbourne is low by global standards, producing demand for housing development at the urban fringes. Requirements of the planning system can work against the objectives of a more sustainable Melbourne, for example preventing increased housing density by limiting the number of dwellings permitted on a parcel of land.
- There is a trend towards greater corporate ownership and management of agricultural land in Victoria, and fewer family farms. New mechanisms for encouraging land stewardship among corporate land managers are required.
- Valuable information about environmental assets is gathered during catchment management activities but could be better integrated into strategic planning processes and statutory planning decisions. The barriers to integration of information between catchment planning and local land use planning are unclear and in need of further investigation.

Description

Land is a resource that is used in a variety of ways to provide products and services used by people, and which is valued for a range of purposes and uses. Use of land to provide some of these services has resulted in declines in the condition of land, water and biodiversity. For this reason, land use is a key driver of environmental change and is itself driven by a range of social, economic and environmental pressures.

Approximately 61% of Victorian land is privately owned and over 95% of this private land is farmed, producing food and fibre. This high level of private land ownership means that the outcomes of decisions about land use and management strongly influence the future condition of land and its capacity to provide essential products and services. Owing to variation across the State in climate, soil type and availability of water, Victoria is able to support a wide range of primary production activities.

Land use is strongly driven by social pressures through the property market, which drives land use towards those with the highest values (for example, housing in urban areas). New analysis of demographic and socio-economic trends in rural Victoria has identified three broad social landscapes for rural areas, in which the highest value land use varies[118]:

- Agricultural production landscapes are dominated by cropping and grazing activities and are likely to remain so due to low competition for land for purposes other than agriculture.
- Rural amenity landscapes in accessible rural areas with good views, moderate climate or near water are favoured for residential purposes and land commands high prices (see Part 2 Driving Forces, Figure DF3).
- Transition away from traditional wool production in response to the slow decline of this industry has produced diversification of land uses in the 'transition' landscapes, with a range of implications for land and biodiversity. Commodity prices have a significant influence on rural land use as farmers adjust output to maximise returns.

Availability of water is another key driver of change in agriculture and land use. The combination of prolonged dry periods, which are expected to become standard, and the establishment of a water market in the Murray–Darling Basin has produced an escalation in the price of water and the trading of water away from irrigated pastures (predominantly for dairy production) towards high-value horticulture. Because water shares can now be traded independently of land, water is being permanently transferred between regions[119], resulting in substantial land use change (for more information on water trading, including limits on trading water out of Victorian irrigation districts, see Part 3.2: Water Resources).

In addition, environmental and biological constraints affect the suitability of land for various purposes. Flat and fertile soils in western Victoria attracted early settlers to establish agriculture there, leaving the steep, forested mountainous areas in the east of the State relatively undisturbed. This broad difference in land use persists today and is manifested in the differences in the extent and condition of native vegetation (see section LB1 Vegetation loss and modification).

Changes in the condition of land, water and biodiversity resources can be both outcomes and drivers of land use. Impacts of previous land use and management practices on land and water resources limit the capacity of these resources to support future activities and to provide some essential ecosystem services. For example, secondary salinity, which has arisen from hydrological disturbance due to the widespread replacement of native vegetation with annual plant species, as well as inefficient irrigation practices, limits the ability of land to support further plant growth. This has necessitated a change in land use for salt-affected land, often from cropping to grazing from salt-tolerant vegetation. Efforts to address dryland salinity have also produced land use change in the form of commercial plantations and other large-scale tree plantings on land previously used for agricultural production.

Future shifts in Victoria's climate[120] are likely to produce unprecedented changes in the distribution of agricultural enterprises across the State[121]. Technological developments also play a role in land use, and the Victorian Government's recent decision to lift the moratorium on genetically modified canola may affect future land use as crop varieties with new capabilities are developed.

The environmental impacts of land use change may be unpredictable and unintended. Many of the environmental challenges currently facing Victoria are the products of past decisions about land use and land management. Outcomes of land use and land use change may be positive or negative for land and biodiversity and depend to a large extent on the management practices applied within any given land use. Land use change, therefore, may be seen as an opportunity to improve the condition of land and biodiversity through policies that encourage sustainable land use and management. Good land management practices and supportive government policy need to be in place for desirable environmental outcomes of land use to be achieved across all tenures.

The Victorian Government makes a substantial investment in natural resource management, which is often more than matched by community and individual investment[122]. A number of market-based instruments are being developed and implemented in an effort to create value and pay for the public benefits of ecosystem services on private land (see section LB2 Vegetation loss and modification). These schemes offer incentives for land holders to manage land for improved ecological outcomes by providing alternative income streams to primary production.

Objectives

- To ensure that future development and gains in profitability from land are not achieved at further cost to ecosystem services
- To manage land use such that impacts of climate change on ecosystem services are minimised

Links

See also: Part 2: Driving Forces; Land and Biodiversity – Salinity, Soil acidification, Impacts of climate change on land and biodiversity

Photo: Jane Tovey

State

Indicator LB9 Land use types in Victoria

Victoria's land is divided into public and private tenures (see Table LB2.1) with widely differing land use patterns and histories. Approximately 39% of Victoria (8.9 million ha) is public land[123], which is managed by State Government agencies. Public land is divided between parks and reserves, managed under the *National Parks Act 1975*, including 40 National Parks[124]; and land managed under the *Forests Act 1958* in State forests, water catchments and a small area of plantation forest. State forests are managed for multiple purposes including timber harvesting, conservation, recreation and water production.

The remaining 61% of Victoria (approximately 13.8 million ha) is privately owned and is predominantly used for agricultural production, including dryland cropping and grazing, and irrigated agriculture and horticulture. Agriculture occupies approximately 13.25 million ha[125], and dryland agriculture (rain-fed or unirrigated) is the dominant form of agriculture, accounting for over 92% of private land. Irrigated agriculture (mostly irrigated dairy pastures – see Part 3: Water Resources) and horticulture occupies less than 2% of Victoria but accounts for 74% of the water extracted for consumption in Victoria (see Part 3: Water Resources). Tree plantations on private land are locally important, but on a statewide scale constitute a minor land use, occupying approximately 1.8% of Victoria (see Table LB2.1).

Metropolitan Melbourne occupies approximately 210,000 ha and is dominated by residential (57%), industrial (9%) and parks and conservation (8%) land uses[126].

The distribution of major land uses over Victoria's CMA regions is shown in Table LB2.2.

Figure LB2.1 shows the approximate distribution of agricultural land uses in Victoria over the period 1999–2004. Dryland cropping and grazing mostly occupy the northern half of the State while grazing is dominant in the south, although cropping is becoming increasingly frequent in south-western Victoria. The major irrigation regions are in north central Victoria and along the Murray River in the north-west, with smaller locations in the north-east, Gippsland and south-western Victoria.

South-western Victoria, in particular, has undergone substantial changes in land use since the early 1990s. Traditionally dominated by grazing for wool production, extensive land use change from grazing to cropping, dairying and blue gum plantations has occurred[127] due to declining wool prices. Land use change continues in this area, with land under plantations, cropping and dairying continuing to expand, and increasing use of rural land for residential and 'lifestyle farming' purposes[128].

Table LB2.1 Major land use classes in Victoria
Source: Australian Bureau of Statistics Agricultural survey 2006/07; Australian Bureau of Statistics Water use on Australian Farms 2006/07; Bureau of Rural Sciences 2007; Department of Sustainability and Environment 2006, 2008; Parks Victoria 2007.

Tenure	Broad land use		Area (million ha)	Area (% of Victoria)
Public	State forest		3.18	14
	Parks and reserves		3.96	17.4
Private	Agriculture	Dryland	12.85	55.7
		Irrigated	0.4	1.9
	Plantation		0.4	1.8
	Melbourne		0.2	0.9
	Other (public and private)		1.9	8.3

Table LB2.2 Major land use classes in Victorian CMA regions
Source: Victorian Resources Online 2008

	Land use (% of CMA region)					
CMA region	Conservation and natural environments	Production from relatively natural environments	Production from dryland agriculture and plantations	Production from irrigated agriculture and plantations	Intensive uses	Water
East Gippsland	30	50	17	1	2	0.3
West Gippsland	17	27	45	4	5	2
North East	60	1	29	2	6	2
Goulburn Broken	13	20	51	10	4	2
Port Phillip & Westernport	18	12	46	3	20	1
North Central	8	6	67	11	6	2
Corangamite	9	15	64	0.4	8	4
Glenelg Hopkins	14	6	74	1	4	1
Mallee	33	8	53	2	3	1
Wimmera	14	5	75	0.5	4	2

Note: Land use is given according to Australian Land Use and Management classification. Conservation and natural environments includes National Parks and reserves. Production from relatively natural environments includes timber production from State forests and grazing from unmodified pastures.

Figure LB2.1 Major land use classes for private land in Victoria 1999–2004
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007

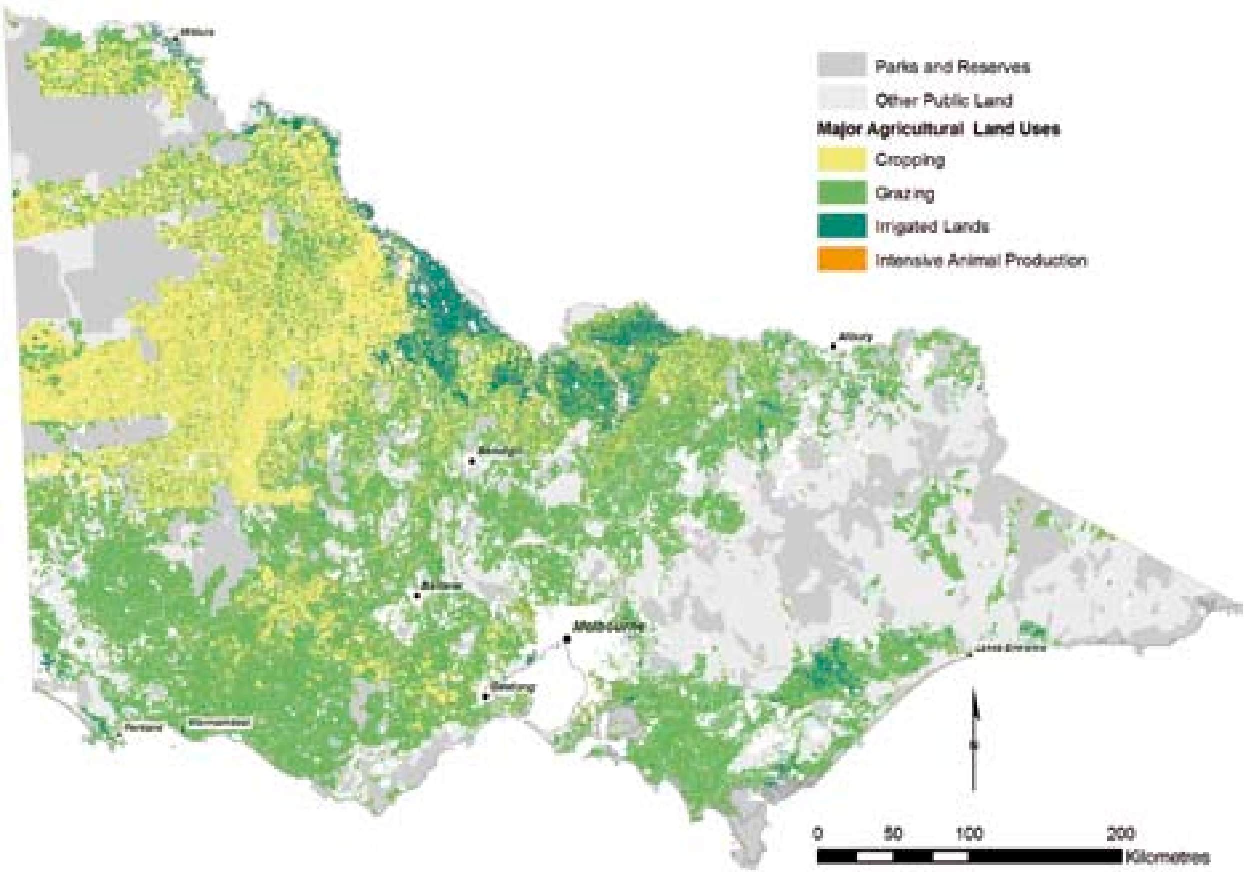
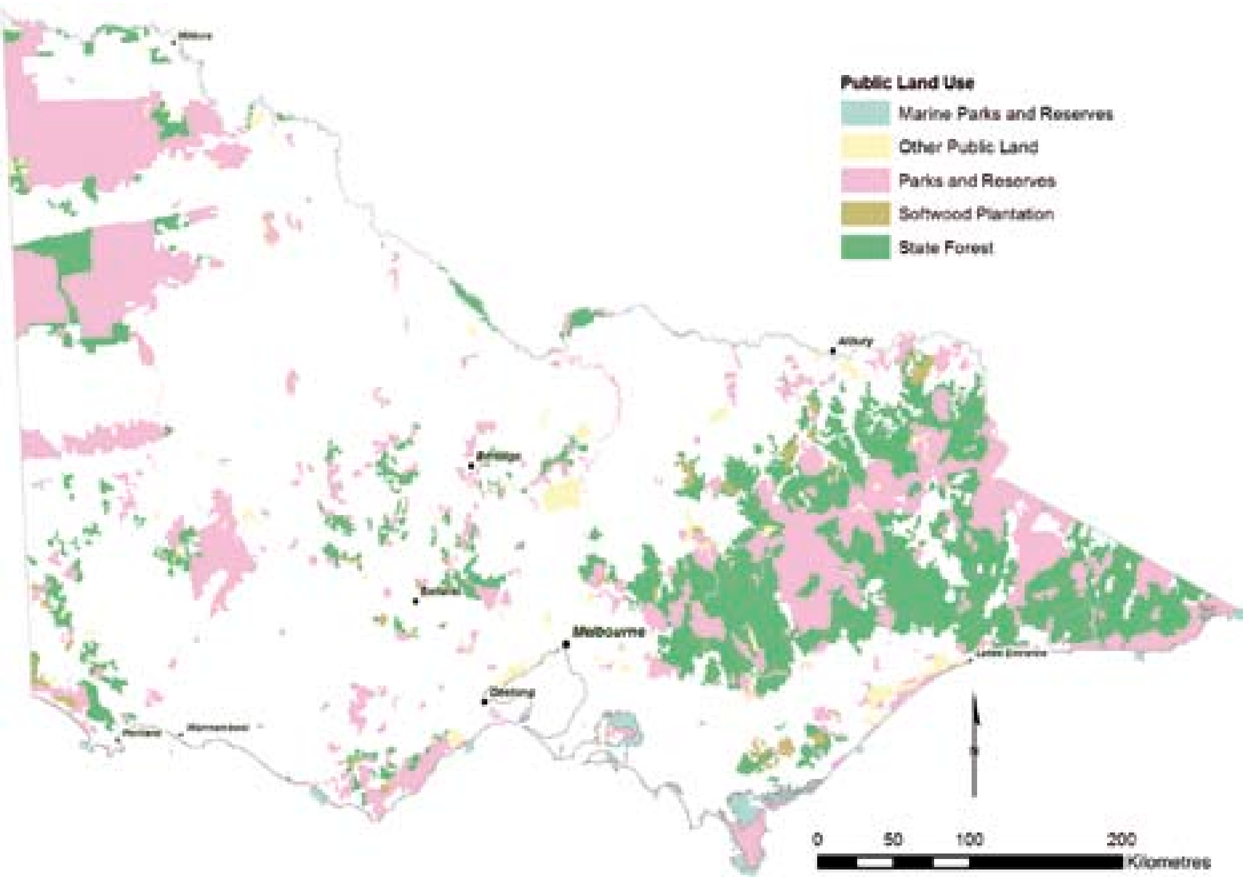


Figure LB2.2 Major land use classes for public land in Victoria
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007

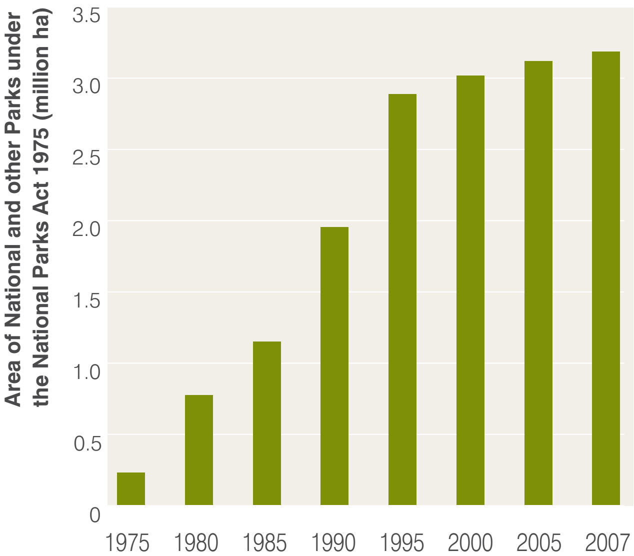


Land uses on Victoria's public land (see Figure LB2.2) include timber harvesting in State forest areas (see section LB1 Vegetation loss and modification, Indicator LB5 Area of native forest harvested), plantation timber, water catchment and storage, and recreational use. These uses are not necessarily mutually exclusive and land may be put to multiple uses.

Approximately 37% of Victoria's public land is managed under the provisions of the *National Parks Act 1975*[129]. The area of land managed as National and other parks under the *National Parks Act 1975* has increased from 227,000 ha in 1975 to 3.3 million ha in 2007 (see Figure LB2.3). The most significant recent addition to the National Parks estate is 60,000 ha within the Great Otway National Park in 2005. This area was converted from State forest and other crown land during the phasing-out of timber harvesting in the Otway Ranges. The total area managed for conservation by Parks Victoria is 3.96 million ha or approximately 17% of Victoria[130].

Figure LB2.3 Area of National and other Parks managed under the provisions of the National Parks Act 1975

Source: National Parks Act Annual Reports 1975–2007



Indicator LB10 Changes in major land uses in Victoria

Comparison of land use data collected for the Australian Natural Resource Atlas for the mid–late 1990s with the most current land use data (derived from Figures LB2.1, LB2.2) indicates that changes in broad land use classes in Victoria over the last decade have been minor. There have been no major changes in the balance between public and private land over this period and at the statewide scale there has been little change in areas used for conservation, forestry, dryland agriculture and irrigated agriculture (see Table LB2.3). The changes in conservation and forestry areas represent the transfer of State forest areas to nature conservation reserves as timber harvesting licences expire or are surrendered. The reduction in irrigated area reflects current low water availability.

The key trends in land use with implications for land and biodiversity, however, have been finer-scale and regionally localised changes within broad land use classes. For example, transitions have occurred between grazing, cropping and timber plantations. Movement of irrigation water between regions and enterprises has resulted in increases in the area of high-value horticulture and reductions in irrigated pasture area. Transition from commercial agriculture to 'lifestyle' farming and other land management objectives has taken place in some regions. For a more detailed discussion of these land-use transitions, see Indicator LB12 Ratio of production value to land value. Increases in urbanisation have been relatively small in area at the statewide scale, but can have large impacts on biodiversity, water use and landscape function.

Table LB2.3 Changes in land use in Victoria

Source: [1]Australian Natural Resource Atlas; [2]Parks Victoria 2007; Department of Sustainability and Environment 2007; Bureau of Rural Sciences 2007; Australian Bureau of Statistics 2008.

Land use	Area (million ha) 1996/97[1]	Area (million ha) 2007[2]
Conservation	3.4	3.96
Forestry	3.9	3.18
Plantation	Not collected	0.4
Dryland agriculture	13.2	12.85
Irrigated agriculture	0.6	0.4

Pressures

Urbanisation

In 2004 it was estimated that Victoria's population would exceed 6.2 million by 2030[131]; however, more recent projections indicate that Victoria's population could reach 6.5–6.9 million by 2026[132]. Nearly 75% of Victoria's population lives in metropolitan Melbourne[133].

The important urban growth trends producing pressure on land and biodiversity are a rapidly growing population[134] and a declining number of residents per household (see Part 2: Driving Forces – Population growth and settlements; Part 3: Materials). This combination of larger population and fewer residents per household, along with a relatively low density of housing[135] (also see Part 2: Driving Forces – Population growth and settlements), has driven a demand for land for housing in metropolitan Melbourne and its peri-urban areas. The greatest increases in population between 2001 and 2006 have been in the inner Melbourne area and in the outer suburbs to the west and south-east of Melbourne[136].

Urban and peri-urban areas are often of high value for biodiversity because cities are typically located in areas of high rainfall and soil fertility. Forty per cent of threatened ecological communities[137] and 50% of threatened species populations in Australia occur in urban fringe areas[138], and rapidly increasing rates of urbanisation are considered to pose one of the greatest threats to the biodiversity values of urban fringe areas. Although urban vegetation is highly fragmented because of past development, it contains the last remaining examples of many vegetation types and is thus significant for conservation. Some of the key processes threatening native vegetation as a result of urban development are[139]:

- drainage and land reclamation – loss of wetlands, loss of saltmarsh and mangroves, loss of seagrass beds
- clearing of land for development, roads, quarrying and fire control
- transformation of water courses
- introduction of weeds and deterioration of remnant vegetation
- disposal of waste, sewage treatment, drainage and stormwater
- traffic and road construction
- recreational use of the environment – weeds and plant diseases can be spread by recreational activities
- salinisation from clearing of recharge areas and run-off from cleared land
- fire suppression.

Box LB2.1 Peri-urban growth in the corridor between Melbourne and Bendigo

The impacts of peri-urban development on biodiversity in the Bendigo regional corridor, which extends north-west of Melbourne along the Calder Highway, have been studied in detail[140]. The study showed significant loss of vegetation in this growth corridor between 1989, when native vegetation clearing controls were introduced, and 2005. Gains in vegetation over the study period, which were concentrated in the least depleted vegetation types, were insufficient to offset losses. Of greatest concern was the loss of areas of native grassland, which is Victoria's most depleted vegetation type (see section LB1 Vegetation loss and modification, Box LB1.1). The remnants of this once-dominant plant community are threatened by urban and peri-urban development on Melbourne's western fringe.

The rapid depletion of significant vegetation in the Bendigo region is due in part to poor alignment between planning zones and the biodiversity value of vegetation. Much of the land zoned for conservation purposes in this region supports vegetation types classified as 'of least concern' – that is, not rare or endangered – while threatened vegetation types occur largely outside of land zoned specifically for conservation purposes. Threatened vegetation in the study area was rarely covered by the Vegetation Protection Overlay, a planning scheme tool that can be used by local governments to provide additional protection to significant vegetation[141].

Rapid loss of significant vegetation due to development in the Bendigo corridor illustrates that despite the range of tools available within the Victorian planning system for supporting the State's native vegetation and biodiversity objectives, shortcomings in the implementation of these tools can result in loss of significant vegetation. The native vegetation plans developed by CMAs and the planning scheme tools used by local governments to direct land use change should more directly support one another to ensure that land supporting significant vegetation is adequately protected from the impacts of land use change.

Continued urban growth creates additional pressure on already depleted vegetation communities unless the vegetation is adequately protected by planning schemes, which dictate the types of development that may be carried out (see Box LB2.1). Precinct Structure Plans being developed for Melbourne's growth areas also incorporate biodiversity considerations.

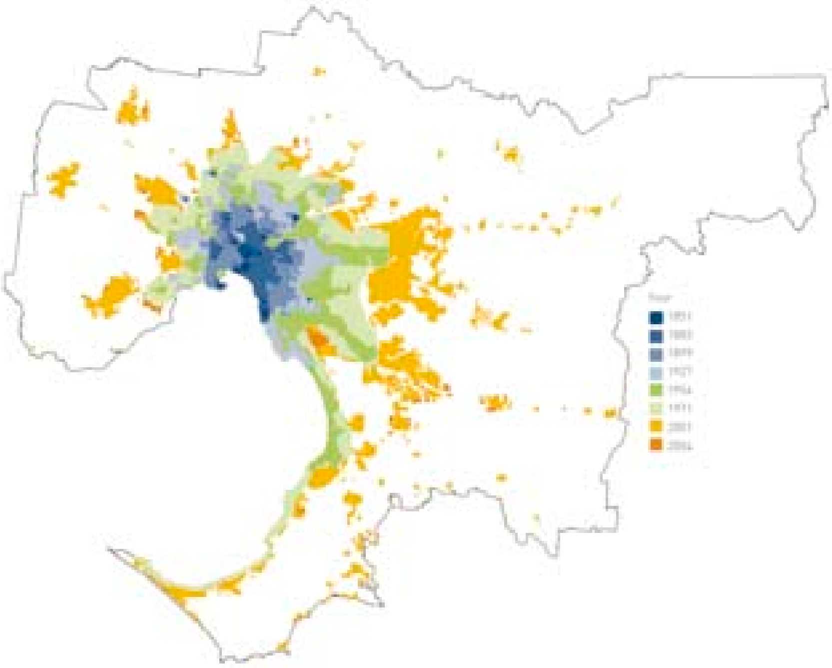
Indicator LB11 Urbanised area of Melbourne

Since 1851 Melbourne has grown from a settlement of approximately 1,400 ha to a city with an urbanised area of 210,000 ha by 2004. The expansion of metropolitan Melbourne over this period is shown in Figure LB2.4. The metropolitan area approximately doubled in size between 1971 and 2004. Melbourne's urban growth has essentially radiated out from the city centre along growth corridors defined in the *Melbourne 2030* growth plan[142] (see Part 2: Driving Forces – Population growth and settlements). Growth areas are located at Casey–Cardinia, Whittlesea, Hume, Melton–Caroline Springs and Wyndham. The urban growth boundary (UGB) will be maintained and future changes will be considered on the basis of updated forecasts, the development capacity of existing urban areas, longer-term urban growth issues (including future economic and employment opportunities) and transport investment requirements. Changes to the UGB in growth areas need to be consistent with Melbourne 2030 planning principles.

The UGB has been expanded on several occasions, most notably in December 2003, when 1,610 ha were added to growth corridors to provide industrial and residential land, and in November 2005, when the growth corridors were expanded by 11,132 ha[143].

One of the key objectives of the *Melbourne 2030* growth plan is to constrain the expansion of Melbourne, thus limiting the impacts of development on biodiversity by increasing housing densities in existing activity centres[144]. The market is yet to respond to this objective[145] and, in fact, elements of the planning system can work against the achievement of this objective. For example, some centres have limited capacity to accommodate increased densities due to heritage or character constraints and restrictive covenants[146].

Figure LB2.4 Expansion of Melbourne's urban area 1851–2004.
The outer boundary of this map shows the boundaries of the metropolitan Melbourne Victorian local government areas considered to be urban
Source: Map – Melbourne Atlas 2005; Data – Department of Infrastructure, Department of Sustainability and Environment.



Recommendation

LB2.1 The impact of urban and peri-urban development on remnant vegetation should be minimised. This could be achieved by developing a biodiversity management strategy to be applied to a planning scheme for urban and peri-urban areas. The development of such a strategy could arise from the current review of Victoria's Biodiversity Strategy.

Rural and peri-urban development

Land use may change in response to social, economic and environmental pressures reflecting the various products and services that society as a whole desires from land resources.

A key land use trend currently occurring in Victoria is the migration of populations from urban centres to rural and coastal areas (see also Part 2: Driving Forces – Population growth and settlements; Part 4.4: Coasts, Estuaries and the Sea). Migration to rural areas in Victoria is occurring particularly in the areas surrounding Melbourne that are within a two-hour drive of the metropolitan area[147,148]. These areas fall within the rural amenity landscapes identified by the Department of Primary Industries[149] and the Green Wedges as identified in *Melbourne 2030*[150].

The growth of urban populations, the search for affordable housing and increasing affluence[151], as well as the extensions of the UGB, have stimulated a growing interest among urban Australians in buying rural land. Land that may have once been most highly valued as an agricultural resource may now be more highly valued as a lifestyle property for its scenic and amenity attributes. The result of this trend has been an escalation in land prices in some parts of Victoria.

Competition for land for non-farming purposes decreases the capacity of farmers to increase productivity by acquiring more land. Reduced availability of productive land in some areas is contributing to the movement of agricultural production towards more intensive operations, which can have both positive and negative implications for the environment, depending on the land management practices adopted (see Indicators LB13 Area sown to crops and pastures, LB14 Area irrigated, LB15 Area of plantations on private land).

Indicator LB12 Ratio of land value to production value

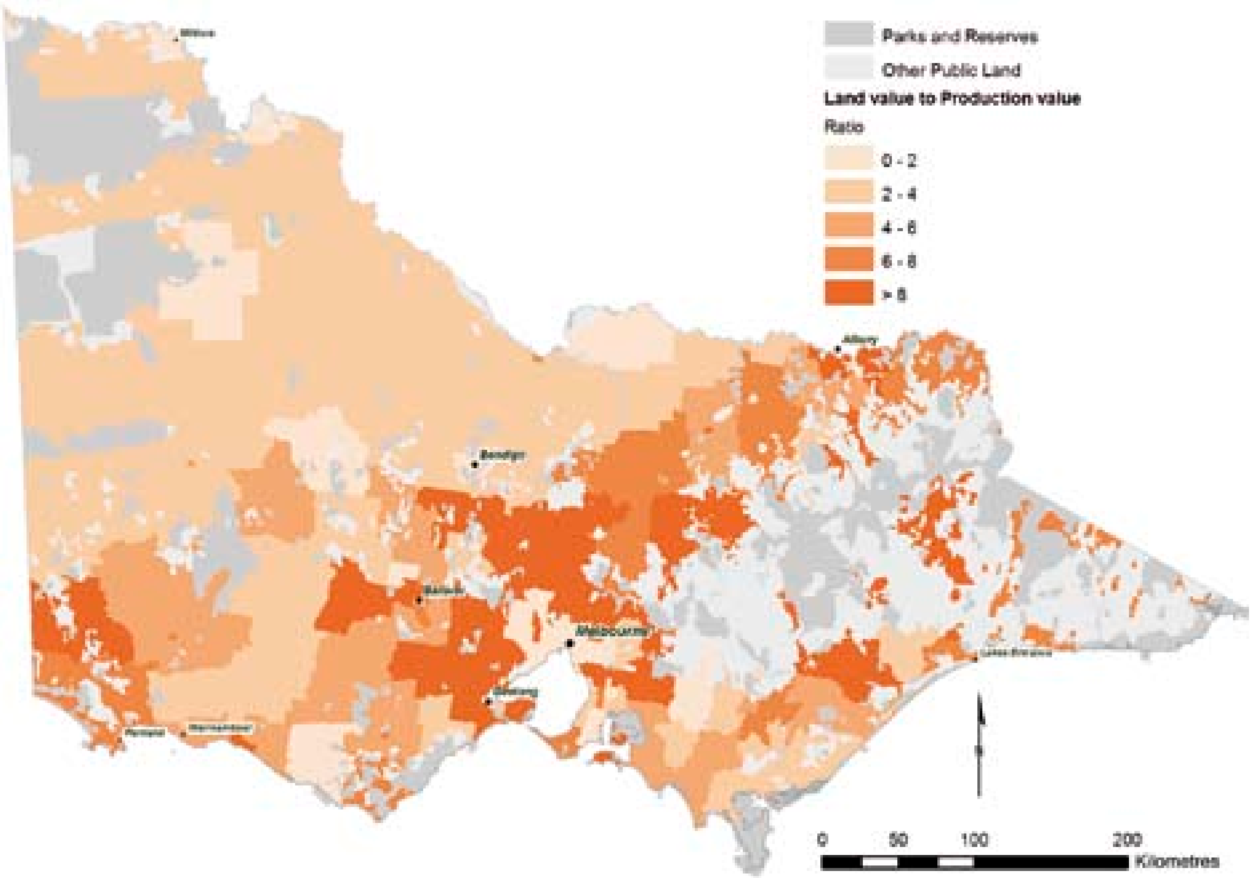
Due to the impact of demand for land on land price, the ratio between the market value of land and the value of commodities produced from it reflects the demand for land for non-agricultural purposes. Higher values of this ratio indicate that land is being sought for high-value uses such as housing, and that a transition away from traditional agriculture may be in progress. These transitions can have environmental implications. Figure LB 2.5 shows the areas in which there is demand for land for purposes other than agriculture and the areas in which there is little market pressure on agricultural land use.

Much of Victoria has a relatively low ratio (four or less) of land value to production value (see Figure LB2.5), meaning that there is low demand for non-agricultural land uses. The areas exhibiting these low values are the western part of the State, where dryland cropping and grazing activities predominate, the north-central irrigation areas and some parts of west Gippsland. Environmental pressures in these areas are likely to relate to farmers' efforts to raise farm productivity, rather than to residential development.

Higher values of the ratio of land value to production value occur in the areas surrounding Melbourne and the large regional centres of Ballarat and Bendigo, and along the corridors created through north-eastern and central Victoria by the Hume and Calder Highways. These areas are within reach of the facilities offered by Melbourne and the regional centres but provide advantages of rural living, such as lower population density. These regions roughly coincide with those that have experienced and are predicted to experience[152] strong population growth (see also Part 2: Driving Forces – Population growth and settlements). Environmental pressures in these areas are likely to be associated with increasing population density and development (see Part 2: Driving Forces; section LB2 Contemporary land use change; Rural and peri-urban development).

Land values in south-western Victoria are relatively high, but this is largely due to demand for land for private blue gum plantations. Demand for land for plantations has also contributed to higher land prices in north-eastern Victoria.

Figure LB2.5 Ratio of land value and production value analysed at Statistical Local Area scale for Victoria 2001
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007



Intensification of agriculture

Intensification of agriculture means increasing land productivity through increasing inputs, such as fertiliser, water and energy (used for cultivation). Examples of agricultural intensification include the replacement of native grasslands with sown pasture and crops (see Figure LB2.6a), increases in the proportion of farms sown to crops (see Figure LB2.6b) and expansion of irrigated areas (see Figure LB2.7). Victorian agricultural productivity has increased, but this has been achieved by increasing the use of fertiliser, water and cultivation. These inputs, if not managed appropriately, can fundamentally change the local land form, nutrient balance, and hydrological and ecological processes.

The fertiliser and fuel inputs that have supported the intensification of Victorian agriculture have traditionally been low-cost inputs. However, the rising cost of fuel and the greenhouse gas emissions (nitrous oxide) that arise from nitrogenous fertilisers (see section LB9 Impacts of climate change on land and biodiversity) make continued reliance on these inputs for productivity gains unsustainable.

The Australian Agriculture Assessment in 2001[153] identified significant increases in the intensity of agricultural production throughout Victoria and across southern and eastern Australia. Continued intensification of agriculture will exert pressure on soil and water resources in Victoria if inputs are not balanced with the capacity of the production system to utilise them.

Because of the changes that they bring to landscape and ecosystem function, cropping, pasture improvement and irrigation are examples of significant intensification pressures in Victorian agriculture with potential to degrade land and biodiversity resources. The areas of Victoria irrigated and sown to crop have increased substantially in the last decade. Increasing areas of hardwood timber plantations (see Figure LB2.9) also constitutes a significant intensification of land use.

Indicator LB13 Area sown to crops and pastures

The area of Victoria sown to crops increased by 85% between 1990 and 2005 (see Figure LB2.6a). The intensity of cropping in Victoria (proportion of farm holdings sown to crops) increased by two-thirds (see Figure LB2.6b) over the same period. The area sown to crops declined from 3.6 million ha in 2005 to 3.25 million ha in 2006, presumably because of below-average rainfall, but recovered to 3.4 million ha in 2007. The diversity of crops sown has also increased over this period, with the introduction of grain legumes into crop rotations and the development of new plant varieties and farming technology that has facilitated the expansion of cropping into areas of Victoria not previously suitable for cropping.

Figure LB2.6a also illustrates the rapid change from native grassland to sown pastures from the early 20th century. Sown pastures (usually a mix of non-native grasses and legume plants) require inputs of phosphorus and the legume plants add nitrogen to the soil. These nutrient inputs produce unfavourable conditions for native vegetation, especially grasslands, which are adapted to very low-nutrient conditions.

Figure LB2.6 (a) Changes in area of land sown to crops and pastures in Victoria since 1840 (b) Increases in cropping intensity in Victoria since 1990[x]

Source: (a) Australian Bureau of Statistics Victorian Year Book 2002; Australian Bureau of Statistics Agricultural Commodities (b) ABS Agricultural census and surveys

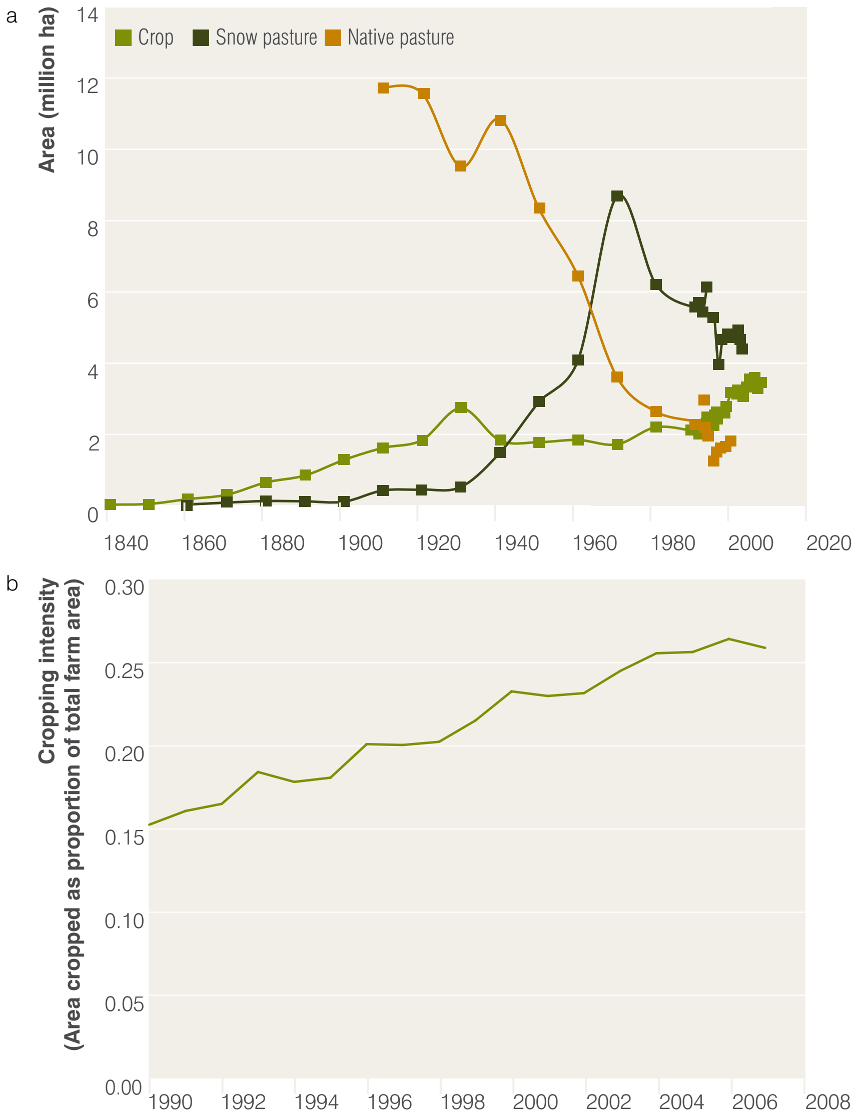
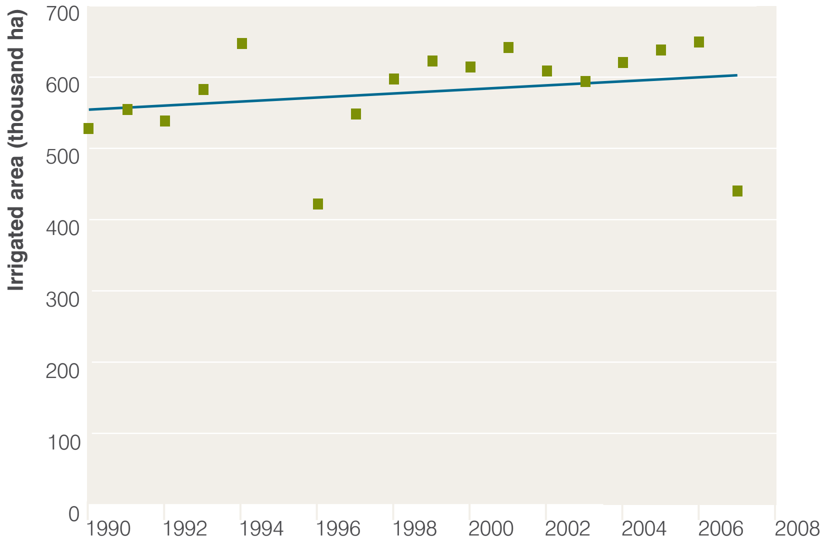


Figure LB2.7 Area irrigated in Victoria 1990–2005

Source: Australian Bureau of Statistics Agricultural census; Agricultural survey; Australian Bureau of Statistics Australian Water Account; Australian Bureau of Statistics Water use on Australian Farms



Indicator LB14 Area irrigated

Irrigation in Victoria is typically associated with high-value fruit and vegetable crops, viticulture and the dairy industry. Irrigated horticulture and agriculture generates $9 billion in production annually (see Part 3.2: Water Resources). Irrigated agriculture is concentrated in the north central irrigation area and along the Murray River in north-western Victoria (see Figure LB2.1; see also Part 3.2: Water Resources). An irrigated horticulture industry based on centre-pivot irrigation is also developing in the western Wimmera region.

Between 1990 and 2006 the area irrigated or potentially irrigated (the area actually irrigated varies depending on local rainfall and allocation of irrigation water) in Victoria increased from 526,417 ha to 648,000 ha (see Figure LB2.7). The reason for the relatively small area irrigated in 1996 is not known. However, in 2007 the area irrigated declined dramatically in response to low water availability. Continuing pressures on water availability may signal a downward trend in the area of land irrigated in Victoria, although this may be offset to some extent by the adoption of more efficient irrigation methods.

The area of irrigated crops in the Sunraysia district in north-western Victoria increased by 42% in the period 1997–2006[154]. This increase has been enabled by trading of water from irrigated pastures in other regions to higher-value horticulture[155].

Irrigation in Victoria's northern irrigation region has contributed to severe salinisation of land and water by disturbing hydrology, mobilising stored salt and reducing river flows.

New irrigation areas in the western Wimmera, based on centre-pivot irrigation sprinklers[xi], have developed since the late 1980s. This form of irrigation not only has implications for hydrology and nutrient flows, but also requires clearing of all tall vegetation within the sweep of the sprinkler boom. Clearing paddock trees to accommodate centre-pivot irrigation has had significant biodiversity impacts[156] (see Box LB2.2).

x The total farmed area in Victoria has declined from about 16.7 million ha to approximately 13.25 million ha since 1940.

xi Centre-pivot irrigation uses a large sprinkler boom rotating about a central point to deliver water to crops.

Box LB2.2 Ongoing loss of habitat for 'Karak', the Red-tailed Black Cockatoo, due to intensification of agriculture in the Wimmera

Since the early 1980s, land use in the western Wimmera has shifted from one of grazing and dryland cropping towards centre-pivot irrigation. The increase in centre-pivot areas has accelerated rates of paddock tree loss within the region[157]. The total area affected by centre pivots in five representative landscapes increased from zero in 1980 to nearly 9,000 ha by 2005 (see Figure LB2.8).

Pivots were more likely to be established in areas that had originally been plains savannah and woodlands containing Buloke (*Allocasuarina luehmannii*), a crucial food source for the endangered south-eastern Red-tailed Black Cockatoo (*Calyptorhynchus banksii*), the mascot for the 2006 Melbourne Commonwealth Games.

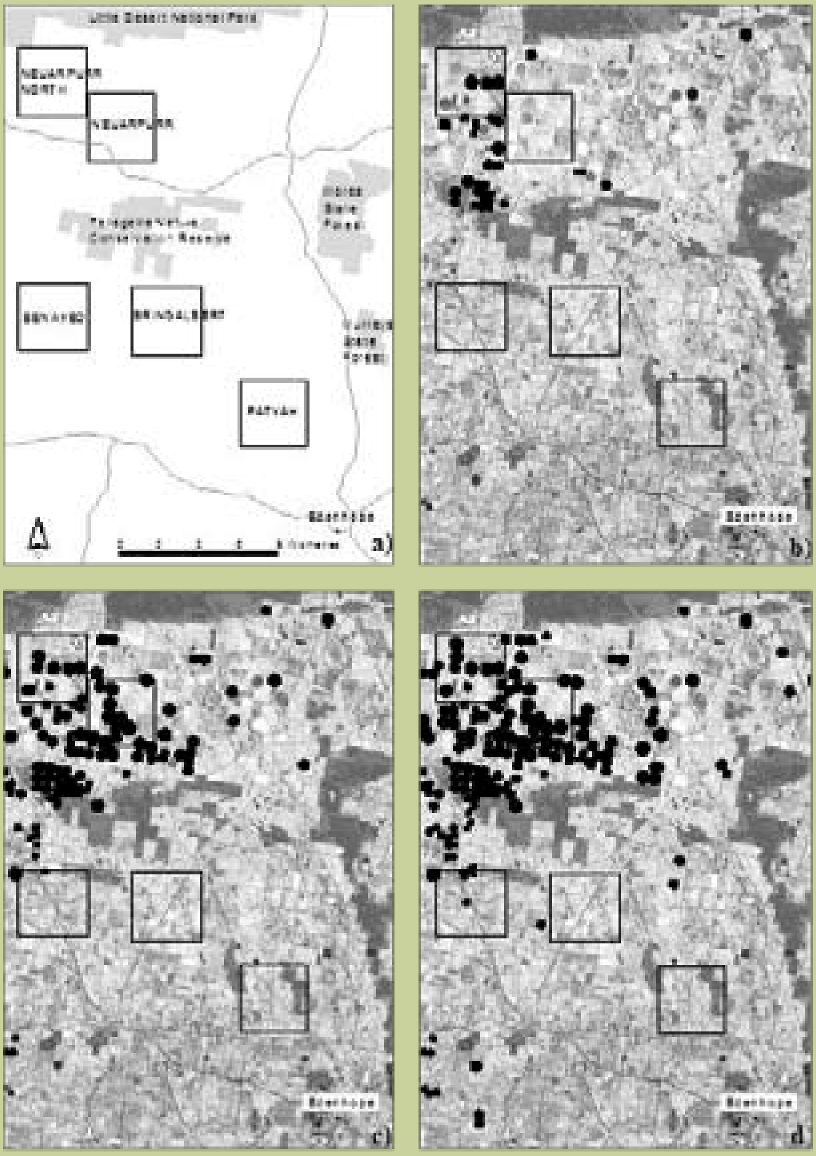
On average, 42% of paddock Buloke trees present in 1982 had been lost by 2005. In the two landscapes containing several centre pivots (Neuarpurr and Neuarpurr North), the loss was 54% and 70%. Substantially higher annual rates of tree clearing occurred between 1997 and 2005 than in the 15 years prior to 1997[158,159]. This occurred despite native vegetation clearing controls being in place since 1989. More recent policy intended to provide some protection for paddock trees was introduced in 2002, and in 2004 the Victorian Planning Provisions were amended to remove the planning permit exemption for removing vegetation to establish a centre-pivot irrigation system. These measures have not prevented the loss of mature Buloke trees from the western Wimmera. This accelerated loss of important components of rural vegetation is likely to result in species declines and local extinctions.

Continuing growth of centre-pivot irrigation is likely to result in markedly changed rural landscapes, with the removal of the majority of woody native vegetation from agricultural land in areas where centre-pivot irrigation is established. It is estimated that if the 3% annual rate of loss detected over the eight years to 2005 continues, paddock trees will be absent from the area within approximately 25 years.

Victorian native vegetation legislation does not adequately provide for the loss of rural vegetation through intensification, yet this is a major threat to biodiversity.

Figure LB2.8 (a) Location of focal landscapes and distribution of areas affected by centre pivot irrigation in the west Wimmera in (b) 1993, (c) 2000 and (d) 2005 (note 2001 SPOT satellite imagery used as background). Pivot areas are represented as black circles

Source: Maron and Fitzsimons 2007



Recommendation

LB2.2 The Victorian Government should investigate options for preventing the loss of significant elements of rural vegetation, including mature paddock trees.

Indicator LB15 Area of plantation forestry on private land

Victoria's plantation estate currently stands at 411,876 ha[160] (approximately 1.7% of Victoria), comprised mainly of native hardwood (mostly *Eucalyptus*) species (46%) and exotic softwood species (usually Radiata pine [*Pinus radiata*]; 53%). The substantial increase in area of plantations since 1995 (approximately 52%) has been largely driven by managed investment schemes and tax incentives for investment in plantations. Privately owned plantations on land previously cleared for agriculture comprise most of this development and all new plantings in 2007 were on private land[161].

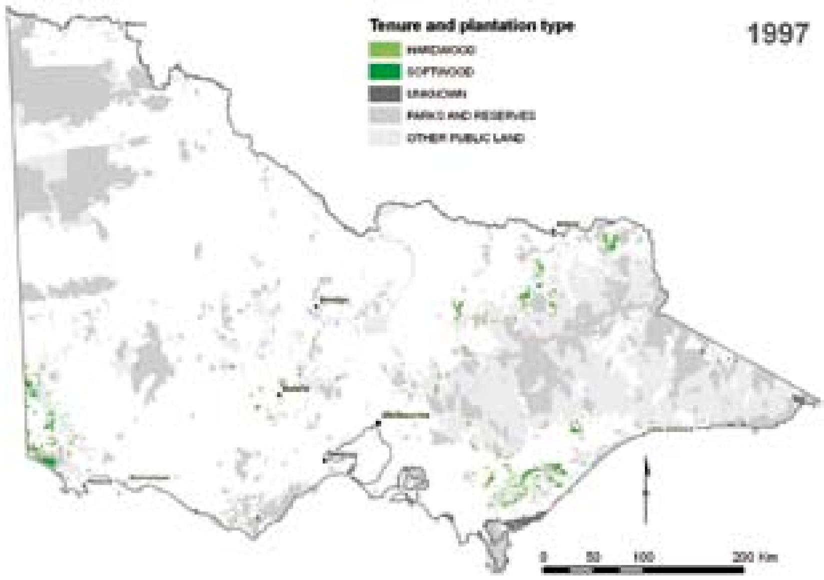
Ninety per cent of the increase in plantation area since 1995 has been hardwood plantation. Over 10,000 ha of new, privately owned hardwood plantation were established in Victoria in 2006. Rapid growth in plantation area has occurred mainly in south-western and north-eastern Victoria (see Figure LB2.9) and is an important change in land use in these regions.

Plantations are established for multiple reasons, including salinity mitigation and managed investment; however, the impacts of plantations on biodiversity, landscape function and catchment water yield vary substantially depending on the composition, age and management of the plantation and its size and location in the catchment[162].

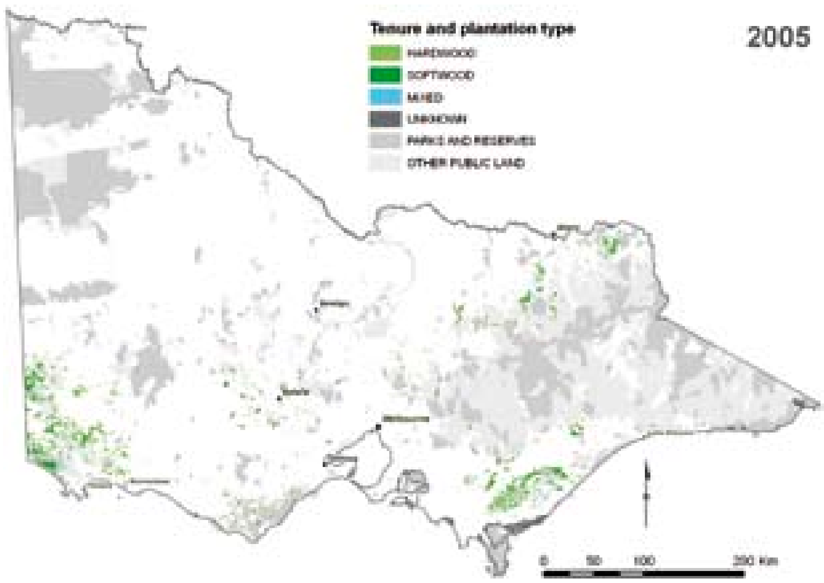
Establishment of timber plantations is expected to continue in response to growing demands for timber and paper products as well as in response to demand for carbon offsets as a means of climate change mitigation. Victoria does not yet have a formal carbon market, but a national system for trading carbon emissions is planned for 2010[163]. Sequestration of carbon in vegetation (biosequestration) is a readily available means of offsetting carbon emissions. Many Australian providers of voluntary carbon offsets currently use plantations as a source of offsets[164] and some providers offer multiple-species plantings with the aim of maximising biodiversity benefits from carbon-offset plantations; for example, the 'Breathe Easy' program provided by Greening Australia.

Figure LB2.9 Distribution of plantation types in Victoria in (a) 1997, (b) 2005
Source: National Plantation Inventory, Bureau of Rural Sciences

(a)



(b)



Recommendation

LB2.3 The Victorian Government should investigate policy options to ensure that investment in carbon offsets provides maximum benefits to biodiversity and native vegetation; for example, by supporting the purchase of biodiverse plantings to offset government greenhouse gas emissions and by targeting tender-based schemes at biodiverse plantings.

Market-driven pressures

The major driver for changes in agricultural land use is the market price for agricultural products. A case study of the Corangamite region undertaken for the Australian Natural Resource Atlas indicated that the overwhelming reason for change in agricultural land uses is economic, relating to the need to make a return on investment[165]. Land use change in this region has been particularly driven by the decline in wool prices since 1991, when the abandonment of a price support scheme for wool resulted in a sudden 40% drop in wool prices[166].

Strong demand for food from a growing global population and changing dietary preferences due to increasing affluence in some developing nations is likely to maintain relatively high prices for food commodities into the future. Thus, food production activities are likely to remain major land uses in Victoria.

The development of a water market in northern Victoria since 1991 has produced changes in agricultural land uses by driving the permanent transfer of water shares out of the Goulburn-Murray irrigation district and into the Sunraysia district[167]. New horticultural industries have developed in the Sunraysia district, while the use of irrigated pastures for grazing has declined but remains the major user of irrigation water in Victoria[168].

New markets for ecosystem services, such as the market-based instruments for native vegetation management currently being developed and implemented in Victoria, are likely to drive further land use change. The intention of these programs is to place a value on ecosystem services so that positive environmental outcomes are encouraged by the market. For example, BushTender agreements, under which landholders can derive income from the Victorian Government for managing native vegetation, are now in place on approximately 250 properties in target areas throughout Victoria.

Climate change pressures on current land uses

Current patterns of land use in Victoria have developed in a period of relative climatic stability and against a trend of slightly higher rainfall in the second half of the 20th century than the first half. This climatic pattern has contributed to the development and location of a range of agricultural and non-agricultural uses of land.

The outlook for the remainder of the 21st century is for a rapid change in global climate. The projected changes in climate for Victoria (increase in temperature of 0.9–3.8°C, reduction in rainfall of 5–11% and up to 50% reduction in run off by 2070, see Part 4.1: Atmosphere – Climate Change), as well as the political and economic changes that are likely to accompany them, will exert pressure on the use of land for production and the availability of habitat for native animals. The key biophysical pressures on land use will arise from declining availability of water, increasing temperature and increasing frequency of fire[169,170] (see also Part 4.1: Atmosphere – Climate change). The development of a market for carbon and possible competition for land from biofuel crops are key economic pressures likely to affect agricultural land use in Victoria[171].

Availability of water is a key driver of land use because of its critical role in plant growth. The higher evapotranspiration and lower water availability predicted for Victoria will result in drier soils and the distribution of agricultural activities throughout Victoria is likely to change in response (see also section LB9 Impacts of climate change on land and biodiversity). For example in the dryland cropping Wimmera region, Horsham is projected to experience temperature increases of up to 2.6°C and rainfall reductions of up to 12%, resulting in an 8% reduction in potential evaporation by 2070 (see Part 4.1: Atmosphere – Climate Change). Dryland agriculture may be further intensified in an effort to recover productivity losses, which is likely to exacerbate pressure on remnant vegetation on farms (see Indicator LB13 Area sown to crops and pastures).

Reduction in streamflow (see Part 3.2: Water Resources; Part 4.3: Inland Waters) will limit the allocation of irrigation water. In Victoria's wine producing region around Rutherglen, for example, temperature increases of up to 2.9°C and declines in rainfall of up to 10% by 2070 are likely to increase evaporation by as much as 9% (see Part 4.1: Atmosphere – Climate Change). This will produce additional demand from plants for water, which is unlikely to be met by irrigation allocations, requiring substantial increases in water-use efficiency. Irrigated agriculture and horticulture rely on consistent and adequate water allocations to keep fruit trees and grapevines alive; some structural adjustment in the irrigation sector seems inevitable.

Depending on the extent of climate change impacts, responses of land managers may range from changing crop variety selection and sowing time to a complete change of enterprise; for example, shifting from agriculture to plantation forestry or native vegetation managed for carbon sequestration or other land uses. Land may be retired from production all together if it becomes uneconomic to farm in the changed climate or in an environment where the cost of water is greatly increased. If this occurs there may be opportunities for revegetation and biodiversity restoration, although the ability to restore functional ecosystems is currently limited. Other benefits of land retirement may include opportunities to control erosion and reduce recharge of saline groundwater; however, such a land use change is likely to require substantial government and private investment.

On a regional scale, the likely pressures on land use arising from climate change will vary depending on the dominant local land uses, the extent of change in temperature and rainfall that eventuates, and on the timing and frequency of severe, unpredictable weather events.

Political and economic pressures of climate change

The reality of climate change has prompted changes in the political and economic environment surrounding land use (see Part 4.1: Atmosphere – Climate change). For example, the development of the national Carbon Pollution Reduction Scheme[172] is likely to influence land use strongly and is likely to provide a major opportunity for the improvement of land and biodiversity management. This will constitute a new market but its development is likely to favour further expansion of plantations and agroforestry, and adoption of land management strategies that maximise soil carbon storage. The environmental implications of these changes may be positive, especially if soil carbon is included in any future carbon trading scheme. Increased soil carbon content is associated with the provision of several important ecosystem services (see section LB4 Soil structure).

Implications

Land use change can add or relieve pressure on land and biodiversity depending on the nature of the change and the land management practices adopted. For example, intensification of agriculture in response to pressure on land availability may produce threats associated with increased run-off of water and nutrients, such as soil erosion and poor water quality, but may also offer the opportunity to set land aside for conservation or restoration purposes. Similarly, a transition from commercial agriculture to lifestyle farming can present biosecurity risks in the form of relaxed management of pest species, but may also be associated with a change in management emphasis towards biodiversity preservation or restoration.

Twelve per cent of Victoria's remaining native vegetation is on private land; of this vegetation, 60% is of a threatened vegetation type. Native vegetation on private land supports 30% of the State's threatened species populations[173]. Therefore, activities on private land have significant implications for Victoria's threatened flora and fauna, and careful management of land use change will be required to protect these communities. Innovative farming systems that incorporate biodiversity retention with productive agriculture will be needed (see Box LB2.3), along with policy that encourages practice change with incentives where necessary.

Threats to vegetation and habitat arising from land use change

Intensification of agriculture in Victoria has been characterised by replacement of dryland grazing with cropping and/or irrigation systems. These changes in land use and management often involve clearing of remnant vegetation. Intensification through increased application of phosphate fertiliser also threatens native plant diversity because most native species have low tolerance to phosphorus[174]. Even when vegetation clearing is not involved, changes in hydrology and nutrient flows that often accompany more intensive land uses can contribute to declining quality of native vegetation and degradation of water quality in freshwater environments (see Part 4.3: Inland Waters) if flows of water and nutrients are not adequately managed.

Road widening and other improvements designed to accommodate increased travel and transport to newly developed areas can threaten roadside vegetation. In extensively cleared areas, roadside vegetation creates corridors allowing movement of species between habitat fragments as well as providing important habitat in its own right[175]. Loss of roadside vegetation can isolate native animal populations, leading to reduced genetic diversity and lack of opportunity to disperse in response to climate change or after fire[176]. Subdivision of farm land at the urban fringes often produces further fragmentation of vegetation, increasing pressure on already vulnerable ecosystems in rural and peri-urban landscapes.

Population growth and residential development in rural and peri-urban areas are associated with fire prevention activities to protect life and assets[177]. Extensive fire prevention threatens fire-dependent vegetation in close proximity to developed areas. For example, native grassland on Melbourne's western fringes requires relatively frequent fire to maintain community structure[178], but fire is actively suppressed in urbanised areas to protect life and built assets. Conversely, frequent

Box LB2.3 Our Rural Landscape – Enhancing biodiversity in agricultural landscapes

Most traditional Victorian farming systems are based on European agriculture and often alter the water balance, soil chemistry and native biodiversity in the landscape. The challenge is to design new farming systems that better integrate with the natural environment, and to prove that they can use resources efficiently and be more environmentally and economically sustainable than existing systems.

The Victorian Government's *Our Rural Landscape* program aims to improve the profitability of agriculture while better integrating agriculture into the natural environment to conserve natural resources and increase the delivery of ecosystem services from farming systems. Pilot projects in Victoria's north-east and south-west aim to improve understanding of the interactions between biodiversity and agriculture and to identify 'win–win' opportunities for interaction between agricultural land, native vegetation and biodiversity. Future farming landscape scenarios with the potential to enhance biodiversity, increase productivity and reduce the environmental impacts of agriculture are being designed and tested in the target regions. A Landscape Biodiversity Index is also being developed to support landscape design scenarios.

Biodiversity and lamb production gains in north-east Victoria

Native vegetation is likely to offer protection to livestock from extreme weather conditions. Pilot experiments have been established to identify the ecosystem services offered by native vegetation to maternal behaviour of prime lamb flocks. The experiments will quantify the maternal behaviours of ewes at lambing in paddocks with and without trees, and measure the effects of different types of vegetation on growth of lambs. If lambs survive and grow better when they are born beneath trees than in open paddocks without trees, this information can be used to encourage producers to restore native vegetation on their properties.

Cooler ewes, bigger lambs and biodiversity gains

The gradual loss of mature scattered trees from Victoria's agricultural landscape is a major threat to biodiversity and ecosystem processes. These mature trees urgently require protection and replacement. The Department of Primary Industries is investigating the costs and benefits of protecting mature trees from further decline and encouraging natural regeneration of tree seedlings in paddocks and, together with Meat and Livestock Australia, is examining the potential of mature farm trees to reduce heat stress in pregnant ewes.

Nutrition from natives

Native perennial shrubs have the potential to contribute to year-round feed supply for livestock, especially under dry conditions. Inclusion of native perennial species in grazing systems also introduces biodiversity benefits by providing habitat for native species. Native shrubs suitable for introduction to Victorian livestock farming systems are being identified.

Biodiversity and crop production gains in south-west Victoria

Victoria's native grasslands are among Victoria's most threatened ecosystems and are under further pressure from land use changes. Native grasslands might help to control agricultural pests by providing habitat for predatory invertebrates. The movement of invertebrates between agricultural systems and adjacent native grasslands will be monitored to demonstrate to land-owners the potential benefits of integrating native grasslands and agriculture.

fuel-reduction burning of vegetation surrounding developed areas in eastern Victoria may exert pressure on forests that require less frequent fire (see also section LB8 Fire in the Victorian environment).

Development of Melbourne, its suburbs and peri-urban regions have placed extreme pressure on the native vegetation of the Port Phillip region. Only one-third of the original vegetation of the Port Phillip region remains and much of this is located in protected water catchment areas outside the city. Natural ecosystems within the Urban Melbourne reporting area (the city and inner suburbs) of the Port Phillip and Western Port CMA have been permanently altered and only 5% of the original vegetation remains[179]. Within the limits of Greater Melbourne there are 92 plant species of conservation concern and 1,000 ha of native grasslands (approximately a quarter of the grassland remaining in the Melbourne region[180]) that are under threat from urban development in growth areas to Melbourne's west[181]. Plains Grassland in the Victorian Volcanic Plain, which includes the grasslands in Melbourne's west, once covered around 870,000 ha but has been reduced to around 1,000 ha of high-quality vegetation. It is one of Australia's most endangered vegetation types[182] (see section LB1 Vegetation loss and modification, Box LB1.1).

A less tangible implication of the high level of urbanisation in Victoria is that most Victorians live in urban areas and are employed in service industries (see also Part 3.3: Materials). Because most Victorians are no longer directly reliant on ecosystem services for their livelihoods, there is a risk of disconnection between the people and their impacts on ecological processes. The need for change in consumer behaviour to reflect the impact of consumption on natural resources is discussed further in Part 5: Living Well Within Our Environment.

Recommendation

LB2.4 The Victorian Government should seek to raise awareness of environmental impacts of everyday living and to promote behaviour change. For example, the 'black balloons' advertising campaign has been effective in raising the level of climate change understanding in the community. A similar public education approach could be adopted for broader environmental concerns and could be targeted to various population sectors; for example, urban and peri-urban residents.

The changing social structure that accompanies rural and peri-urban development can also have environmental implications. New rural landowners are likely to have less experience in natural resource management than long-term residents, or may visit the property infrequently if it is not their primary residence. Less intensive land management by new owners increases risks of weed and pest animal proliferation. New rural residents often utilise different sources of information on natural resource management from traditional farmers[183], so new approaches to extension activities are needed to engage these residents in catchment-scale activities.

Opportunities for habitat and vegetation improvement

Land use change creates opportunities to improve environmental outcomes as well as posing risks. New rural residents are likely to have different land management objectives from long-term land owners. For example, small blocks may be managed primarily for native vegetation and biodiversity rather than production objectives[184]. This change in land management emphasis presents an opportunity to encourage re-establishment of native vegetation on cleared land and protection of areas of high habitat value or significant vegetation with protective conservation covenants (see section LB1 Vegetation loss and modification, Response indicator LB8 Vegetation conservation activities on private land). A study of the Corangamite catchment, which is undergoing a land-use transition away from traditional agriculture, showed that new residents are approximately three times more likely than long-term rural residents to own land protected by a conservation covenant (14% vs 5%) and about twice as likely to have long-term plans involving conservation covenants (20% vs 10%)[185].

Small patches of remnant vegetation on agricultural land can form the building blocks for larger scale revegetation efforts; for example, a long-term program of revegetation building on sparse remnant vegetation, combined with farm forestry, at the grazing property 'Lanark' in south-western Victoria has restored wetlands and other habitats, attracting over 150 species of birds[186]. Revegetation is more successful if based on existing vegetation that is in moderate to good condition[187] and the remnant vegetation that currently exists in Victoria's agricultural landscapes presents an opportunity to capitalise on natural regeneration potential (see Box LB2.4). The 'Biolinks' strategy proposed in the *Land and biodiversity in a time of climate change* Green Paper could provide initiatives and incentives to engage land-holders in landscape-scale efforts to connect existing vegetation.

Opportunities for improved outcomes for native species from agriculture can also potentially arise from intensification of production. More intensive production from suitable land potentially allows for revegetation of less productive land without substantial change in total farm productivity[188] (see also Box LB2.4). However, recent research suggests that small set-asides are often only affordable on farms that are not intensively managed – often the same farms that support extensive areas of native vegetation[189].

Opportunities arising from land use change are complemented by programs such as BushTender and other market-based schemes, under which land-holders are able to enter into land and vegetation management agreements with the State Government. These agreements allow land-holders to derive income for improving native vegetation and delivery of other ecosystem services on their land.

Establishment of plantations and farm forestry on cleared land offers the potential opportunity to improve biodiversity and habitat value by linking fragmented vegetation[190]. The need to connect native vegetation may limit harvesting options for such plantings. The value of plantations for biodiversity varies substantially depending on plantation design and management[191]. Growing demand for carbon offsets is likely to increase the establishment of plantations and revegetation activities, providing further opportunity to improve delivery of ecosystem services by offering income for these services. Benefits for biodiversity will be maximised by encouraging biodiverse plantings rather than monoculture plantations.

Box LB2.4 Revegetation and restoration: change of tactic required *and quickly*.

Management to sustain biodiversity in Victorian agricultural landscapes will require re-establishment of large amounts of native vegetation[192]. Revegetation efforts to date have typically resulted in small and scattered patches and unconnected linear strips, often on less productive parts of farms or landscapes. The Victorian Government's *Land and biodiversity at a time of climate change* Green Paper identifies large-scale ecological connectivity as a key requirement for improving outcomes for Victoria's biodiversity and identifies existing patches of native vegetation as the starting point for building connectivity.

Recent research has found that natural regeneration has the *potential* to make considerable contributions to future tree cover in some Victorian landscapes. Scenario testing in central Victoria suggests that under current patterns of tree cover, 40% of the total area has a high probability of supporting natural regeneration in the absence of livestock grazing. However, due to paddock tree decline, this regeneration capacity could be reduced to 18% of total farm area if no management action is taken in the next 30 years[193]. Taking advantage of this natural regeneration capacity now could produce significant economic savings for restoration efforts.

However, relying on natural regeneration will not be enough. Due to time lags in the provision of habitat resources through revegetation[194] and the senescence of paddock trees, some high-productivity (highly fertile) sites must be actively revegetated to quickly establish replanted habitat[195].

Recommendations

LB2.5 As part of policy development resulting from the *Land and biodiversity at a time of climate change* Green Paper/White Paper process, the Victorian Government should undertake a study to identify parts of the agricultural landscape suited to natural regeneration processes, as well as highly fertile sites requiring active revegetation, and instigate ecologically defensible large-scale restoration projects; for example, through targeting of BushTender or related projects to areas of high regeneration potential.

LB2.6 Options for developing a 'Biolinks' strategy are outlined in the Green Paper and the development of such a strategy should be considered an urgent priority, given the opportunities that currently exist for regeneration from existing vegetation.

Implications for soil and water

Intensification of agricultural production has important implications for soil and water, predominantly through use of fertiliser to support greater plant production from a given area of land. Use of acidifying nitrogenous fertiliser, or fertiliser in excess of the amount absorbed by crops, can contribute to soil acidification (see section LB7 Soil acidification), while run-off or drainage of excess fertiliser represents a significant source of waste and affects nutrient balances in downstream aquatic environments (see Part 4.3: Inland Waters – Water quality). Appropriate management of nutrient and water flows from more intensive forms of agriculture is therefore essential to protect adjacent land and waterways.

Frequent cropping can be associated with declining soil structure as a consequence of cultivation, sowing and harvesting operations, as well as removal of organic matter (see section LB5 Soil structure and erosion). Intensification of agricultural production by increasing the frequency of cropping can therefore exacerbate existing pressures on soil condition. Again, these impacts can be reduced by best land management practices. The adoption of crop management practices that minimise pressures on soil structure and erosion, such as minimum tillage cropping and retention of crop stubbles (residues) (see section LB5 Soil structure and erosion) is an important requirement for sustainable agricultural development.

Plantations can be used in groundwater recharge areas to address salinity because trees use more water than annual crops and pastures. Conversely, in some areas where plantations have become a significant land use, there is concern that use of water by plantations may limit availability of run-off for agricultural, domestic and environmental use[196].

The impacts of plantation water use on both groundwater recharge and streamflow vary depending on species, growth stage, plantation management, rainfall, previous land use and proportion of catchment forested, as well as characteristics of the catchment itself, such as size, topography and geology[197]. Given the significance of likely reductions in streamflow and water availability as a result of climate change (see Part 3.2: Water Resources), the impacts of plantations on run-off warrants further attention so that future plantations may be strategically established to minimise adverse effects on water availability[198]. In addition, surface and groundwater resources need to be managed as part of an integrated system (see Part 4.3: Inland Waters).

A number of models exist to evaluate the run-off and streamflow implications of plantations and afforestation activities. These tools can be used to support land use planning and regulation of plantation establishment for maximum effectiveness and lowest costs to the economy, communities and the environment[199].

Recommendation

LB2.7 The Victorian Government should expand the scope of Action 2.20 of *Our Water, Our Future* to develop a regulatory framework to control the water resource pressures exerted by the full range of potential surface water diversions including plantation forestry, restoration of riparian vegetation and farm dams (see also Part 4.3: Inland Waters). Development of such a framework should involve a full investigation of the impacts of all potential sources of water interception on catchment water yield and extensive policy analysis to assess the impact of the proposed regulation on water users and the environment.

Management responses

Land use change reflects a complex interaction between social preferences for lifestyle, market forces on property and commodity prices, environmental attributes of land, climatic and geographic variables, ownership or tenure arrangements, and statutory regulation of land uses permitted by the Victorian land use planning system. Responses to land use, land use change and the environmental outcomes of land use change, therefore, encompass the full spectrum of social, economic and environmental drivers of land use change.

The land use planning system is the primary mechanism for controlling land use and development at the strategic level in Victoria. The planning system is administered largely by local governments and contributes to the achievement of State and local policy objectives across a range of areas, including environment and sustainability, economic development, heritage and long-term community benefit. As such, concerns about the impacts of land use change on flora and fauna are part of a much broader array of factors contributing to land use planning decisions. The Victorian planning system includes strategic or future planning for land use change and development and statutory elements, which regulate current permitted land uses.

Changes in land use present both threats and opportunities for land and biodiversity. In order to capitalise on opportunities for improvement and minimise environmental risks of land use change, responses to this change must address two key objectives: (1) *that land use is appropriately matched to land capability* and (2) *that sustainable land management is practised over the range of land uses*. Responses to current trends in land use are still evolving, but representative responses at catchment and government levels indicate efforts to engage a broad spectrum of rural land-holders in sustainable land management.

Response Name
Regional Catchment Strategies

Responsible Authority
Catchment Management Authorities

Response Type
Strategy/policy

Regional Catchment Strategies (RCS) are revised every six years by CMAs in consultation with communities. They are the principal catchment planning tools that provide the focus for natural resource management in each CMA region. On behalf of the State, these strategies articulate the vision of the community and CMA for the regional landscape, and usually provide an inventory of the biophysical, to some extent, the social capital of the region. Investors may choose to invest in achieving the resource condition targets contained in RCSs and the natural resource management outcomes produced from the implementation of the Strategies. Regional Catchment Strategies are also intended to inform land use planning decisions by local governments.

Land use changes and issues arising from relevant land uses are considered and actions may be developed to address these issues. In regions where land use is known to be in transition, the RCS documents ecological assets (productive and natural) and outlines actions aimed at mitigating likely impacts of land use change on natural resource condition. Regional Catchment Strategies may also articulate goals such as matching land use with land capacity and facilitating the development of Environmental Management Systems by individuals to align regional natural resource management priorities with sustainable and productive land use.

Land management issues vary between regions because of the range of land uses and management practices throughout Victoria. Regionally based plans, therefore, are constituted at an appropriate scale for strategic planning. In general, the regional delivery model for natural resource management funding is viewed as an effective means of directing investment to on-ground environmental works[200], and individual strategies have made some significant gains. For example, the Goulburn–Broken CMA achieved a 42% increase in area covered by whole-farm plans between 1997 and 2003.

Current Regional Catchment Strategies include a statement of vision or aspirational targets, along with resource condition targets and management action targets to guide progress towards achieving the desired resource condition.

The specificity and measurability of resource condition targets varies between asset classes and between regions.

The often long lag times between interventions and responses in environmental condition can make it difficult to evaluate the effectiveness of RCSs over the five-year span of each strategy. This has led to a focus on reporting outputs of strategies and plans rather than environmental outcomes. This focus makes it difficult to determine whether the activities and interventions are actually achieving the desired changes in environmental condition. Evaluation of progress towards targets might be assisted by development of agreed resource condition standards and agreed indicators against which CMAs could report.

Effectiveness of RCSs as catchment planning tools may be limited by poor alignment of their objectives with those of the land use planning system. Although they are intended to form an integral part of the statutory land use planning system under the *Planning and Environment Act 1987*, the information contained within RCSs is not always well integrated into the land use planning process, which is administered at the local government level[201]. Alignment of natural resource management and statutory planning processes needs to be strengthened from both perspectives.

Recommendations

LB2.8 The Victorian Government should ensure that Regional Catchment Strategies are underpinned by the best available scientific and technical information.

LB2.9 Regional Catchment Strategies include measurable resource condition targets as a means of improved evaluation of outcomes.

LB2.10 CMA reporting against Regional Catchment Strategy objectives should include public reporting against an agreed set of key environmental performance indicators.

LB2.11 The Victorian Government should explore options for improving linkages between catchment planning objectives and local planning schemes.

Response name
Planning and Environment Act 1987 and Victorian planning system

Responsible authority
Department of Planning and Community Development

Response type
Legislation/structure

The *Planning and Environment Act 1987* and the Victorian Planning Provisions (VPP) create the framework for planning schemes, which, in turn, regulate land use and development in Victoria. The VPP provides State Planning Policies and more detailed provisions for the assessment of planning permits, and planning schemes provide a mechanism for the management of sensitive environments. Government policy on biodiversity protection is implemented in the VPP and all planning schemes. These policies are the responsibility of the relevant Minister.

The purpose of the *Planning and Environment Act* is 'to establish a framework for planning the use, development and protection of land in Victoria in the present and long-term interests of all Victorians'. The Act was a major reform of planning in Victoria, incorporating the environment as an equal partner with land use and development, whereas prior to 1987, land use planning was concerned only with facilitation of development and was not aimed at achieving conservation objectives.

Planning schemes developed by planning authorities (usually local governments) provide the means of implementing State and local policy objectives as articulated in the State Planning Policy Framework (SPPF) and Local Planning Policy Frameworks (LPPFs). The SPPF contains specific clauses relating to land and biodiversity, including biodiversity conservation, management of native vegetation, ecosystem health, management of resources and the roles of the CMAs, and native habitat and biodiversity in the metropolitan area. Municipal Strategic Statements (MSS) further the objectives of planning in Victoria to the extent that they are applicable to individual municipal districts. MSSs contain: the strategic planning, land use and development objectives of the planning authority; strategies for achieving the objectives; and an explanation of the relationship between the objectives and strategies, and the controls on use and development of land in the planning scheme.

The intention of the *Planning and Environment Act*, to provide a consistent approach to management of environmental assets is clear[202]. However, instances of misalignment between environmental assets, such as threatened vegetation, and planning tools, such as zones and planning overlays, have occurred (see Box LB2.1). These misalignments limit the protection of significant environmental assets during land use change processes. Effective implementation of land management strategies in the planning system relies on strategic work that clearly identifies the problems and actions necessary to address those problems (within the planning system, within other relevant legislation and by non-statutory measures such as stakeholder education). Good communication is essential between planning authorities, CMAs and other land managers to ensure appropriate and effective use of the planning system in managing land and biodiversity resources.

It will be important to understand the nature of potential barriers to effective protection of land and biodiversity assets in order to improve the environmental outcomes of land use change. Key issues to explore include:

- The exchange of information between CMAs and planning authorities. Regional Catchment Strategies contain detailed information about regional environmental assets and natural resource management objectives, which could be used to inform strategic planning processes but the information may not be presented in a format accessible to planners. Strategies need to clearly identify actions that are best implemented through the planning systems by the regulation of land use and development. Likewise, the information needs of planners should be clearly conveyed to CMAs and it is important that planning authorities participate actively in the strategic development process.
- The addition of an appendix to RCSs, containing specific recommendations to planning authorities, including advice on appropriate zoning and use of overlay controls (such as the Environmental Significance Overlay and Vegetation Protection Overlay), might improve the integration of this information into MSSs and planning schemes.
- Alignment of review cycles for planning schemes and RCSs. Currently planning schemes are reviewed every five years and RCSs every six years. Concurrent review of planning schemes and RCSs might facilitate the alignment of catchment management and land use planning objectives.
- The flow of information between the State Government and planning authorities. For example, Government departments could assist planners to identify significant environmental assets by providing mapping tools and products at an appropriate scale and in a format compatible with existing maps used within planning authorities. Clear expression of regional natural resource management and biodiversity objectives at a sub-regional scale would provide guidance to planners and a means of weighing the competing priorities associated with each planning application.
- The adequacy of strategic planning work, i.e. the identification of on-ground assets and the application of appropriate planning controls.
- Clarity of expression of State objectives in the SPPF and the adequacy of reference in the *Planning and Environment Act* to primary environmental legislation such as the *Flora and Fauna Guarantee Act* and the *Catchment and Land Protection Act*.
- Levels of resourcing for provision and interpretation of environmental information and implementation of planning tools. For example, CMAs should be adequately resourced to provide information in a format suitable for use by planning authorities and planning authorities require adequate resources to employ staff who are able to interpret such information and implement planning tools accordingly.
- Community acceptance of policy underlying planning decisions. For example, acceptance of native vegetation management policy relating to clearing may not be high, creating difficulty in implementing the Native Vegetation Management Framework through the Victorian Planning Provisions.
- Selection of the appropriate tool, either within the planning system, or from a range of options outside the planning system, to address each individual natural resource management or biodiversity issue. While the planning system has a role in determining land use outcomes, other tools such as land use and management agreements (for example, BushTender) and community education programs can also be useful in achieving desired outcomes.

Recommendation

LB2.12 The Victorian Government, in consultation with local governments, should undertake a study to identify the most significant barriers to effective protection of environmental assets and act on opportunities identified. This investigation should include relationships between CMAs and planning authorities, alignment between catchment planning and land use planning processes and objectives, resourcing of strategic and statutory planning in relation to environmental assets, and flow of information between State Government departments and planning authorities.

The planning system has an important role in facilitating Victoria's adaptation to climate change, particularly in coastal areas. For further discussion of this aspect of planning, see Part 4.4 Coasts, Estuaries and the Sea; Part 5 Living Well.

Response Name

Rural zoning

Responsible Authority

Department of Planning and Community Development

Response Type

Strategy/policy

Changing land use in Victoria's high-amenity rural areas has led to concerns about the availability of agricultural land for farming. There is also a potential for tension between the amenity expectations of newer rural residents and the operations involved in commercial agriculture. In response to these concerns and in an effort to strike a balance between the continued provision of agriculturally productive land, the protection of lifestyle values, and the protection of environmentally sensitive areas[203], the Victorian Government reviewed land use zoning for rural areas in 2003. New rural land use zones were introduced through amendments to the Victorian Planning Provisions in 2004.

The aim of the new Farming Zone is to protect agriculture as the primary land use in rural Victoria and to enable farming businesses to expand and intensify without being affected by non-farming land uses in rural areas. The Rural Conservation Zone aims to protect and enhance the natural environment, natural processes, natural resources and biodiversity, and to encourage sustainable land management.

While the new land use zones and associated implementation projects address the risk of loss of agriculturally productive land to inappropriate residential and other development, the scope of the review did not include an investigation of the role of rural land zoning in biodiversity conservation and catchment management planning.

The Victorian Government provided a grant of $150,000 to the Municipal Association of Victoria to assist local governments with implementation of the new zoning arrangements. A further $500,000 has been allocated to the one-year Rural Land Use Planning Program, which is intended to complement new rural zones and to assist Victoria's 48 local councils to undertake the strategic planning needed to improve protection and management of rural land.

The *Future Farming Strategy*, which includes $3.79 million over four years to establish a new Regional Strategic Planning Expert Group to identify and plan for future scenarios for farming and farming communities, is another initiative of the Victorian Government to improve rural land use planning. Action 4.4 of the strategy (Improving rural land use planning) aims to provide farming businesses with flexibility and certainty in a period of change by facilitating changes to the land use planning system to ensure policy alignment with the objectives of the Future Farming Strategy.

Evaluation of responses to land use change

Victoria has a comprehensive set of legislation, policies and strategies aimed at improving the condition of land and biodiversity resources. Nevertheless, land use decisions in Victoria to date have contributed to disruption of a range of ecological processes. These disruptions are reflected by the fragmented state of much of Victoria's native vegetation, the continuing loss of high-quality native grasslands, increasing numbers of threatened species and continued impacts of pest plants and animals, as well as ongoing concerns about salinity, episodic erosion and soil health.

It is important to distinguish between land use and land management in the discussion of responses to land use change. Land use refers to a broad classification of the purpose for which land is used; for example, dryland agriculture, conservation or residential. Land management refers to the way land and operations are managed within that land use. On private land management decisions are made by individual land-holders or managers within the constraints of duty of care, as defined in the CaLP Act (see LB0 Introduction), and any specific regulations for particular activities; for example, control of effluents. Land management as it relates to the condition of land and biodiversity is discussed in detail in other sections of this report. This section focuses on responses to land use and land use change in Victoria.

Land use patterns occur in response to a complex array of pressures, including: attributes of the land, such as soil type and topography; land and commodity prices; proximity to infrastructure; and social preferences. Broadscale land use and changes in land use are regulated by Victoria's planning system. This system is governed by the *Planning and Environment Act 1987* (see LB0 Introduction) and a range of subordinate instruments including State and local Planning Policy Frameworks (SPPF, LPPF) and the Victorian Planning Provisions (VPP). The aim of the planning system is to give effect to State and local government policy objectives.

Environmental policy is one of a large number of potentially competing policy areas considered within the planning system. Nevertheless, the intent of the *Planning and Environment Act 1987* – to change the focus of land use planning in Victoria from one of facilitating development to a consideration of environmental concerns in the land use planning process – is clear (see LB0 Introduction). In a significant policy reform, the Native Vegetation Management Framework is given effect through the VPP, and frequent reference to biodiversity is made in the VPP, SPPF, purposes of zones and overlays, and decision guidelines. For example, Clause 15.09 of the VPP relates to conservation of native flora and fauna, Clause 52.17 relates to native vegetation, and Clause 56 implements vegetation precinct plans in residential subdivision. The Vegetation Protection and Environmental Significance Overlays and the Rural Conservation Zone are also intended to protect significant environmental assets. Thus, the Victorian planning system contains a range of tools aimed at achieving the State's environmental and biodiversity objectives.

Although the intentions of the *Planning and Environment Act 1987* regarding biodiversity are clearly articulated, there appear to be shortcomings in the implementation of planning tools in relation to assets of conservation significance[204],[205]. The apparent misalignment of planning instruments with conservation significance in some instances[206] suggests that better information on the location and significance of environmental assets may be needed to support the effective implementation of planning system tools by local governments to support Victoria's environmental objectives.

The Land Capability and Biodiversity Study currently being undertaken by the Moyne Shire in south-western Victoria aims to 'improve the quality and quantity of information available to Council for assessing development and planning applications under principles of sustainable development and land use, while preserving the biodiversity assets and agricultural productivity of the Moyne Shire'. Improvement in the information underpinning planning decisions by local governments is a positive step towards achieving better environmental outcomes from land use change and should be adopted statewide.

A developing market for carbon is likely to induce substantial land use and land management change, as carbon sequestration services through vegetation and soil carbon begin to offer income streams to land-holders. These new income opportunities are likely to drive broadscale changes in land use towards carbon-storing enterprises. Although these market-driven changes may benefit the environment, there remains a role for government in regulating the establishment of new industries and enterprises to ensure that unintended side effects are minimised. For example, an increase in plantation area is likely to provide environmental benefits, but maturing trees may reduce run-off, with implications for environmental water, town water supplies and availability of water for other enterprises in the region[207]. Monoculture plantations also present risks for biodiversity and it would be preferable to encourage biodiverse plantations for carbon sequestration (see also LB9 Impacts of climate change on land and biodiversity).

Climate change itself is also likely to drive major changes in land use throughout Victoria. These changes will present the opportunity to align land use more closely with land capability, therefore, it is important that the land use planning system is responsive to the most current information on environmental threats, natural resource assets and land capability estimates. The Future Farming Strategy contains an action aimed at improving the rural planning systems so that it becomes more responsive to the changing needs of the farming sector[208]. Any change in the flexibility of the planning system should consider, equally, the need to be responsive to land use changes arising from rapid environmental change.

Key response indicator: The Department of Sustainability and Environment is currently developing an index of land health. This will be the ideal indicator of the environmental impact of land use. Until this indicator is available, the impacts of land use may be gauged by the National Land and Water Resource Audit's (NLWRA) Landscape Stress Index, an expert opinion-based assessment of landscape condition. With the exception of sub-regions covering the major public land areas in the east and west, Victoria falls into the two highest stress classes[209].

Recommendations

LB2.13 Where clearing is approved by local governments, it should be recorded by DSE in the Native Vegetation Tracking tool.

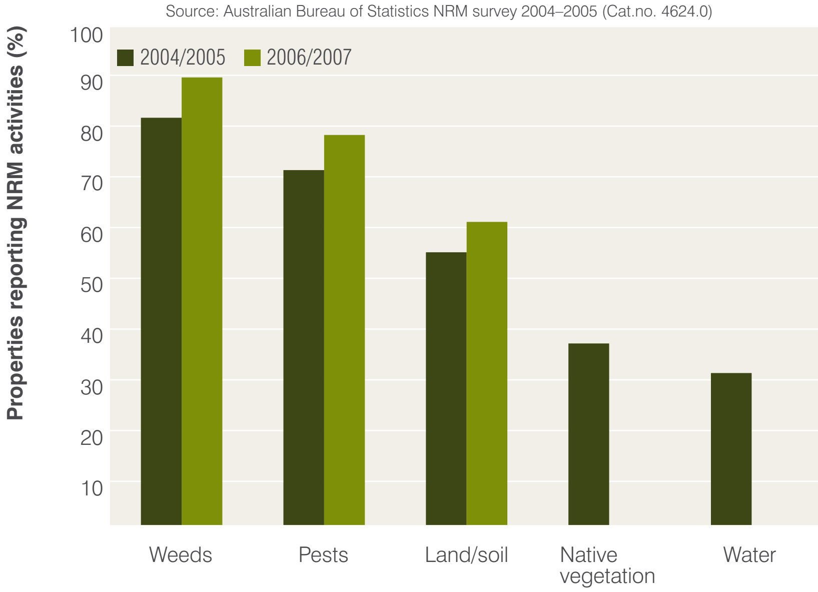
LB2.14 The Victorian Government should continue to support the development and application of a land health index. Analysis of the relationship between land use and land health should inform Victorian land use planning decisions at statutory and strategic levels to achieve better alignment between planning decisions and biodiversity or conservation objectives.

Response Indicator LB16 Participation in natural resource management activities

Approximately 96% of the privately owned land in Victoria is farmed. Therefore, farmers collectively have a major influence over responses to land degradation and biodiversity issues in Victoria. Over 90% of Victorian rural landholders undertook natural resource management activities on their properties in 2004/2005[210], while in 2006/2007, 66% of farm businesses in Victoria reported *improved* natural resource management practices, with profitability and sustainability nominated as key drivers of adoption[211]. Activities relating to management of weeds and pests were most frequently reported, followed by activities related to land and soil degradation (see Figure LB2.10). The proportion of properties reporting weed, pest and land and water activities increased between 2004/2005 and 2006/2007. Activities aimed at improving the condition of native vegetation and water were least frequently reported.

The patterns of activity reported were similar throughout the State, although relatively more activity related to native vegetation and water was reported in East Gippsland and less emphasis was placed on these activities in the Mallee.

Figure LB2.10 Natural resource management activities undertaken on Victorian farms 2004/2005 and 2006/2007. Note: data on activities relating to native vegetation and water were not collected in 2006/2007
Source: Australian Bureau of Statistics NRM survey 2004–2005 (Cat.no. 4624.0)



Response Indicator LB17 Participation in Landcare

The activities of private landholders through voluntary structures, such as Landcare, make an important contribution to achieving Victoria's natural resource management objectives. Landcare is a community-driven initiative, supported by government, aimed at addressing environmental problems such as land degradation, water quality, salinity and the impact of pest plants and animals, as well as more profitable agriculture (see section LB0 Introduction – Management responses). Involvement of land-holders in Landcare is linked with higher rates of adoption of sustainable agricultural management practices such as excluding stock from areas of degraded land and maintaining vegetation along drainage lines and protecting areas of conservation value[212]. Landcare is regarded as an effective community engagement tool, although natural resource management outcomes may vary according to local group resources and priorities.

After the establishment of the movement in Victoria in the late 1980s, Landcare membership increased rapidly in the 1990s, with statewide membership increasing from approximately 13,000 in 1993 to 27,590 in 1998. A decline in Landcare membership to 23,220 was observed in 2004, accompanied by a decline in the number of groups, from 890 in 1998 to 721 in 2004[213].

Between 1995 and 2004, Victorian Landcare membership declined from 50% to 41% of properties statewide. Landcare participation levels vary throughout Victoria, with larger group sizes generally found in more densely populated regional centres and areas with more intensive land uses[214]. The proportion of properties involved in Landcare in 2004, however, is currently highest in the Mallee region (69% of properties), which is dominated by broadacre cropping enterprises.

The proportion of landholders participating in Landcare remains high relative to that for most rural extension programs215, but the declining trend may indicate that the perceived importance of Landcare in Victorian natural resource management may be falling. Alternative mechanisms for improving the land and biodiversity outcomes from use of land resources, such as market-based instruments, seem to be emerging. Demographic change also has implications for Landcare participation. Victoria's farming population is aging, declining in number and in some regions includes a high proportion of absentee land-holders[216]. The apparent trend towards corporate farming will also produce a group of land-holders and managers not targeted by Landcare or current NRM policy. New approaches to encourage land stewardship will be required to target this group.

For further information

Catchment management: www.dse.vic.gov.au/DSE/nrenlwm.nsf/childdocs/-E9B6826F3AB828F64A2567D7000B1BA6-82A6DD30CA52A8C0CA256E69002F506C?open

Land use planning: www.dse.vic.gov.au/dse/nrenpl.nsf/Home+Page/DSE+Planning~Home+Page?open

Landcare: www.landcareonline.com/

Photo: Jane Tovey

LB3 Threatened species

Key findings

- The number of threatened species in Victoria increased between 2002 and 2007, yet Action Statements to improve their status under the *Flora and Fauna Guarantee Act 1988* have not been developed. 157 native vertebrate species and 778 native plant species are considered rare or are threatened with extinction.
- The *Flora and Fauna Guarantee Act 1988* is failing to meet its stated objectives and is in need of review. It requires a change in focus to facilitate improved understanding of Victoria's natural ecosystems and their vulnerabilities to climate change and an adequate allocation of resources to ensure effective achievement of objectives.
- Climate change is likely to exceed the evolutionary adaptive capacity of some species, compounding existing threats to native species and increasing the number of threatened species.
- There are significant knowledge gaps with respect to Victoria's threatened species. For example, survey effort for native species has declined significantly over the last 5–10 years, limiting the ability to track population trends. Knowledge of the status of invertebrates is particularly poor, hampering assessments of conservation needs.
- Trends in populations of individual threatened species are variable. While some populations of threatened species continue to decline, a small number of threatened species populations are increasing in number in response to management activities. There are many species whose population trends are inconclusive or variable and which require ongoing monitoring.
- The impact on ecological processes of the extinction of 24 species of vertebrates from Victoria (18 of which are mammals) and 51 species of plants is largely unknown.

Description

Victoria has a diverse range of native species. These species are integral to the functioning of natural and agricultural systems that humans depend upon. However, due to a range of factors such as past vegetation clearing, habitat modification and the introduction of exotic plant and animal species, a large number of native species is now considered threatened. Victoria has the highest number of threatened species by subregion in Australia[xii,217]. Amongst these species are Victoria's mammal emblem, the Leadbeater's Possum, which is endangered, and the State's bird emblem, the Helmeted Honeyeater (*Lichenostomus melanops cassidix*), which is critically endangered.

The high level of landscape stress and cleared vegetation in Victorian bioregions (see sections LB1 Vegetation loss and modification; LB2 Contemporary land use change) is reflected in the high number of threatened species in Victoria[218] and indicates the importance of habitat in biodiversity conservation. The implications of factors that affect habitat quality, such as loss of native vegetation, land use change, fire regimes and climate change for biodiversity conservation in Victoria are discussed in detail in other sections of this report (e.g. see sections LB1 Vegetation loss and modification; LB2 Contemporary land use change; LB8 Fire in the Victorian environment; LB9 Impacts of climate change on land and biodiversity).

Threatened species classification provides a means of highlighting species at high risk of extinction. Threatened species lists in isolation may be of limited value as indicators of changes in environmental condition[219] but when considered together with an analysis of survey effort and trends in specific populations, as presented here, a discussion of threatened species contributes to an understanding of the habitat pressures on biodiversity. There are many other ways to report on biodiversity and different species may be the focus under different reporting methods. The importance of habitat management and retention should underpin all biodiversity conservation efforts.

Without actions to reduce the pressures that have led to a species' conservation status, the species may continue to decline to the point of extinction. Further pressures associated with land use change and climate change pose significant risks to native species and significant management challenges for governments charged with ensuring the survival of species.

Despite an increase in the number of species listed as threatened and the increasing risks posed to them, survey effort for species distribution appears to be declining. Furthermore, the disparate nature of species datasets amongst a variety of institutions charged with managing them hampers conservation planning efforts.

Objectives

- To improve the conservation status of Victoria's flora and fauna
- To manage habitat and ecological processes to benefit maximum numbers of native species
- To increase survey effort and data availability for native species

Links

See also: Land and Biodiversity – Vegetation loss and modification, Contemporary land use change, Impacts of climate change on land and biodiversity, Salinity, Fire in the Victorian environment.

xii The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into 85 bioregions. 404 sub-regions have been defined, based on the major geomorphic features of each region. Sub-regions correspond approximately to Victorian Bioregions.

State

Indicator LB18 Number of threatened species in Victoria

Australia is one of the world's 17 biologically 'megadiverse' nations[220], with a high proportion of endemic species – those that are found nowhere else in the world. Due in part to its wide range of ecosystems, Victoria has a diverse array of native terrestrial species, including at least 3,140 species of vascular plants, 900 lichens, 750 mosses and liverworts, 111 mammals, 447 birds, 133 reptiles, 33 amphibians, and a large number of invertebrates, fungi and algae species, many of which are yet to be described[221].

In Victoria the Department of Sustainability and Environment maintains 'Advisory Lists' for threatened species that document a species' threat status[xiii]. Legal protection is also offered to species listed under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

At least 24 vertebrate species have become extinct from Victoria, including nine which have become globally extinct. Some 157 vertebrate species are currently considered to be 'vulnerable', 'endangered', or 'critically endangered' in Victoria (see Table LB3.1). A further 87 species are considered to be 'near threatened' or 'data deficient'[222]. In terms of legislative protection, 173 of these species are listed under the FFG Act, while 87 are listed under the EPBC Act. There is no current published advisory list of threatened invertebrate fauna in Victoria (although an outdated list exists[223] and a new one is currently in development); however, 57 non-marine invertebrates are listed on the FFG Act and two on the EPBC Act. This discrepancy in the number of vertebrates to invertebrates listed is in part a result of lack of basic ecological information on most invertebrates[224,225,226]. Even for some larger, more 'charismatic' invertebrate groups there is a lack of basic distribution and ecological information available[227].

Recommendation

LB3.1 The Victorian Government should allocate funding for the ongoing maintenance of advisory lists for all taxa, including invertebrates.

Regarding vascular plants (see Table LB3.2), 49 species have become extinct from Victoria, with a further 745 species listed as vulnerable or endangered, 804 species as rare, and 228 are poorly known[228]. Unlike vertebrate fauna, where the Advisory List and FFG listings record a similar number of species, only 288 vascular plant species are listed under the FFG Act (less than 37% of those considered vulnerable, endangered or extinct in Victoria). One hundred and forty seven Victorian vascular plant species are listed nationally under the EPBC Act. For lesser known groups of non-vascular flora, lichen and fungi, 33 are considered threatened in Victoria, although 77 are listed as poorly known and 34 are rare. At least two species are known to have become extinct. In terms of legislative protection for these species, only 15 are listed on the FFG Act and only one on the EPBC Act (see Table LB3.2). Again, this is more a reflection of a lack of ecological study than a reflection of conservation status[229].

In all except three of Victoria's 28 bioregions, more threatened animal species were recorded up to 2007 than to 2002[xiv] (see Table LB3.3). This could be the result of a number of factors, including greater recognition and listing of species as threatened in 2007, a greater survey effort being made for those individual species since 2002 (despite an overall decline in survey effort in Victoria, see Figures LB3.1, LB3.2, LB3.3) resulting in a higher detection rate in some bioregions, or a real increase in the numbers of individual threatened species since 2002. For some species that were listed as threatened in 2002, improved knowledge of their distribution or population numbers has meant they were not considered threatened in 2007. The Gippsland Plain and Victorian Volcanic Plain had the highest number of threatened fauna recorded in 2007 (both with 100 species). This is likely to be due to a combination of the extensive clearing and modification of habitat in those bioregions (see section LB1 Vegetation loss and modification) and the likely higher survey effort in those regions close to Melbourne.

Similarly for flora, 20 bioregions had more threatened species up to 2007 than to 2002 (see Table LB3.4). Four bioregions had the same number of threatened plant species in both years, while four had more up to 2002, a result of some species no longer being considered threatened in 2007. The Murray Mallee bioregion had the highest number of threatened flora species in 2007 (100), followed by the East Gippsland Uplands, Wimmera, Victorian Alps and Victorian Riverina. Low numbers of threatened species were recorded in the Highlands–Far East and Monaro Tablelands bioregions, possibly due to the small areas they occupy and relative survey effort, but also as a result of the relative intactness of those landscapes (see section LB1 Vegetation loss and modification).

Photo: Courtesy of Fairfaxphotos

xiii These advisory lists are not the same as the schedules established under the Victorian *Flora and Fauna Guarantee Act 1988*. There are no legal requirements or consequences that flow from inclusion of a species in advisory lists. However, some of the species in these advisory lists are also listed as threatened under the FFG Act. The FFG Act schedules only include items that have been nominated, assessed by the Scientific Advisory Committee and approved for listing by the responsible minister.

xiv The records up to 2007 include all records prior to this date, not just those between 2002 and 2007.

Table LB3.1: Number of Victorian fauna species listed on the 'Advisory List of Threatened Vertebrate Fauna in Victoria – 2007', on the *Flora and Fauna Guarantee Act 1988* (FFG Act; Vic) and on the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (DSE 2007[230,231])[xv]

	Victorian Advisory List of Threatened Vertebrate Fauna - 2007							FFG Act listed fauna	Environment Protection and Biodiversity Conservation Act 1999				
	Near Threatened	Data Deficient	Vulnerable	Endangered	Critically Endangered	Regionally Extinct	Extinct		Conservation Dependant	Vulnerable	Endangered	Critically Endangered	Extinct
Mammals	13	2	7	7	4	9	9	34	1	11	10	0	8
Birds	42	0	46	27	9	2	0	78	0	21	9	1	0
Reptiles	9	12	8	10	9	1	0	29	0	5	4	0	0
Amphibians	0	5	4	2	6	0	0	11	0	6	2	0	0
Fishes	2	2	6	5	7	3	0	21	0	6	3	0	0
Vertebrates Total	66	21	71	51	35	15	9	173	1	49	28	1	8
Invertebrates*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	57	0	1	0	1	0
Fauna Total	66	21	71	51	35	15	9	230	1	50	28	2	8

This assessment excludes cetaceans, marine fish and marine invertebrates but includes seals, reptiles and pelagic birds.

There is currently no published advisory list of threatened invertebrate fauna in Victoria (although one is currently in development).

Table LB3.2 Number of Victorian plant species listed on the 'Advisory List of Rare and Threatened Plants in Victoria – 2005', on the *Flora and Fauna Guarantee Act 1988* (FFG Act; Vic) and on the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (DSE 2005[232,233])[xvi]

	Victorian Advisory List of Rare & Threatened Plants - 2005					FFG Act listed species	Environment Protection and Biodiversity Conservation Act 1999				
	Rare	Poorly known	Vulnerable	Endangered	Extinct		Conservation Dependant	Vulnerable	Endangered	Critically Endangered	Extinct
Vascular Plants	804	228	475	270	49	288	0	92	47	2	6
Non-vascular plants, lichen and fungi	34	77	20	13	2	15	0	1	0	0	0
Plants Total	838	305	495	283	51	303*	0	93	47	2	6

* Note: Three taxa are listed only at the species level in the FFG list, but at sub-specific level in the Advisory List.

xv Threatened fauna includes all species FFG listed on 30 June 2007, all species with status Vulnerable, Endangered, Critically Endangered or Extinct on the Victorian Advisory List 2007, and all species listed under the EPBC Act (1999) on 30 June 2007.

xvi Threatened flora includes all species FFG listed on 30 June 2007, all species with status Vulnerable, Endangered, Critically Endangered or Extinct on the Victorian Advisory List 2005, and all species listed under the EPBC Act (1999) on 30 June 2007.

Table LB3.3 Number of threatened fauna taxa recorded in Victorian bioregions up to June 2002 and up to June 2007
Source: DSE 2007[234,xvii]

Victorian bioregion	Taxa recorded up to 2002	Taxa recorded up to 2007	2002–2007 threatened fauna comparison		
			Taxa recorded up to 2002 but not threatened in 2007	Taxa recorded considered threatened in both 2002 and 2007	Taxa recorded up to 2007, either not recorded in the bioregion up to 2002 or not listed as threatened in 2002
Bridgewater	43	42	5	38	4
Central Victorian Uplands	64	67	5	59	8
Dundas Tablelands	40	43	1	39	4
East Gippsland Lowlands	73	78	6	67	11
East Gippsland Uplands	39	43	2	37	6
Gippsland Plain	95	100	9	86	14
Glenelg Plain	62	63	7	55	8
Goldfields	57	63	4	53	10
Greater Grampians	38	43	1	37	6
Highlands - Far East	10	12	0	10	2
Highlands - Northern Fall	46	54	2	44	10
Highlands – Southern Fall	65	75	3	62	13
Lowan Mallee	40	49	2	38	11
Monaro Tablelands	14	15	0	14	1
Murray Fans	58	57	5	53	4
Murray Mallee	73	82	4	69	13
Murray Scroll Belt	47	52	4	43	9
Northern Inland Slopes	53	50	5	48	2
Otway Plain	73	79	8	65	14
Otway Ranges	34	34	5	29	5
Robinvale Plains	46	48	4	42	6
Strzelecki Ranges	36	35	5	31	4
Victorian Alps	29	36	0	29	7
Victorian Riverina	77	81	6	71	10
Victorian Volcanic Plain	94	100	9	85	15
Warrnambool Plain	61	63	7	54	9
Wilsons Promontory	35	36	5	30	6
Wimmera	66	72	4	62	10

xvii Threatened fauna includes all species FFG listed on 30 June 2007, all species with status Vulnerable, Endangered, Critically Endangered or Extinct on the Victorian Advisory List 2007, and all species listed under the EPBC Act (1999) on 30 June 2007.

Table LB3.4 Number of threatened flora taxa recorded in Victorian bioregions up to June 2002 and up to June 2007
Source: DSE 2007[235,xviii]

Victorian bioregion	Taxa recorded up to 2002	Taxa recorded up to 2007	2002–2007 threatened flora comparison		
			Taxa recorded up to 2002 but not threatened in 2007	Taxa considered threatened in both 2002 and 2007	Taxa recorded up to 2007, either not recorded in the bioregion up to 2002 or not listed as threatened in 2002
Bridgewater	8	11	1	7	4
Central Victorian Uplands	41	46	2	39	7
Dundas Tablelands	28	34	3	25	9
East Gippsland Lowlands	62	62	3	59	3
East Gippsland Uplands	80	88	1	79	9
Gippsland Plain	69	74	4	65	9
Glenelg Plain	35	39	2	33	6
Goldfields	60	74	1	59	15
Greater Grampians	35	38	2	33	5
Highlands – Far East	7	6	1	6	0
Highlands – Northern Fall	41	48	2	39	9
Highlands - Southern Fall	49	56	1	48	8
Lowan Mallee	51	57	4	47	10
Monaro Tablelands	19	19	2	17	2
Murray Fans	52	49	7	45	4
Murray Mallee	91	100	4	87	13
Murray Scroll Belt	35	36	4	31	5
Northern Inland Slopes	45	49	1	44	5
Otway Plain	33	38	2	31	7
Otway Ranges	12	11	1	11	0
Robinvale Plains	55	60	2	53	7
Strzelecki Ranges	10	10	1	9	1
Victorian Alps	85	86	4	81	5
Victorian Riverina	83	85	8	75	10
Victorian Volcanic Plain	76	74	9	67	7
Warrnambool Plain	16	16	1	15	1
Wilsons Promontory	13	17	1	12	5
Wimmera	86	87	7	79	8

Indicator LB19 Trends in populations of selected threatened species

Presenting estimated trends for a range of threatened species populations allows for greater scrutiny than numbers of species in statewide threatened species lists. Analysis for this report was ultimately limited to those species with adequate information on trends available in the Department of Sustainability and Environment's Actions for Biodiversity Conservation database[xix]. Some threatened fauna such as the Grey-headed Flying-fox (*Pteropus poliocephalus*) population in Melbourne and the Brush-tailed Rock-wallaby (*Petrogal penicillata*) population at the Snowy River National Park are considered to be improving (see Table LB3.5). However, others, such as the Eastern Barred Bandicoot (*Perameles gunnii*), Baw Baw Frog (*Philoria frosti*), Mallee Worm-Lizard (*Aprasia aurita*) and Glenelg Spiny Crayfish (*Euastacus bispinosus*) are in decline.

A small number of threatened plant species have populations that are considered to be improving, including the Crimson Spider-orchid (*Caladenia concolor*) at Castlemaine Diggings National Heritage Park and Whipstick Westringia (*Westringia crassifolia*) in Greater Bendigo National Park. Both species have benefited from fencing (see Table LB3.6). However, for a range of reasons, a number of other species continue to decline including Limestone Spider-orchid (*Caladenia calcicola*; fire regime and grazing), Frankston Spider-orchid (*Caladenia robinsonii*; drought, habitat fragmentation), Basalt Peppercress (*Lepidium hyssopifolium*; weed invasion) and Bald-tip Beard-orchid (*Calochilus richiae*; illegal collecting). For both flora and fauna, there are a large number of species whose estimated population trend is stable, inconclusive, unclear or variable and require ongoing monitoring.

xviii Threatened flora includes all species FFG listed on 30 June 2007, all species with status Vulnerable, Endangered, Critically Endangered or Extinct on the Victorian Advisory List 2005, and all species listed under the EPBC Act (1999) on 30 June 2007.

xix The Actions for Biodiversity Conservation (ABC) is a database system that has been designed and implemented by DSE to store information on the management of threatened species, communities and threatening processes across the State. It was first implemented in 2003, and currently contains information on approximately 200 species and communities at more than 2,000 locations across Victoria (see http://www.dpi.vic.gov.au/CA256F310024B628/0/3AD52F2A5D0C512ACA2572C6002468B0/$File/Introduction+to+ABC+April+2007.pdf)

Table LB3.5 Trends in populations of selected threatened fauna species
Source: Actions for Biodiversity Conservation database, DSE 2008 and other published sources

Common name	Scientific name	Location	Estimated trend*	Comments	DQ#
Eastern Bristlebird	*Dasyornis brachypterus*	Howe Flat, east of Mallacoota	U	Monitoring along transect lines has been undertaken at this site every 2–3 years since 1996. However, the number of observations is low compared to the total population, which, from entire survey results, is estimated to be 80 pairs. Hence, population trends may not be truly reflected in the monitoring data.	3
Major Mitchell's Cockatoo	*Cactatua leadbeateri*	Wyperfeld NP	Im	The population at Wyperfeld National Park is estimated to have increased over the past four years. Breeding pairs have been counted annually since 1995 and previously had declined from 1995 to 2003, probably as a result of illegal poaching.[236]	4
Swift Parrot	*Lathamus discolor*	Muckleford State Forest & NCR	S	Annual surveys across the State since 2000 indicate that the population is likely to be stable.	4
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Lake Eildon	Im	Breeding pairs on Lake Eildon are estimated to be increasing, based on a broadscale survey of the lake undertaken in 2005 and ad hoc observations since that indicate an expansion of the distribution of the species in the area.	2
Malleefowl	*Leipoa ocellata*	Eastern Big Desert	Ic	18 years of monitoring data across seven sites in the Mallee indicates that 2005 was a better breeding season than preceding years. However, breeding numbers are still lower than observed in the early 1990s. The number of active nests counted has been highly variable, and analysis of the data indicates that nest activity appears to be correlated with rainfall[237].	4
Red-tailed Black-Cockatoo	*Calypto-rhyncus banksii graptogyne*	Naracoorte and Casterton areas	Im	The population is widely distributed across Naracoorte and Casterton, where annual flock counts have been undertaken since 1998. Estimates of population size have been variable, although analysis of data on the annual number of breeding males provides evidence recruitment has increased since 1997.[238]	5
Brush-tailed Phascogale	*Phascogale tapoatafa*	Reef Hills SP Hepburn–Wombat State Forest Mount Pilot–Kinglake NP–Warrandyte SP Ararat–Dunneworthy–Muckleford State Forest Clunes State Forest	Ic	Regular monitoring for a number of Brush-tailed Phascogale populations has occurred since 2000. Whilst trapping of individuals has been successful each year that monitoring has been undertaken, the numbers have varied over time and population trends are difficult to discern without further analysis of monitoring data.	4
Brush-tailed Rock-wallaby	*Petrogale penicillata*	Snowy River National Park	Im	This very small population occurring in Snowy River National Park is estimated to have increased slightly since 2003, based on 10 years of monitoring. This species is difficult to detect and surveillance cameras, trapping and direct observations are all required to monitor the population.	4
Eastern Barred Bandicoot	*Perameles gunnii*	Woodlands Historic Park Mooromong Mount Rothwell	D (Woodlands) U (Mooromong /Mount Rothwell)	Woodlands HP - This population has declined from 600+ in 1996 to very low densities in 2006 due to fox predation and over-browsing of habitat by kangaroos. Mooromong - This population has persisted since introductions were made in the late 1990s, however population numbers are unknown. Mount Rothwell - This population was introduced to the site in 2004. The current population size is uncertain, although estimated to be about 50 animals.	4 (Woodlands) 3 (other sites)

Common name	Scientific name	Location	Estimated trend*	Comments	DQ#
Greater Long-eared Bat (south-eastern form)	*Nyctophilus timoriensis*	Nowingi	U	This species was first found at the site in 2004. Recent trapping in 2007 confirmed that animals were still present, with 9 individuals caught. However there is currently insufficient data to determine a trend.	2
Grey-headed Flying-fox	*Pteropus poliocephalus*	Melbourne - Yarra Bend Park	Im	The population has been determined to have increased based on an analysis of more than 20 years of monitoring and observational records dating back to the 1980s. The increase in the population from the 1980s-1990s is likely to be attributable to increased food resources or changed migration patterns.[239]	5
Heath Skink	*Egernia multiscutata*	South Big Desert	Im	The extent of the distribution of this species decreased after a fire in 2002, but has been observed to be increasing since then. More pronounced increases have occurred in the last 12 months.	3
Hooded Scaly-Foot	*Pygopus schraderi*	Lake Ranfurly - Lower Murray Water	U	Annual surveys conducted since 2003 have consistently recorded low numbers of individuals. It would appear that the population(s) of the Hooded Scaly-foot within the study area is at extremely low densities and that occupied habitat is patchy. A spread of age classes exists, indicating good heath, given this is a potentially long-lived species[240].	3
Striped Legless Lizard	*Delma impar*	Eppalock	S	A population at Eppalock is estimated to be stable, based on observations from monitoring over the last 9 years. However, as this species has consistently been caught in very low numbers this estimate is highly uncertain.	4
Mallee Worm-Lizard	*Aprasia aurita*	Wathe Flora and Fauna Reserve	D	Fifteen sites originally surveyed in 1993 were surveyed again in 2006 for the Mallee Worm Lizard. There was a 20-25% drop in capture rates for the period[241]. The decrease could be due to the effects of drought on the food supplies and habitat for this species.	3
Pink-tailed Worm-Lizard	*Aprasia parapulchella*	One Tree Hill, Bendigo	S	Based on four years of monitoring, the population located around One Tree Hill is estimated to be stable; however, further monitoring and analysis is required to determine if there is a significant population trend.	4
Corangamite Water Skink	*Eulamprus tympanum marieae*	13 populations in south- western Victoria	V	Two populations, one each at Lake Bolac and Deep Lake, both have a high probability of positive population trends. Of another 11 populations monitored in the Corangamite CMA, four populations have a high probability of being positive, one population has a significantly negative trend and six populations' trends are likely to be either stable or declining. Trends have been determined by a statistical analysis undertaken in 2005 based on nine years of monitoring data for each population[242].	5

Common name	Scientific name	Location	Estimated trend*	Comments	DQ#
Spotted Tree Frog	*Litoria spenceri*	Taponga River (Lake Eildon catchment)	V	Two populations, one each at Still Creek and Taponga River, were determined to be decreasing and stable (respectively), based on a scientific analysis of more than 10 years of monitoring data in 2004[243].	5
Baw Baw Frog	*Philoria frosti*	Baw Baw Plateau and escarpment	D	Populations on the Baw Baw Plateau above 1400 m appear to have declined, whilst populations between 960 and 1400 m appear to have remained relatively stable, based on an analysis of nine years of monitoring data in 2004[244].	5
Booroolong Tree Frog	*Litoria booroolgensis*	Burrowye Forest Creek	D	Prior to the 2006/07 drought the population was estimated to be stable. However, a significant decline is anticipated as a result of unprecedented drought effects in the locality, resulting in the stream drying up for a significant length of the extant section of creek. Due to the short (1-year) lifespan of the adult male this could result in catastrophic drought-induced decline[245].	5
Southern Purple-spotted Gudgeon	*Mogurnda adspersa*	Cardross Lakes, south of Mildura	E	This population has become extinct.	4
Barred Galaxias	*Galaxia fuscus*	Perkins Creek, Woods Point	Im	After the removal of predator species, the population in Perkins Creek increased and is currently estimated to be stable, based on a long-term monitoring program over 17 years.	4
Dandenong Amphipod	*Austrogammarus australis*	Dandenong Ranges	Im	Increase in abundance and slight increase in distribution was observed from 1995 to 1999.[246]	4
Sherbrooke Amphipod	*Austrogammarus haasei*	Dandenong Ranges	Im	Increase in abundance and slight increase in distribution from 1995 to 1999.[247]	4
Glenelg Spiny Crayfish	*Euastacus bispinosus*	Crawford River	D	The population at Crawford River is currently estimated to be declining, based on 20 years of monitoring data. No juveniles have been recorded since 2006. Fisheries Victoria is currently undertaking a three-year project to assess the status of the species. Fishing has been banned in the interim.	4
Golden Sun Moth	*Synemon plana*	Craigieburn Grassland Nature Conservation Reserve	U	Surveys since 2004 have recorded variable numbers of moths present - differences in survey effort between groups and differences in transect sizes between years mean that count figures for moths are not directly comparable. The variation highlights desirability to repeat surveys at a higher frequency.[248]	3
Eltham Copper Butterfly	*Paralucia pyrodiscus lucida*	Pauline Toner Reserve	Im	In 2002, three populations occurring on eucalypt woodland reserves in Eltham were estimated to be increasing, based on an examination of 15 years of monitoring data. However, the variability in population counts within and between years makes it difficult to interpret long-term population trends[249].	3

*Estimated Trend: Im=Improving, S=Stable, Ic=Inconclusive, V=Variable, U=Unknown, =Declining, E=Extinct.
Data Quality (DQ) Category=1 - Ad-hoc personal/other observations (Reliability=Low), 2 - One-off data collection/observations, 3 - Limited monitoring data (further monitoring required), 4 - Adequate monitoring data (analysis required), 5 - Adequate monitoring data + analysis and/or modelling (Reliability=High).

Table LB3.6 Trends in populations of selected threatened flora species
Source: Actions for Biodiversity Conservation database, DSE 2008 and other published sources

Common name	Scientific name	Location	Estimated trend*	Comments	DQ#
Maiden's Wattle	*Acacia maidenii*	Deasey's Cutting Rd, Bete Bolong	S	An assessment in 2006 described the population as very healthy, with evidence of recruitment and a good population structure.	2
Limestone Spider-orchid	*Caladenia calcicola*	Bats Ridge Wildlife Reserve	D	Annual monitoring of this population has indicated a significant decline, probably due to lack of fire and excessive browsing.	4
Crimson Spider-orchid	*Caladenia concolor*	Castle-maine Diggings National Heritage Park	Im	The population appears to be stable or increasing slightly, with the number of flowering plants observed increasing from 20 in 2003 to 28 in 2006. The maintenance or slight change in population numbers at this location may be due to the protective caging of individual plants. It is the only population of this species that has been observed to maintain its number of flowering plants through the drought years of 2003–2006.	4
Elegant Spider-orchid	*Caladenia formosa*	Meereek	U	This population has been monitored for nine years; however, further analysis of results is required to determine the population trend. The most recent monitoring results from 2006 indicated that the drought has led to very poor flowering, with only one seed capsule observed within the monitoring grid.	4
Mellblom's Spider-orchid	*Caladenia hastata*	Portland	Im	Fungal slide baiting and seed sowing around parent plants as well as translocations undertaken have been very successful, with more than 600 juvenile plants within the population in 2003. This population is being treated as a nursery population and trials are being run to establish extent populations. However no natural pollination is occurring and the long-term survival of the population is still dependent on artificial pollination being conducted.	4
Eastern Spider-orchid	*Caladenia orientalis*	Wonthaggi Heathland Reserve -site 1	Ic	This species occurs at two sites within the reserve. One is situated on a dune crest within relatively open vegetation and is meeting conservation targets for population growth. At the other site, which occurs in a dune swale where increased soil moisture promotes more vigorous vegetation growth, the population is predicted to decline to half its current size within eight years[250].	4
Frankston Spider-orchid	*Caladenia robinsonii*	Rosebud	D	Population hovering around 20 plants and the observed trend is continuing decline in population size and extent. The maximum dormancy period for this species is unknown and there is an insufficient population size for reliable statistical trend analysis. More years of monitoring data are needed to determine a reliable trend. It is likely that the drought is affecting seedling establishment and that past invasion of habitat by Coastal Tea-tree and habitat fragmentation have caused the population to decline.	3
Bald-tip Beard-orchid	*Calochilus richiae*	Rushworth	D	There has been an observed, steady decline in flowering plants at the known site, from approximately 20 plants seen in the early 1980s, to only one flowering plant in 1996[251]. Since then, between zero and four plants have flowered each year[252]. It is likely that illegal collecting of whole plants has contributed to this decline.	2
Swamp Sheoak	*Casuarina obesa*	Karadoc Swamp	D	Swamp Sheoak has declined at Karadoc Swamp over the past 20 years. Tree death may have occurred episodically prior to 1989, but since 1995 tree death has increased, moving west toward the aeolian-alluvial sediment fringe of the swamp. Aside from a few restricted stands, most living trees are considered to be in poor condition and the overwhelming majority of trees at Karadoc Swamp are dead.	4

Common name	Scientific name	Location	Estimated trend*	Comments	DQ#
Small Scurf-pea	*Cullen parvum*	Goulburn River, Chinamens Gardens	S	The population currently consists of 14 plants. As this is a perennial species there has been little annual variation observed since monitoring was initiated in 2001.	3
Late-flower Flax-lily	*Dianella tarda*	Bendigo/ Castlemaine	D	From a survey of all VicRoads roadsides in the Bendigo region undertaken from 2004-2006, populations were observed to be widely dispersed and sometimes consisting of fewer than 10 individuals. It is likely that threat from fire break construction, roadside destruction and browsing will cause population declines for this species.	2
Wedge Diurus	*Diuris dendrobioides*	Bonegilla	D	The population at Bonegilla has been determined to be stable or increasing, based on 16 years of monitoring data. However, the analysis also determined that there is a recent slightly negative trend, where it is likely that the effects of drought have contributed to growth rate decline[253].	5
Sunshine Diuris	*Diuris fragrantissima*	Sunshine	Ic	The population appears to be increasing since intensive management has been undertaken at the site.	4
Purple Diurus	*Diuris punctata var. punctata*	Mornington Tourist Rail Reserve (Nepean Hwy to Wooralla Drive)	D	Populations were observed to be stable, with slight fluctuations up until 2006. The drop in population numbers since then is probably due to non-targeted weed spraying and destruction of habitat by Swamp rats.	4
Small Golden Moths	*Diuris sp. aff. chryseopsis (Basalt Plains)*	Rockbank	Ic	Recent increases in plant numbers have been observed, and are probably due to changing weather patterns. However, not enough data has been systematically collected to analyse trends in the population as yet.	4
Trailing Hop-bush	*Dodonaea procumbens*	Bakers Rd, Talbot	Ic	There is currently insufficient data to determine a population trend. Parts of the population have been altered due to invasion of agricultural weeds over time.	2
Ben Major Grevillea	*Grevillea floripendula*	Troys Dam Rd, Beaufort	U	An original population of 200 plants was killed in a fuel reduction burn and, since then, approximately 100 new plants have recruited.	3
Anglesea Grevillea	*Grevillea infecunda*	Loves and Grevillea Track	V	Two locations within the Corangamite catchment are estimated to be stable, based on transect monitoring since 1997. At another site, also in the catchment, a slight decline has been observed, attributable to disturbance from trail bikes. Further work is required to determine the full extent of the species distribution in the general area.	4
Mallee Hemichroa	*Hemichroa diandra*	Nowingi freehold	Ic	The population has increased since 1991 due to replanting and vegetative growth from the original plant. However, the success of the replantings has been poor and the remaining plants are in relatively poor condition. Loss of replanted specimens is in part due to drought[254].	3
Basalt Peppercress	*Lepidium hyssopifolium*	East Bolwarrah Old School Site	D	A population at East Bolwarrah is estimated to be declining, based on more than 10 years of monitoring and observations. The observed decline is most likely to be attributable to severe weed invasion at the site.	4
Marble Daisy-bush	*Olearia astroloba*	Marble Gully	Iv	Monitoring was initiated in 2004 as part of a post-fire recovery study after the 2003 bushfires. Transect data indicates that plant density decreased and plant height increased.	4
Spiny Rice-flower	*Pimelea spinescens subsp. spinescens*	Hands Road	U	This species is a slow-growing plant and seedlings are rarely seen. An increase in population size, measured in both number of plants and area covered, would be something that could only be measured over decades.	3

Common name	Scientific name	Location	Estimated trend*	Comments	DQ#
Basalt Rustyhood	*Pterostylis basaltica*	Woorndoo	S	One small population at Woorndoo is currently estimated to be stable, based on 20 years of monitoring data. Artificial pollination and weed control have been undertaken to assist the population's survival.	4
Turnip Copperburr	*Sclerolaena napiformis*	Creswick Swamp	Im	The number of individuals at Creswick Swamp has been observed to increase, based on population counts made over the last nine years; however, further monitoring is required to measure the survival of new plants in the population.	4
Stiff Groundsel	*Senecio behrianus*	Grinter Road, Carag Carag	Ic	This population has been monitored for the last 15 years. The appearance of plant stems has been observed to fluctuate with rainfall and a trend cannot be determined due to the population variability.	4
Red Swainson-pea	*Swainsona plagiotropis*	Hunter Unused Rail Reserve	D	Surveys found that there were 10 fewer plants in 2006 than 2005. Plant condition has also declined and drought has been observed to be a factor in the number of plants to reappear.	3
Whipstick Westringia	*Westringia crassifolia*	Greater Bendigo National Park (Kamarooka section)	Im	The increase in population size has a direct link to the fencing of all populations over the last five years and therefore removing the grazing pressure.	4

* Estimated Trend: Im=Improving, S=Stable, Ic=Inconclusive, V=Variable, U=Unknown, D=Declining.
# Data Quality (DQ) Category=1 - Ad-hoc personal/other observations (Reliability=Low), 2 - One-off data collection/observations, 3 - Limited monitoring data (further monitoring required) 4 - Adequate monitoring data (analysis required), 5 - Adequate monitoring data + analysis and/or modelling (Reliability=High).

Indicator LB20 Input into flora and fauna databases

Biological surveys are crucial to any assessment of the conservation status and distribution of a species. For animal species, and particularly vertebrates, the main repository for such information is the Atlas of Victorian Wildlife, administered by the Department of Sustainability and Environment. There have been three main peak periods for fauna surveys: 1978–1981, which produced surveys to inform Land Conservation Council (LCC) investigations; the LCC pre-logging surveys in 1986–1994; and 1999–2002, when the New Birds Australia Atlas data became available (see Figure LB3.1). The mid- to late 2000s has seen a dramatic drop in the data being collected and entered into the system. The majority of records in the Atlas are for birds, with relatively few for fish and invertebrates (see Figure LB3.2).

The Victorian Flora Information System incorporates information from vegetation surveys, herbarium specimens, pest plant databases, professional and amateur collecting trips and a range of non-structured surveys. There have been three general surges in collection effort[255] (see Figure LB3.3). The first was in 1973 when ecological survey work was undertaken by botanists at Monash University and the University of Melbourne on heathlands, woodlands and salt marshes south-east of Melbourne and the catchment of the Macalister River in the central highlands[256]. From 1978 to 1980, ecological survey and mapping work in the catchments of the Yarra River, Western Port and the Gippsland Lakes, East Gippsland, the alpine regions and the Grampians was undertaken by National Herbarium botanists[257]. The third peak was from 1986 to 1993, when the (then) Department of Conservation and Natural Resources conducted a number of forest-oriented ecological surveys for the purposes of planning native forest management and timber resource allocation, mainly in East Gippsland. The Mallee, the Goldfields, Greater Melbourne, the Basalt Plains and Victorian wetlands have also formed the basis for a significant amount of ecological effort[258]. There has been a steady decline in flora records being entered into the system since the late 1990s.

Species data collection and storage

At present, information on species distribution (both native and exotic) is held across a range of institutions, in a range of databases with limited compatibility and limited accessibility to the public and to some agencies charged with species management. Public institutions such as the Department of Sustainability and Environment, Department of Primary Industries, Museum Victoria, and National Herbarium of Victoria all hold extensive datasets on species distribution. Birds Australia also holds extensive datasets on bird abundance and distribution. Having dispersed and non-integrated datasets and databases hampers comprehensive assessments of species distribution and abundance and, thus, conservation status in Victoria.

Recommendations

LB3.2 The Victorian Government nominate a central data agency to integrate existing species distribution datasets, facilitate the integration of future datasets and make all data available to the agencies with responsibility for managing threatened species.

LB3.3 The Victorian Government support an enhanced strategic, coordinated and ongoing level of survey effort for Victoria's flora and fauna so that the distribution and conservation status of Victoria's plant and animal species can be confidently determined and resources allocated to species conservation in a cost-effective manner.

Figure LB3.1 Collection dates for fauna records entered into the Atlas of Victorian Wildlife
Source: Department of Sustainability and Environment 2008, from the Atlas of Victorian Wildlife

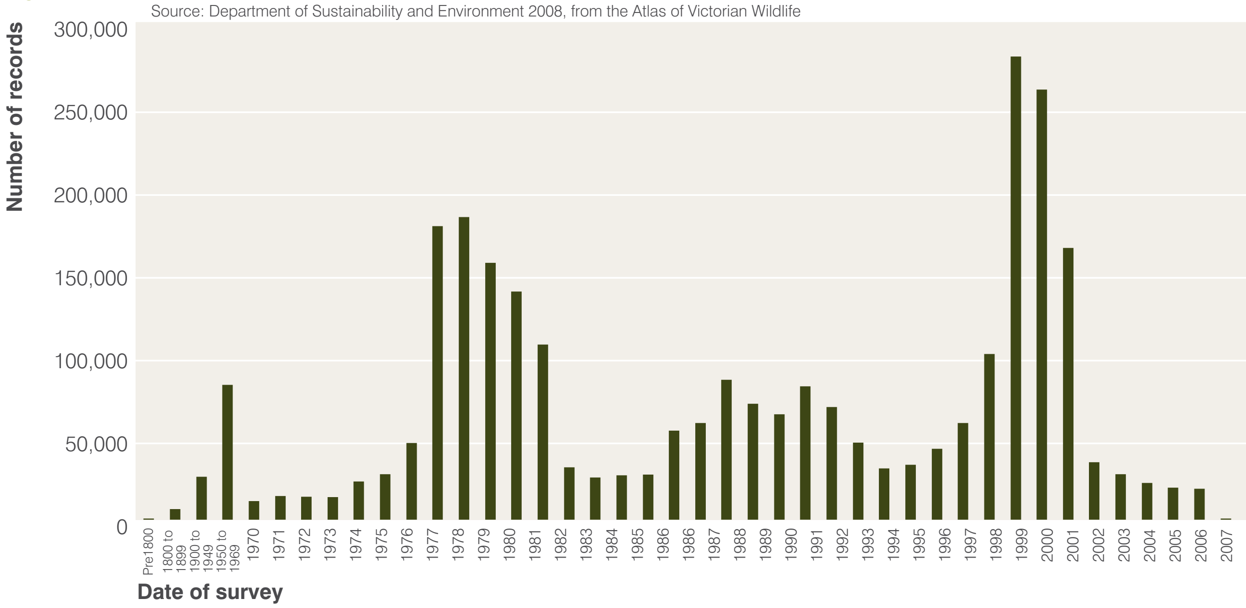


Figure LB3.2 Number of records for fauna taxa group in the Atlas of Victorian Wildlife in January 2008
Source: Department of Sustainability and Environment 2008, from the Atlas of Victorian Wildlife

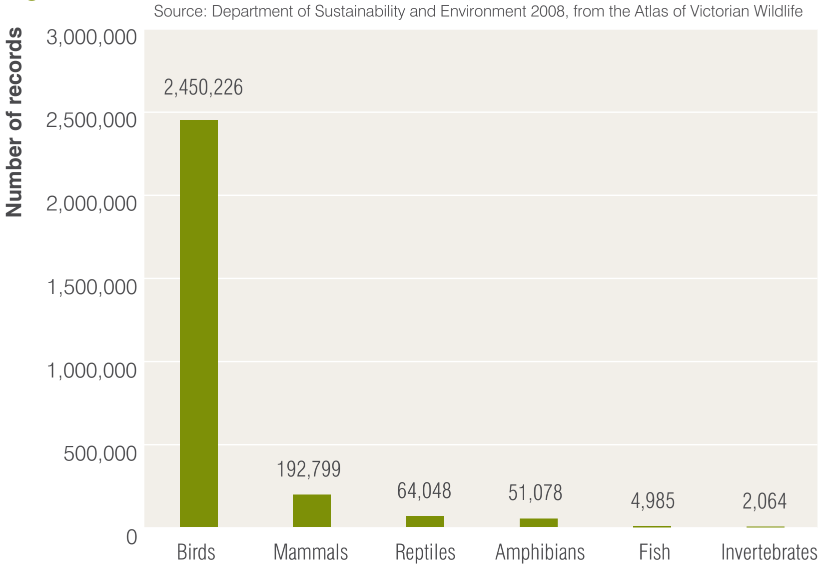
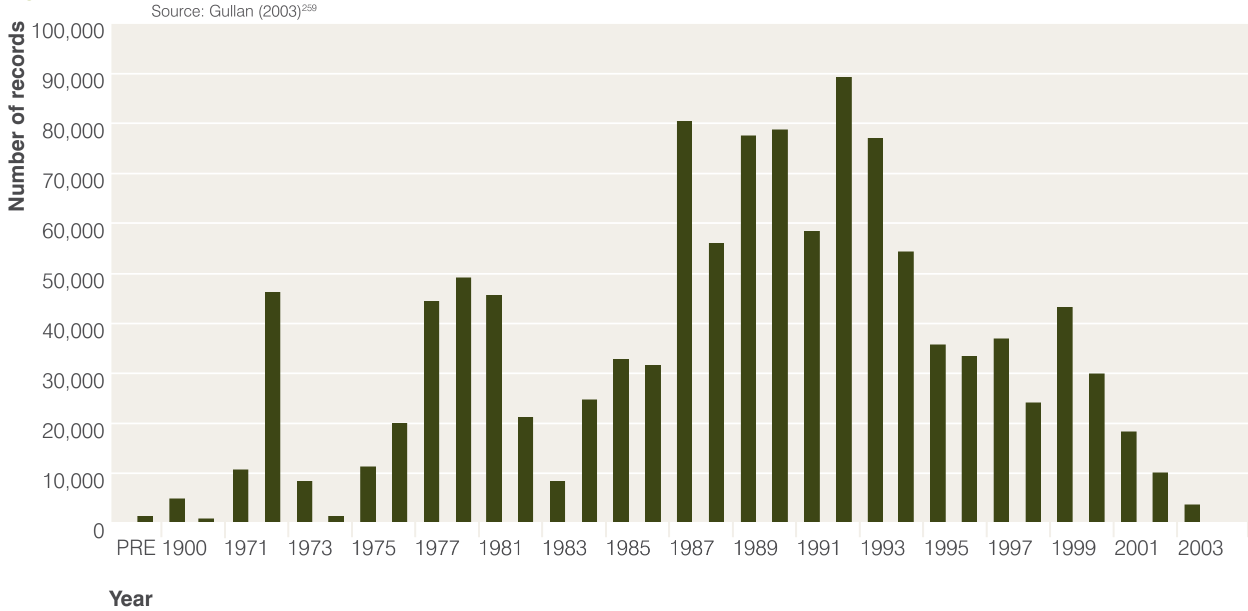


Figure LB3.3 Collection dates for flora records entered into the Flora Information System to 2003
Source: Gullan (2003)[259]



Pressures

Indicator LB21 Impact of threatening processes on native species

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

As at December 2007 there were 37 'Potentially Threatening Processes' listed under the *Flora and Fauna Guarantee Act 1988*. The Actions for Biodiversity Conservation (ABC) database system currently contains information on approximately 200 threatened species and communities at more than 2,000 locations across Victoria. Weed invasion, habitat loss, inappropriate fire regimes and grazing are the four most commonly identified threatening processes posing immediate threats for species in the ABC, with between 70 and 90 species affected (see Figure LB3.4). However, the relative impact of particular threatening processes varies between flora and fauna. For example, weed invasion and grazing were considered threats mostly for plant species, whereas predation by introduced species affected only fauna. Habitat loss threatened a similar number of threatened plant and animal species.

Although disease is identified as an immediate threat for only a small number of threatened species, some diseases have important impacts on specific species or groups of species. For example, the spread of Cinnamon fungus (*Phytophthora cinnamomi*), which causes a dieback disease in *Eucalyptus* trees, is listed as a threatening process in the *Flora and Fauna Guarantee Act 1988*, as is the infection of amphibians with Chytrid fungus. This fungus is known to affect the critically endangered Spotted Tree Frog (*Litoria spenceri*)[260].

Climate change is not yet listed as a potentially threatening process under the *Flora and Fauna Guarantee Act*, but it has been identified as a threat for several especially vulnerable species (see Figure LB3.4). This emerging threat is likely to be defined for more species in future as its impacts on biodiversity are better understood (see section LB9 Impacts of climate change on land and biodiversity). It will be important to update threatened species Action Statements to account for threats posed by climate change.

Although not listed as an active and immediate threat in the ABC, land use change is an overriding threat for many threatened species.

Implications

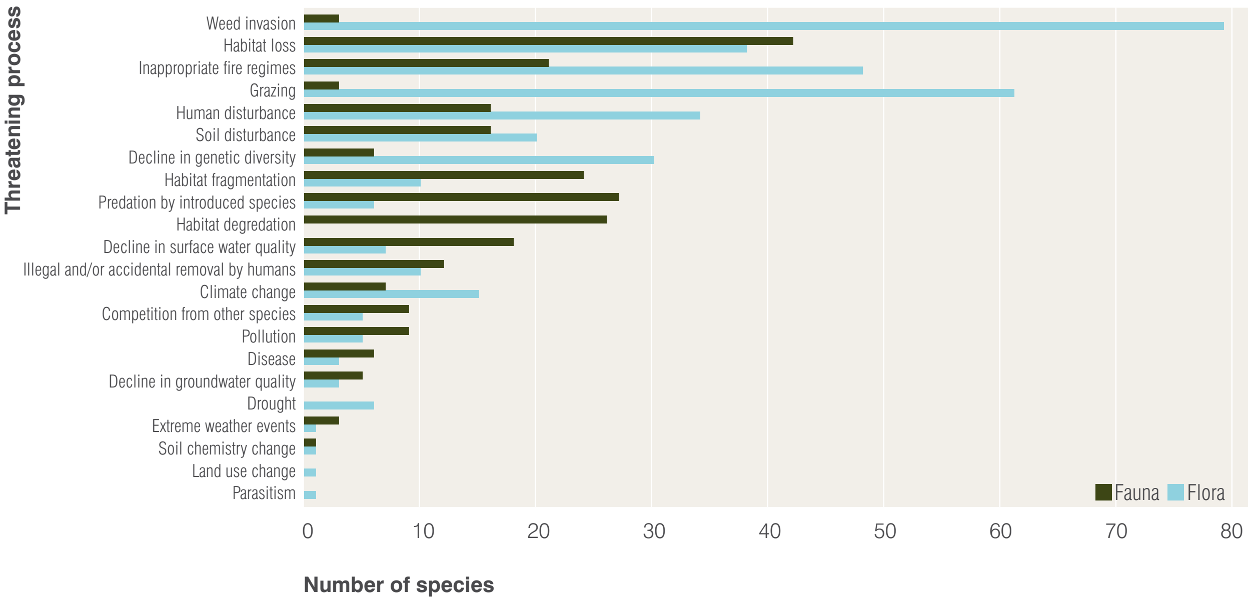
Ecosystem processes

The loss or decline of species from an ecosystem has potentially significant consequences for the function of that ecosystem. A detailed understanding of the relationships between species and ecosystem processes is limited to a relatively small number of species, but such processes include pollination, nutrient cycling, maintenance of soil fertility and predator–prey relationships. The impact of the extinction of the 24 vertebrate species from Victoria (18 of which are mammals) and 51 species of plants on ecological processes and the ecosystem services they provide is largely unknown. Local declines and extinctions of species from particular regions, which are continuing to occur, are also likely to impact on ecosystem processes.

In addition to the immediate impacts of species decline and loss on ecosystem processes, the decline of species potentially limits future possibilities for adaptation to change by reducing ecosystem resilience. One means by which ecosystems achieve resilience to change, i.e. the ability to absorb disturbance and re-organise itself so as to retain essentially the same structure and function[261], is by having a number species performing similar functions, so that populations may fluctuate without producing substantial changes in ecosystem function. The loss of species or populations from an ecosystem reduces this functional redundancy and means that the ecosystem has fewer options for adapting to future changes, such as climate change. See also Part 5 Living Well Within Our Environment.

Figure LB3.4 Number of threatened flora and fauna species affected by threatening processes as listed in the Actions for Biodiversity Conservation database[xx]

Source: Actions for Biodiversity Conservation database, Department of Sustainability and Environment 2008



xx This does not represent all threatened species and does not necessarily represent all threatening processes affecting all populations. Only threats identified as having a moderate-catastrophic impact are included. Includes vertebrate and invertebrate fauna.

Economic Impacts of Recovery Actions

Expenditure on threatened species programs are increasing in many countries; however, evaluation of the effectiveness and cost-efficiency of these programs rarely occurs[262]. In Victoria, where Action Statements must be prepared for species listed under the FFG Act, and Recovery Plans under the EPBC Act, considerable resources are devoted to researching, planning and undertaking management actions to stabilise or improve the species populations.

Allowing species to decline to a state where their only hope of survival is a captive breeding program increases the cost of recovery efforts[263]. Although some *in situ* conservation efforts can be costly, the emphasis on habitat protection means that multitudes of species beyond particular target species are simultaneously conserved[264].

The Victorian Government's Green Paper, *Land and biodiversity in a time of climate change*, recognises the value and effectiveness of habitat preservation and proposes to 'build threatened species habitat into the process of identifying and prioritising assets in the landscape'. In this way not only will threatened species protection be built into market-based instruments for land management, but in addition all species supported by the target habitat or ecosystem will benefit, rather than just the individual threatened species. The Green Paper also focuses on increasing the resilience of critical habitats to facilitate adaptation to climate change and maximise species survival[265].

Resources allocated to recovery efforts for individual species vary in Victoria based on the species requirements, the level of threat and, in some instances, its level of public profile. For example, resources proposed for allocation to the state bird emblem, the Helmeted Honeyeater between 1999 and 2003 were estimated to be $1,675,600[266] and a further $2,443,500 for the five years from 2008[267], while the Euroa Guinea-flower (*Hibbertia humifusa* subsp. *erigens*) was allocated only $354,000 for the five years from 2006[268]. A more effective allocation of the limited resources available for biodiversity conservation, i.e. one that minimises overall species loss, is achieved by allocating resources to recovery actions such that for each additional dollar spent, the increase in viability is equalised across all threatened species[269].

Management responses

Current government responses to threatened species should acknowledge and address the legacy of historic vegetation clearing, ongoing processes threatening biodiversity and future threats, especially from climate change and land use change. Climate change is likely to bring about rapid changes in some habitats, and measures to protect threatened and endangered species will need to be adequate in timing and scale.

Threatened species are at risk from a broad range of threatening processes, so management responses should address the key objective: *to improve the conservation status of Victoria's flora and fauna*. Threatened species legislation at State and Commonwealth levels is the cornerstone of threatened species protection.

Response name
Flora and Fauna Guarantee Act 1988

Responsible authority
Department of Sustainability and Environment

Response type
Legislation

The *Flora and Fauna Guarantee Act 1988* (FFG) is one of the primary pieces of State legislation protecting biodiversity in Victoria. The FFG Act aims to conserve Victoria's communities of flora and fauna and genetic diversity, and to manage potentially threatening processes. It also has an education component, aiming to ensure sustainable use of flora or fauna by people and to encourage co-operative management of flora and fauna.

The FFG Act provides for listing of threatened species and ecological communities and identification of potentially threatening processes. There are 229 animal species, 308 plant species and 36 communities of flora and fauna listed as threatened, and 37 potentially threatening processes have been identified. Action Statements (=Recovery Plans) have been approved for 158 animal and 110 plant species or groups of species; however, many species listed as threatened under the FFG Act have no Action Statements. A further 25 draft Action Statements are in preparation.

The primary objective of this Act is 'to guarantee that all taxa of Victoria's flora and fauna can survive, flourish and retain potential for evolutionary development in the wild', but the number of threatened species in Victoria increased between 2002 and 2007[xxi] and not all have Action Statements. Populations of some threatened species have continued to decline, including many with Action Statements.

The objectives of the FFG Act reflect Victorian and Australian obligations under the Convention on Biological Diversity; however, they imply a very high aspiration that is unlikely to be satisfied at the current levels of investment in biodiversity protection and in the context of the projected impacts of climate change. The *Land and biodiversity in a time of climate change* Green Paper indicates that the primary goal of the FFG Act is, 'probably beyond our management capacity and could be revised to a more realistic objective'[270].

Climate change is real and inevitable for Victoria (see Part 4.1 Atmosphere) and natural ecosystems are highly vulnerable to small changes in temperature (see section LB9 Impacts of Climate Change on Land and Biodiversity). Some of Victoria's threatened species are at high risk of extinction under a warmer climate and have very limited adaptive capacity (see section LB9 Impacts of Climate Change on Land and Biodiversity). In this situation a useful role for the FFG Act is to address the risks that are within the Victorian Government's ability to control, while acknowledging that climate change itself lies largely beyond Victoria's control. Legislative objectives that facilitate an improved understanding of Victoria's natural ecosystems and their vulnerabilities to climate change, and that maximise the adaptive capacity of Victoria's native species, e.g. by building vegetation and landscape connectivity, may be more realistic and beneficial than attempting to guarantee survival of all species.

xxi This does not represent all threatened species and does not necessarily represent all threatening processes affecting all populations. Only threats identified as having a moderate-catastrophic impact are included. Includes vertebrate and invertebrate fauna.

Recommendations

LB3.4 The Victorian Government should ensure that current Action Statements are prepared for all species listed under the *Flora and Fauna Guarantee Act*, and that all Action Statements include an assessment of threats from climate change.

LB3.5 The Victorian Government should review the *Flora and Fauna Guarantee Act* and resources allocated to it to ensure maximum effectiveness in protecting Victoria's biodiversity within the constraints of unavoidable and projected climate change. This process should include a review of the Act's objectives, the interactions between the FFG Act and other legislation to protect a maximum number of species across all land tenures, and extensive consultation with the Victorian community about the biodiversity implications of any proposed changes. Climate change should be declared a threatening process under the *Flora and Fauna Guarantee Act.*

LB3.6 The Victorian Government should provide sufficient resources to implement a suite of tools to achieve biodiversity conservation.

LB3.7 The Victorian Government should work with the Commonwealth Government to ensure adequate maintenance of lists of threatened species and ecological communities, and consistency of such lists between State and Commonwealth threatened species legislation.

Response name
Environment Protection and Biodiversity Conservation Act 1999

Responsible authority
Australian Government Department of the Environment, Water, Heritage and the Arts

Response type
Legislation

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally significant flora, fauna, ecological communities and heritage places – defined in the Act as matters of national environmental significance. The EPBC Act aims to protect nationally threatened species and ecological communities by providing for:

- identification and listing of species and ecological communities as threatened
- development of conservation advice and recovery plans for listed species and ecological communities
- development of a register of critical habitat
- recognition of key threatening processes
- where appropriate, reducing the impacts of these processes through threat abatement plans.

The EPBC Act requires that a person who proposes to take an action that will have, or is likely to have, a significant impact on a threatened species or ecological community to refer that action to the Australian Minister for the Environment for a decision on whether assessment and approval is required under the Act. Substantial penalties apply for taking such an action without approval. A 'significant impact' is defined differently for species listed as vulnerable and those listed as endangered or critically endangered[271] but 'significance' can be open to interpretation[272].

Unlike the FFG Act, the EPBC Act's provisions for threatened species apply equally across public and private land. However, the EPBC Act has received criticism for its failure to maintain adequate lists of threatened species and ecological communities[273], its focus on vertebrates and vascular plants[274] and the slow process for decisions on nominated species and ecological communities[275]. The Australian Auditor General concluded that the resources allocated to the EPBC Act limit achievement of its objectives given the scale of the prescribed tasks required by the legislation and the technical requirements for assessing, protecting and conserving over a thousand individual species and hundreds of ecological communities[276].

Evaluation of threatened species responses

Poor resourcing, implementation and enforcement of the FFG Act are considered to be key factors in its poor performance[277,278]. A general lack of application of the Act on private land and its poor enforcement provisions limit its usefulness in protecting biodiversity across the landscape. The identification and declaration of 'Critical Habitat', which could potentially see threatened flora or fauna habitat protected on private land, has been used only once in 20 years, while Interim Conservation Orders have never been used. The current taxon listings under the FFG Act are skewed towards vascular plants and vertebrates, with only a minor representation of invertebrates, non-vascular plants and other groups[279].

The lack of focus on invertebrates is important, given the poor protection offered to invertebrate species through other legislative instruments. The *Wildlife Act 1975* protects all native vertebrate species (and specific game species), and prescribes the activities that may be carried out with a permit. The *National Parks Act 1975* protects all species that occur in National Parks. However, other than the FFG Act, there is no legislative protection for invertebrate species on private land.

A lack of recognition of climate change as a key threatening process in the *Flora and Fauna Guarantee Act* is a further limitation on its likely effectiveness in the future, given the projected magnitude of climate change impacts on Victorian species generally and threatened species in particular (see section LB9 Impacts of climate change on land and biodiversity).

Besides specific threatened species legislation, a number of pieces of legislation and policy also directly seek to protect threatened species. Much of the provisions relating to vertebrate species are contained in the *Wildlife Act 1975*. The *Wildlife Act 1975* aims to protect and conserve wildlife and the prevent taxa of wildlife from becoming extinct, as well as promoting the sustainable use of and access to wildlife and regulating wildlife-related activities, e.g. restrictions on capturing native species. In the context of the *Wildlife Act*, wildlife refers to all Australian indigenous vertebrate taxa, deer, non-indigenous quail, pheasants and partridges and any taxon of invertebrates listed under the FFG Act. Thus this Act refers to exotic as well as native species, and applies only to those invertebrate taxa already listed under the FFG Act, which is known to under-represent invertebrates[280].

The *Native Vegetation Management Framework* (2002) emphasises the importance of an area of vegetation as habitat for one or more threatened species when assigning a conservation significance rating to that area of vegetation. The conservation significance of vegetation is used to determine whether or not an area may be cleared and/or the extent of the offset required. This approach is consistent with the idea that habitat protection is the most effective means of biodiversity conservation and has the advantage of protecting all species within the habitat, not just the identified threatened species.

The establishment and legal protection of various categories of parks and reserves provides important habitat protection for a variety of threatened species. The *National Parks Act 1975* provides for protection of the natural environment in National Parks, State Parks, Marine National Parks and Marine Sanctuaries, and preservation of indigenous flora and fauna in the parks. This Act is also consistent with the notion of protecting biodiversity by conserving habitat in reserved areas. However, as many species are threatened because of historic and/or ongoing clearing in regions dominated by private land, parks and reserves, such protection will have a limited role in these landscapes. Private land habitat protection mechanisms (such as those outlined in section LB1 Vegetation loss and modification, Response indicator LB8: Area and number of properties involved in private vegetation conservation mechanisms) increasingly target properties with threatened species and ecological communities, but their effectiveness is limited by the voluntary nature of such agreements and by the limited funding these programs receive.

The implementation of market-based instruments such as EcoTender, targeting vegetation management for environmental services, including biodiversity protection, is aimed at encouraging the retention and restoration of habitat. These instruments offer land holders the opportunity to derive an alternative income stream from management of vegetation for biodiversity objectives. Success with this approach for native vegetation management has been demonstrated in BushTender trials, but its applicability to threatened species protection is yet to be shown.

Key response indicator: Number of threatened species

Recommendation

LB3.8 The Victorian Government should prioritise incentives to improve the status of biodiversity on private land. This could be achieved by expanding market-based incentive programs such as BushTender and EcoTender, which provide biodiversity benefits from vegetation management and deliver a reliable alternative income stream to land holders.

For further information

Flora and Fauna Guarantee Act 1988: http://www.dse.vic.gov.au/DSE/nrenpa.nsf/LinkView/0488335CD48EC1424A2567C10006BF6DB4F254CBD292B50F4A256817002AFF40

Environment Protection and Biodiversity Conservation Act 1988: www.environment.gov.au/epbc/index.html

Photo: Courtesy of Melbourne Zoo

LB4 Pest plants and animals

Key findings

- Pest species continue to establish in Victoria and pose a major threat to biodiversity, primary production and the aesthetics of natural landscapes.
- Weeds affect all Victorian landscapes. Approximately 90% of the native bushland in Melbourne is badly affected by weeds, with more than 50% considered severely degraded. Almost 80% of recently recorded plant naturalisations in Victoria are of garden origin.
- The economic impact of invasive species is high. The total cost of pest species in Victoria is estimated at $900 million per year. Costs associated with control of pest species compromise resources available for other resource management activities.

Description

The introduction and establishment of non-native plant and animal populations in Victoria has been both deliberate and accidental. These include deliberate introductions for the purpose of hunting (rabbits (*Oryctolagus cuniculus*), foxes (*Vulpes vulpes*)), food (Blackberry (*Rubus fruticosus*)), biological control of other pests (e.g. Common Myna (*Acridotheres tristis*)), escapees of agricultural crops or horticulture (e.g. Toowoomba Canary Grass (*Phalaris aquatica*), Radiata Pine (*Pinus radiata*)) or from households (e.g. feral cats (*Felis catus*), many environmental weeds). When these species have naturalised and become established, they have often had negative impacts on natural ecosystems and the species that rely on them, as well as significant economic and social impacts.

Pest plants and animals can have significant negative impacts on primary production systems as well as on peoples' enjoyment of natural systems. The cost of managing weeds on Victorian farms was $20,701 per 1,000 ha in 2006/2007 – the highest in Australia, while the cost of managing pests was second only to Tasmania at $12,198 per 1,000 ha[281]. Pest plants have the potential to invade native plant communities, displacing native flora and changing the structure of those communities. Preventing the naturalisation of potentially invasive plant species will be increasingly challenging.

Weeds rate second only to habitat loss as a threat to Victoria's biodiversity and invasion of native vegetation by weeds is listed as a potentially threatening process under the *Flora and Fauna Guarantee Act 1988*. Weeds may include: environmental weeds, which threaten natural ecosystems and may reduce biodiversity; agricultural weeds, which threaten crops, horticulture, pasture production and may be toxic to livestock; or both. The focus of this report is on environmental weeds. Weeds have invaded all Victorian landscapes and are a concern across all land tenures, affecting bushland, rangeland, coasts, forests, farms and urban environments. Fourteen of Australia's Weeds of National Significance are known to be present in Victoria.

Pest animals threaten biodiversity by modifying habitat through browsing, introducing weeds, promoting erosion or directly preying on native fauna. Key pest animal species in Victoria include the Red Fox, rabbits, feral cats and wild dogs. Although this section primarily deals with exotic species (i.e. those not indigenous to Victoria), some native species, particularly plants, can also become pests if planted outside of their natural range or if particular natural processes are disrupted (see Box LB4.1).

Objectives

- To limit the introduction of new exotic species
- To reduce the impacts of pest species on native and agricultural systems and make best efforts to ensure no new exotic species reach pest status

Links

See also: Land and Biodiversity – Vegetation loss and modification, Contemporary land use change, Impacts of climate change on land and biodiversity, Salinity, Fire in the Victorian environment.

Box LB4.1 Sweet Pittosporum – a native environmental weed

Sweet Pittosporum (*Pittosporum undulatum*) is a native plant species with the potential to spread beyond its natural range, which in Victoria is in areas east of Westernport and south of the Great Dividing Range. It is not native to the Melbourne area but its popularity as a garden plant has facilitated its escape from gardens into adjacent forest areas, such as Sherbrooke Forest[282].

Sweet Pittosporum is considered an environmental weed for its ability to damage local plant communities but is not listed as a noxious weed. Its impacts on eucalypt forests include increased plant competition, shading and increased soil moisture, resulting in loss of local biodiversity. The establishment of this species outside its natural range has been assisted by fire suppression at the urban fringes, as Sweet Pittosporum is sensitive to fire.

The current distribution of Sweet Pittosporum includes areas north and east of Melbourne, the Mornington Peninsula, extending east to the NSW border, and along Victoria's south eastern coast between Geelong and Lorne, with a cluster of infestations around Portland[283]. The potential distribution of this species extends throughout eastern Victoria with scattered areas of potential infestation throughout central and western Victoria[284].

State

Indicator LB22 Number of introduced plant and animal species in Victorian bioregions

The number of introduced plant species recorded in Victorian bioregions remained relatively constant between 1990–1999 and 2000–2007 (see Figure LB4.1). Bioregions with the greatest number of introduced species were the Gippsland Plain, Victorian Volcanic Plains and Highlands–Southern Fall. These three bioregions meet in the Greater Melbourne district, and the higher species numbers recorded in these regions is likely to be due to a combination of naturalisations of escaped garden plants and higher survey efforts. New and emerging species are unlikely to be recorded unless specifically searched for and survey effort may not be consistent between periods, so such comparisons should be treated with caution.

The number of introduced vertebrate species recorded in Victorian bioregions also remained relatively constant between 1990–1999 and 2000–2007 (see Figure LB4.2). As for introduced flora, the Victorian Volcanic Plain, Gippsland Plain and Highlands–Southern Fall had the highest number of introduced vertebrate species recorded (see Figure LB4.2). However, the differences in numbers of species across bioregions were not as great as for flora.

For both introduced pest plant and animal species, lowest numbers of species were recorded in the Highlands–Far East and Monaro Tablelands bioregions (these bioregions also have small numbers of threatened species), probably due to their remoteness, having relatively intact native vegetation and lower survey effort. Again, variations in survey effort and geographical spread of effort are likely to influence these records.

In addition to the number of vertebrate species in Figure LB4.2, a high number of exotic invertebrate species have been accidentally or deliberately introduced into Victoria[285]. More than 500 exotic species of insects and arachnids have become established in Australia[286,287].

Figure LB4.1 Number of introduced plant species recorded in Victorian bioregions between 1990–1999 and 2000–2007
Source: Derived from Flora Information System (Department of Sustainability and Environment 2008)

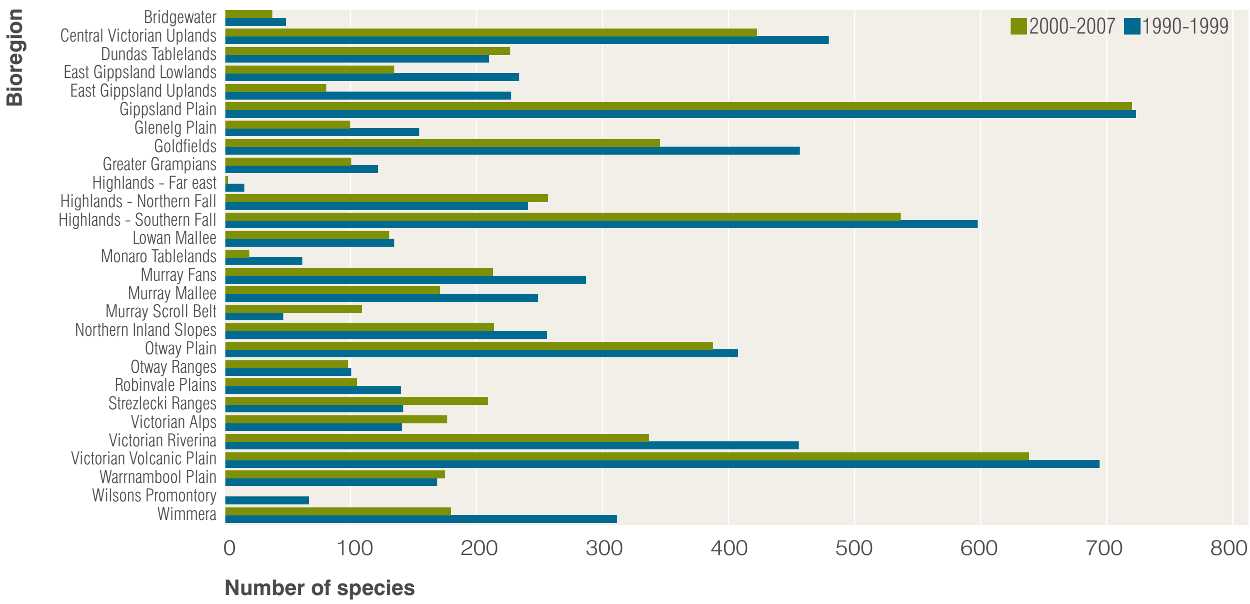
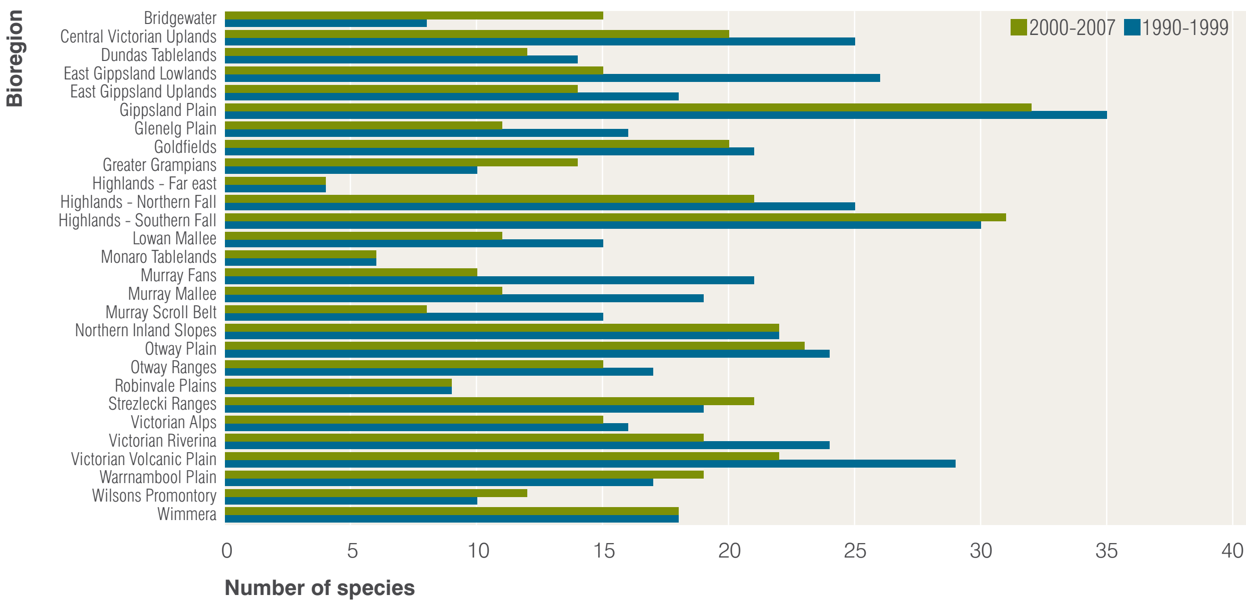


Figure LB4.2 Number of introduced vertebrate species recorded in Victorian bioregions between 1990–1999 and 2000–2007
Source: Derived from Victorian Fauna Database (Department of Sustainability and Environment 2008)



Pressures

Indicator LB23 Trends in populations of invasive plant species

Exotic species represent approximately 30% of the Victorian flora,[xxii] with 1,282 species considered naturalised and a further 214 species considered incipiently naturalised in Victoria[288,289]. This has increased from 878 naturalised species in 1984 (see Figure LB4.3). It is estimated that an average of 7.3 new plants establish in Victoria per year, and this number is increasing by a rate of 0.25 plants per year[290]. Almost 80% of recently recorded naturalisations in Victoria are of garden origin[291,292]. The area occupied by naturalised species increases annually[293] and the increase in the distribution of some species has been dramatic (for example, the aquatic weed Arrowhead (*Saggitaria graminea*), see Part 4.3 Inland Waters). Nevertheless, 15 of Victoria's 25 State Prohibited weeds have shown improvement (decrease in infestations or traded less frequently) or no change in occurrence between 2002 and 2007[294].

Substantial potential exists for increases in distribution of some of Victoria's priority weeds based on modelling of climate, land use and vegetation types[295]. Climate change is likely to facilitate the spread of weeds and may alter the distributions of some weed species.

Indicator LB24 Trends in populations of pest animals

Most pest animals occur and are managed on local scales and data on pest animal populations are mostly collected for the specific purpose of monitoring the impacts of local pest control activities. For this reason there are no statewide data on trends in populations of pest animals and the quantity of data reflects the level of investment in individual species.

The first efforts to map occurrence of key animal pest species were published by the Victorian Catchment Management Council in 2007. These maps are based on a number of Victorian datasets supplemented by regional expert opinion, and provide a very coarse indication of statewide occurrence of the key pest species (foxes, rabbits, feral pigs and wild dogs). While foxes and rabbits are widespread throughout Victoria, wild dogs and feral pigs are absent or unknown over large areas of Victoria. Wild dogs occur mainly in East Gippsland and north-eastern Victoria, as well as in the southern Mallee, while feral pigs are localised to relatively small areas, mostly in eastern Victoria[297].

Implications

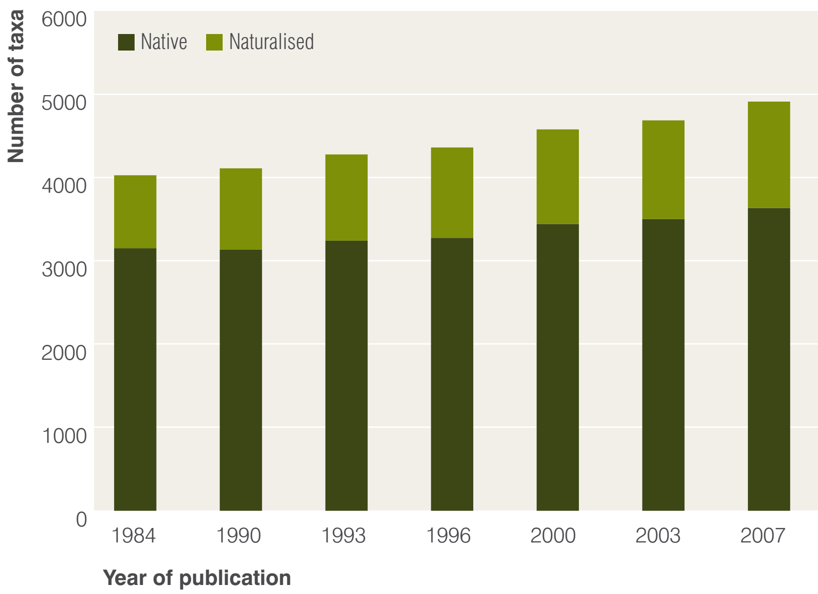
Ecological impacts of invasive species

Environmental weeds and pest animals threaten biodiversity and disrupt ecosystem processes and function. Plant invasions are considered one of the major factors in the loss of biodiversity, along with land-clearing and climate change[298,299]. In addition to threatening native flora and fauna, environmental weeds have other impacts on ecosystem function, including: changing hydrological cycles, which leads to increased soil erosion, alteration of soil chemistry and nutrient cycling patterns; alteration of geomorphic processes (e.g. dune configuration), and alteration of stream flow and flooding characteristics (e.g. willow invasion of streams)[300]. Weeds are an important and costly issue across all Victorian landscapes and tenures.

Some weeds can have multiple impacts. For example, Toowoomba Canary Grass is a very serious weed of grasslands, dry forests and woodlands, out-competing most understorey species and reducing habitat for native fauna, such as the Grey-crowned Babbler (*Pomatostomus temporalis*)[301]. Furthermore, the grass has a high biomass and thus changes the fire regime of areas invaded, resulting in more intense fires[302] (see section LB8 Fire in the Victorian environment).

Approximately 90% of the native bushland in Melbourne is badly affected by weeds, with more than 50% severely degraded by weeds[303]. This is in large part due to garden escapees – a major source of weeds in Victoria.

Figure LB4.3 Native and naturalised vascular plants in Victoria as published in the Census of Vascular Plants in Victoria
Source: Adapted from Statjsic and Vaughan (2007)[296]



xxii Including species and subspecies.

The impacts that predators such as foxes and cats have on native fauna are significant and inflict large costs[304]. Eradication of established pest species is extremely difficult; nevertheless, co-ordinated ongoing management can have positive outcomes for biodiversity. The impact of ongoing targeted and strategic control methods for foxes has had positive impacts for ground-dwelling mammals in East Gippsland such as the Long-nosed Potoroo (*Potorous tridactylus*) (see Figure LB4.1)[305]. Predation by foxes, cats and dogs is a known threatening process for at least 26 species of threatened fauna in Victoria (Figure LB3.6) and is now one of the main threats that places the remaining populations of the critically endangered Eastern Barred Bandicoot at risk of extinction. Most bandicoots now survive within fox- and cat-proof reserves. However, the relationship between foxes and feral cats, especially in relation to control of either or both species, and the associated impacts on native species and ecological communities and rabbit populations is still not clear[306].

Aside from direct predation, pest animals also compete with native species for food and habitat. Ecosystem function impacts include erosion and associated water quality declines due to soil disturbance from burrowing, grazing and the action of hard hooves (e.g. deer, goats) and the spread of disease and parasites. Rabbits pose a particular threat to native vegetation, as they prevent regeneration by removing seedlings. Loss of native vegetation by rabbit grazing places pressure on native herbivores and the presence of rabbits can sustain fox and feral cat populations. These predators, in turn, place further pressure on native prey species. Feral pigs occupying forests and marshes can damage wetlands and habitat of ground-nesting birds. Land disturbance by pigs also facilitates weed invasion.

Sale of weedy plant species

The sale of declared noxious weeds is illegal in Victoria under the *Catchment and Land Protection Act*, but infringements of this Act occur. For example in 2008 Mexican Feather Grass (*Nassella tenuissima*, related to Serrated Tussock) was identified in several Victorian retail outlets. Such occurrences are monitored and managed by DPI through nursery audits and subsequent follow up, but these occurrences increase the risk of weed infestation by facilitating dispersal of weed species.

Controlling the sale of plants that are not declared noxious weeds but that have weed potential is more problematic and requires assessment of weed risk potential and ongoing co-operation between DPI and the nursery industry. The current review of the Victorian noxious weed list is expected to increase the number of horticultural species declared noxious (see Management Responses).

Economic impacts of invasive species

The economic impact of invasive species in Australia is high. The economic impact of weeds and 11 key vertebrate pest animals has been calculated at $4 billion and $720 million per annum respectively[307]. Rabbits, foxes, feral pigs and feral cats have the greatest cost impact on the Australian economy, with a total impact of $553.1 million annually. The total cost of pest species to Victoria is estimated at $900 million per year. These figures primarily represent production losses and control costs, as the cost of invasive species to native biodiversity is largely incalculable[308]. Eradication of established pest animals from large areas is not possible; the goal of pest management is to reduce pest numbers to levels where they have no significant impact. This goal requires ongoing and co-ordinated management (see Box LB4.2).

Serrated Tussock (*Nassella trichotoma*) is now one of the most serious weed problems of the west and central grazing areas. Serrated Tussock out-competes palatable pasture grass and reduces the carrying capacity for sheep and cattle as they do not feed on this grass. It also invades native grasslands. In heavily infested areas it can reduce the carrying capacity to 0.5 'dry sheep equivalents' per hectare, compared with 7–15 dry sheep equivalents in pastures without the weed[309]. Serrated tussock is estimated to cost the Australian grazing industry more than $50 million per year and the cost is increasing[310,311].

Economic losses do not just result from lost production. The spread of the aquatic weed Arrowhead (see Part 4.3: Inland Waters) costs Goulburn–Murray Water alone in excess of $1,023,000 per year in chemical and mechanical control, contractors, maintenance and research[312]. The extremely high costs associated with weed and pest control also compromise the delivery of other resource management activities by competing for available funding.

An ongoing challenge is to monitor, control and, where possible, eradicate potential 'sleeper weeds' (invasive plants that have naturalised in a region but not yet increased their population size exponentially). Such weeds could have serious future economic impacts[314]. Climate change may alter the potential range of some weeds.

Photo: Jane Tovey

Box LB4.2 Southern Ark - Management response to the threat posed by foxes to native wildlife in East Gippsland

Southern Ark began in November 2003, its aim to recover and restore the native wildlife of East Gippsland by reducing fox numbers over large areas of forest and coastline. The aim is to undertake year-round fox control across all public land east of the Snowy River as well as some land west of the Snowy River near the coast, equating to approximately one million ha. Currently, 500,000 ha are under ongoing fox control and this will continue to increase. The foxes are controlled through a highly species-specific baiting program using manufactured baits containing the toxin 1080, which are deep-buried within 3,500 bait stations.

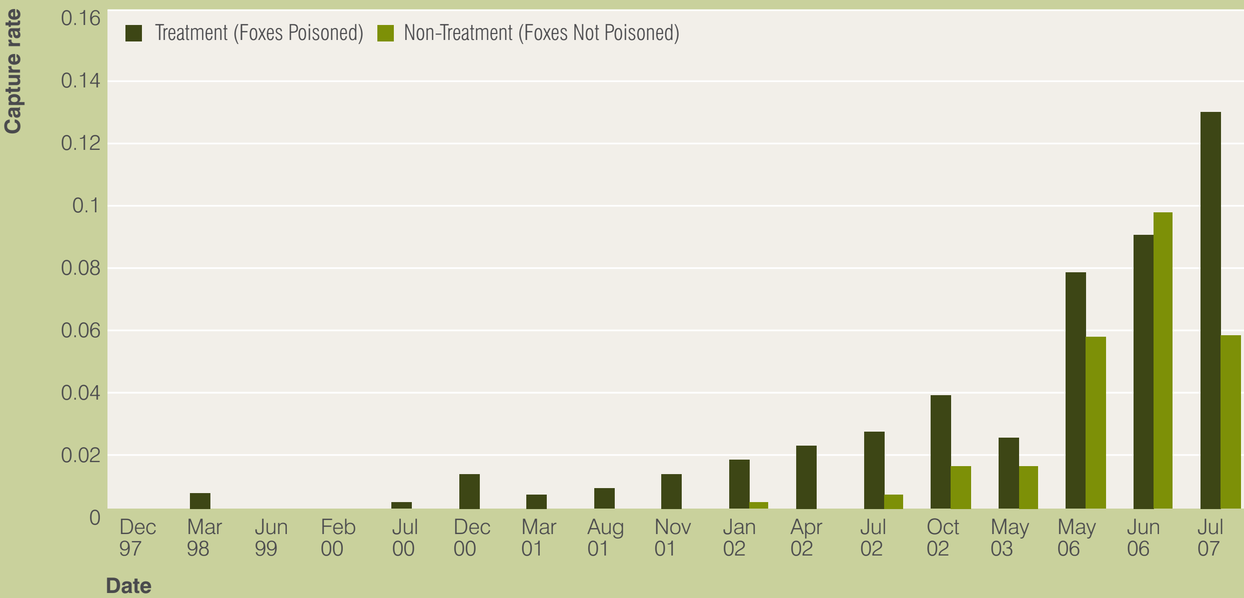
The most significant result to date is the response of the population of Long-nosed Potoroos (*Potorous tridactylus*) in the Cape Conran area of East Gippsland. This area has been subject to ongoing fox control for the past nine years. Capture rates for this species have increased from an average of 0.14% between 1997 and 2000 (which equates to three captures of potoroos over 2,100 trap-nights) to a trap success of 17.8% in July 2007, when 88 potoroos were captured during a week of trapping (see Figure LB4.4). This included 48 individuals that had not previously been captured. The responses of other species are not as clear[313] and may be influenced by environmental factors.

A wide range of terrestrial mammals, birds and reptiles are expected to benefit from the decline in the fox population. The group of animals most likely to benefit directly are the medium-sized mammals such as potoroos, bandicoots and possums. These species have declined significantly since the arrival of foxes, with many now listed as endangered. As these species recover, they are likely to support the recovery of a range of native predators such as the Spot-tailed Quoll (*Dasyurus maculatus*), Sooty Owl (*Tyto tenebricosa*) and Masked Owl (*Tyto novaehollandiae*). While the recovery of endangered species *per* se is important, of equal significance is the recovery of ecosystems and the range of ecological processes to which these animals contribute. Processes such as the dispersal of hypogeal fungi, soil aeration, breakdown of leaf litter, consumption of soil invertebrates, plant germination and seed dispersal all involve these species, and the overall 'health' of the forest depends on these processes continuing.

Deakin University students measuring a Long-nosed Potoroo.
Source: Andrew Murray, Department of Sustainability and Environment 2007

A Long-nosed Potoroo captured at Cape Conran, East Gippsland
Source: Andrew Murray, DSE 2007

Figure LB4.4 Capture rate of Long-nosed Potoroos in both the treatment site (foxes poisoned) and the adjacent non-treatment site (foxes not poisoned) at Cape Conran.
Note: capture rate is the total number of porotoos captured divided by the number of trap nights during the study period.
Source: Department of Sustainability and Environment, unpublished data 2007



Recommendations

LB4.1 The Victorian Government should investigate options for developing further partnerships with the broader community to achieve weed and pest animal control, since these problems occur across tenures.

LB4.2 The Victorian Government should continue to support long-term regional scale projects to protect biodiversity from exotic predators; for example, the Southern Ark and Glenelg Ark projects.

Management responses

Victoria takes a biosecurity approach to the management of pest plant and animal species. This means protection of the economy, environment, social amenity and human health from the impacts of invasive species. Biosecurity involves prevention of new invasions, surveillance and early identification of outbreaks, and preparedness for, response to and recovery from outbreaks of invasive species as well as ongoing management of established pests. Victoria's approach to invasive species management encompasses economic, social and environmental implications. For the purpose of this report, analysis will focus on the environmental relevance of responses. The key objective of these responses is *to limit the establishment of new introduced species*.

Response name
Victorian Pest Management – A Framework for Action

Responsible authority
Department of Primary Industries

Response type
Policy/Strategy

The *Victorian Pest Management Framework* (VPMF) was developed in 2002 to provide strategic direction for the management of declared and potential pests in Victoria. It gives recognition to the impacts of weeds and pest animals on economic productivity, the value of Victoria's natural resources, and biodiversity. The VPMF identifies the key actions, responsibilities, timelines and partnerships required for effective management of pest species. As part of the VPMF, specific management strategies have been developed for weeds, rabbits, wild dogs, foxes, feral pigs and feral goats, and public land management. The principal legislation relating to pest plant and animals in Victoria is the *Catchment and Land Protection Act 1994*. Some initial results from the pest management strategy on public land are outlined in Box LB3.1.

Weeds are declared noxious under the *Catchment and Land Protection Act 1994* according to their environmental or economic impact or potential for impact. The CaLP Act is the primary legislative instrument regulating weed control in Victoria, therefore it is essential that the underlying list of weeds triggering action and penalties under this Act is up to date and complete.

The Weed Management Strategy component of the VPMF requires a review of the noxious weed list by the end of 2005, a list that has not had a systematic review since 1974. A review of noxious weeds is currently progressing and is a significant step forward in weed management in Victoria. The review has been conducted in three phases, the first of which was a review of the existing list of 79 Regionally Prohibited and Regionally Controlled weed species. This phase is complete and changes in weed classification have been gazetted and published. Phase two is a review of eight species identified as priority species by the CMAs and is nearing completion. Phase three is a review of species not previously listed as noxious weeds. Sixty-five species were identified from the National Environmental Alert list, Nursery and Garden Industry of Victoria list and the Weeds of National Significance list and 70 species were identified through community consultation by the CMAs. Evaluation and classification of these species is in progress and due for completion in 2009. The addition of new species to the noxious weed list will enhance DPI's capacity to regulate the sale of weedy species.

Noxious weeds have historically been declared in the case of weeds which have severe negative implications for agriculture and/or the economy, with a lesser consideration of those with a mainly negative environmental impact. The review addresses this situation by including in its assessment Weeds of National Significance and species on the National Environmental Alert List, both of which identify species that pose threats or potential threats to the environment.

The Weed Alert Project addresses the priorities identified in the VPMF and aims to prevent new weeds from establishing in Victoria through increased awareness, surveillance, collection, identification and a rapid response to potential, new and emerging weeds. The weed potential of many plants sold in nurseries and planted in gardens is an issue that receives relatively low recognition in Australia[315] but requires much greater attention.

Recommendations

LB4.3 The Victorian Government should allocate resources for a regular review of the Noxious Weeds list to ensure that the *Catchment and Land Protection Act* is informed by accurate and up-to-date listings of weed species threatening Victoria's environment and economic productivity.

LB4.4 The Victorian Government should investigate mechanisms for raising Victorians' awareness of the weed potential of garden plants sold in nurseries and should continue to consult with the nursery industry to limit the sale of weedy plants.

Response name
Biosecurity Victoria

Responsible authority
Department of Primary Industries

Response type
Function

Biosecurity Victoria is a business group formed within the Department of Primary Industries in 2004. Biosecurity Victoria's role is to develop and manage the delivery of the Victorian Government's biosecurity and market access programs for the livestock, plant, fisheries and forestry industries. Its functions include developing Victoria's capacity to monitor, detect and respond to pest plant and animal disease threats. The transfer of responsibility for weed and pest animals from the Department of Sustainability and Environment to the Department of Primary Industries in 2007 means that Biosecurity Victoria will lead biosecurity policy development for pest management programs across all land tenures. The formation of Biosecurity Victoria reflects DPI's adoption of a biosecurity approach to pest management, meaning protection of the economy, the environment or human health from the negative impacts associated with invasive species of plants, animals and pathogens. This approach covers preparedness, prevention, detection, surveillance, monitoring, control, and response to and recovery from new incursions and outbreaks of invasive species, as well as the ongoing management of some established species.

A Biosecurity Strategy, intended to update the VPMF, is under development and will provide a new policy framework for management of weeds and pest animals in Victoria.

Response name
Quarantine

Responsible authority
Australian Quarantine and Inspection Service

Response type
Function

The Australian Quarantine and Inspection Service (AQIS) manages quarantine controls at our borders to minimise the risk of exotic pests and diseases entering the country. AQIS also provides import and export inspection and certification to help retain Australia's highly favourable animal, plant and human health status and wide access to overseas export markets. In February 2008, the Minister for Agriculture, Fisheries and Forestry announced an independent review of Australia's quarantine and biosecurity systems. The review, to be undertaken by an independent panel of experts, is the first wide-ranging assessment of quarantine and biosecurity in this country for many years. It includes, but is not limited to, the functions of the Australian Quarantine and Inspection Service and Biosecurity Australia.

Evaluation of pest species responses

The *Catchment and Land Protection Act 1994* is the primary legislation relating to control of pest plants and animals in Victoria. This Act sets out land owners' roles and responsibilities in relation to weeds and pests. The CaLP Act specifically regulates the control of plant species declared as restricted and prohibited weeds. These schedules are currently being revised for the first time since 1974. This revision should improve DPI's ability to enforce control of a greater number of important agricultural and environmental weeds. For weeds not declared as noxious, management responsibility on public land is contained within the objectives of the FFG Act, the *National Parks Act 1975* and the *Sustainable Forests (Timber) Act 2004*; however, there is no legislation covering management of non-declared noxious species on private land. The discrepancies in coverage of weed control between public and private tenures creates a situation where there is a lack of enforceable legislation for some weed species on private land.

The Victorian Government acknowledges that despite substantial public and private investment, weeds and pest animals remain a significant threat to Victoria's land and biodiversity resources. To address this, a number of projects aimed at encouraging public engagement with weed and pest control have been developed in recent years; for example, the Tackling Weeds on Private Land Initiative (2004–2007, $9 million) and Improving Provincial Victoria's Biosecurity (2007–2010, $6.2 million). For public land, the document Guidelines for Managing Environmental Impacts of Weeds on Public Land was published in 2007, funded through the Weed and Pest on Public Land initiative. These projects aim to achieve consistency in weed and pest management across land tenures in Victoria, which has been lacking to date.

Key response indicator: Number of pest plant and animal species

Trend: stable

For further information

Victorian Pest Management Framework: www.dse.vic.gov.au/dse/nrenpa.nsf/FID/-038A3D1C93643E3BCA256BD000166FA7

Biosecurity Victoria: www.dpi.vic.gov.au/dpi/nrenfa.nsf/LinkView/DBA0AD81A92A3546CA256EB6000BFDB2A60F43DD8ADE04E1CA256E75007F7C03

Australian Quarantine and Inspection Service: http://www.daffa.gov.au/aqis

Photo: Courtesy of DPI

LB5: Soil structure and erosion

Key findings

- The extent of soil structure decline in Victoria is not clear because there is no single measure of soil structure condition and there is no program in Victoria to monitor indicators of soil structure. In 1991, 30% of Victoria's agricultural land was considered to be severely degraded due to soil structure decline. There is no update on this estimate.
- At least 13.4 million ha of Victoria (approximately 60%), including 73.4% of the State's agricultural land, has sodic soils, which are prone to erosion and soil structure decline. Soil type, land form and land management practice also contribute to risks of erosion and soil structure decline.
- Advances in farming systems and awareness of the issues have reduced erosion and may have reduced soil structure decline in some areas. Reduced tillage, precision agriculture and controlled traffic are innovations that can assist in improving soil structure and lessening the likelihood of erosion. Management of soil organic matter also has a major influence on soil structure and erosion.
- The extent of gully erosion in Victoria was mapped in detail in the 1970s and early 1980s but has not been comprehensively mapped since 1982. Erosion has been better controlled since the end of broadscale clearing, but significant episodes still occur during severe weather events.

Description

Soil underpins the productive potential of Victorian agriculture and forestry[316] as well as its native terrestrial ecosystems, supporting the essential ecosystem services of provision of food, fibre, timber and clean water as well as decomposition and detoxification of wastes.

Victoria has a wide variety of soil types that reflect differences in soil-forming processes controlled by factors such as geology, landform, stream activity, vegetation, climate and age. Rates of soil formation in Victoria are exceptionally slow relative to other parts of the world, and fertile soil is effectively a finite, non-renewable resource[317]. Victorian soils are widely susceptible to a number of forms of degradation; so, if land management practice is not well matched to the soil's resilience to disturbance, there is a risk of both erosion and soil structure decline.

Healthy soil contains stable aggregates of soil particles that create a three-dimensional pore structure that supplies oxygen to the soil and regulates the flow of water. Passage of water through the pores of the soil provides a filtration and cleaning service. Soils with good structure are aerobic, fostering the activity of soil microbial and invertebrate populations that support the ecosystem services of nutrient cycling and decomposition of wastes. Soils with degraded structure are generally compacted, may be impermeable to water and oxygen and often erode readily.

Erosion is a naturally occurring process involving the gradual wearing away of land by wind and water. The natural erosion rate varies depending on landform, slope, soil type, vegetation cover and climate. However, erosion can be accelerated by human activities. Vegetation cover protects soil from erosion by slowing the movement of wind and water across the surface and by reducing the impact of raindrops. Historic clearing of native vegetation has been a primary cause of erosion in Victoria. Accelerated erosion due to human activities was observed as early as 1853 in south-western Victoria[318].

Some soils are inherently more susceptible to erosion than others. For example, soils on steep slopes and those with weak structures (e.g. sandy soils) are more prone to erosion by water. Victoria's extensive sodic soils are particularly prone to gully erosion. Wind erosion is a common occurrence in the north-west of Victoria due to the drier climate as well as the inherent nature of the soils and landscape.

Soil structure decline and erosion are intimately linked and each exacerbates the other. The disruption of stable soil aggregates increases the likelihood of erosion, while erosion selectively removes the top layer of soil, which contains the organic matter and biological populations (for example, microorganisms, fungi, earthworms) that bind and stabilise soil aggregates. Both soil structure and erosion are potentially influenced by land management practices that physically break up stable soil aggregates and reduce aggregate formation by reducing organic matter input.

Soil health, meaning the 'fitness' (or condition) of soil to support specific uses in relation to its potential, is an emerging area of interest in Victoria and is the subject of current policy development.

Objectives

- To gain a clearer understanding of the extent to which soil structure decline threatens soil health and sustainability of farming in Victoria
- To limit soil structure decline by identifying and avoiding processes that degrade soil structure
- To identify and encourage land management practices that improve soil structure
- To stabilise and rehabilitate eroded land
- To minimise further progression and occurrence of erosion
- To understand and improve soil health under a range of productive uses and landscape contexts

Links

See also: Land and Biodiversity – Soil acidification; Part 4.3: Inland Waters.

State

Susceptibility of Victorian soils to soil structure decline and erosion

The natural susceptibility of soil to structural degradation, independent of land use, is a feature of soil type and is moderate to very high throughout Victoria (see Figure LB5.1). Soils in central and western Victoria are generally more susceptible to soil structure decline than those in eastern Victoria. This is largely due to the inherently higher organic matter content and better structure of soils found in the higher rainfall areas of the State.

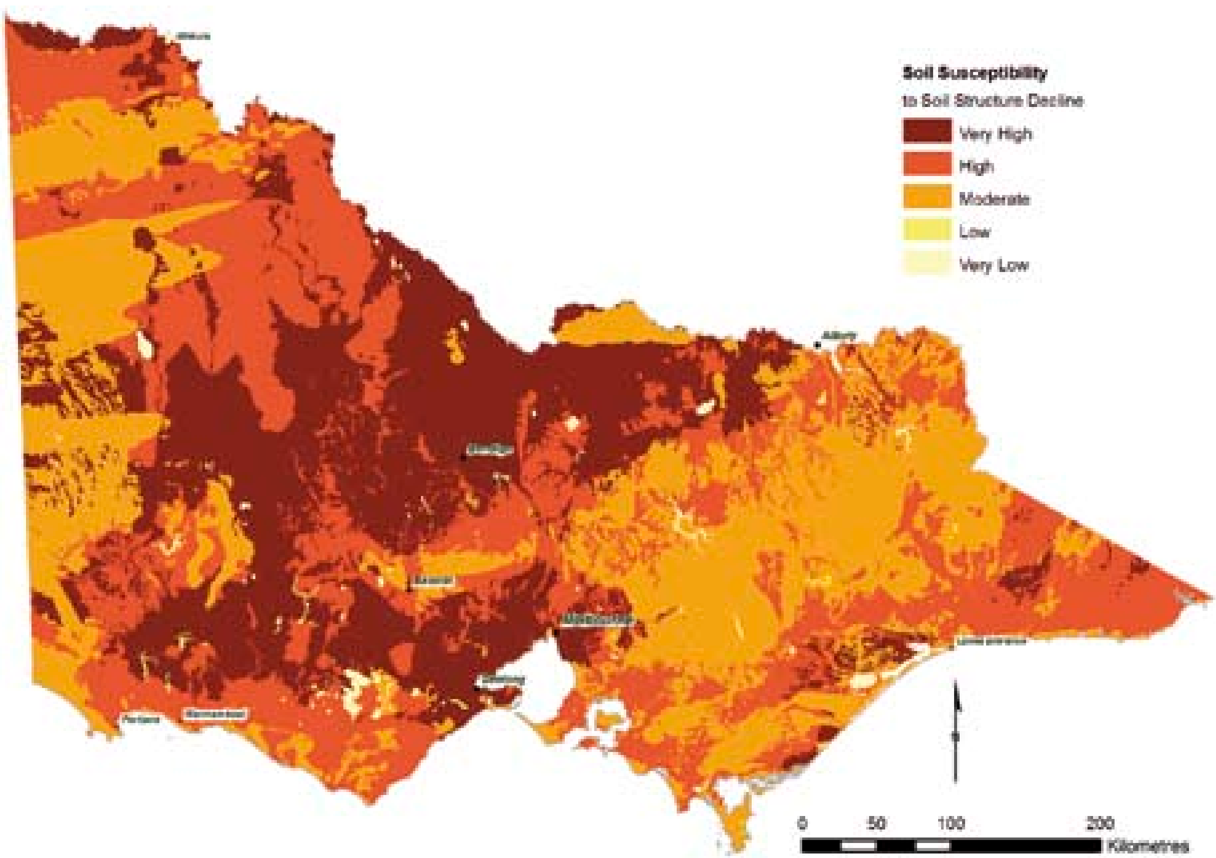
Soil type is an important determinant of susceptibility to soil structure decline and erosion. Sodic soils (containing more than 6% of exchangeable sodium[xxiii,319]) are susceptible to structural breakdown in water because the sodium increases swelling, disrupts adhesion and promotes dispersion of clay particles[320]. Sodic soils tend to form hard surface seals and crusts, have low permeability to water and are prone to waterlogging and erosion. Victoria has up to 13.4 million ha of naturally occurring sodic soils, which accounts for nearly 60% of the State's soils[321]. Approximately 73.4% of the State's agricultural land, or about 10 million ha, consists of sodic soils.

Within Victoria's cropping region, approximately 90% of soil is considered to be highly or very highly susceptible to soil structure decline, based on inherent soil characteristics. Soils on public land in Victoria are less susceptible to soil structure decline than those of the cropping region, with approximately 60% of public land estimated to be moderately susceptible[322].

Victorian soils naturally vary in their susceptibility to water erosion, ranging from low in the relatively dry, flat areas of western Victoria to very high in the Central Highlands and east Gippsland[323] (see Figure LB5.2). The susceptibility of soil in Victoria's public land to water erosion is particularly high, with over 55% of public land considered to be of high or very high susceptibility to water erosion[324]. This reflects the higher rainfall (higher flows of water) and steep slopes (greater speed of runoff), both of which strongly influence erosion, of the upland areas that dominate public land in central and eastern Victoria. In contrast, only 0.2 million ha of Victoria's cropping land is highly or very highly susceptible to water erosion[325].

The soils of greatest susceptibility to wind erosion occur mostly in the drier areas of north-western and western Victoria (see Figure LB5.3). Nearly 1.2 million ha of soils in Victoria's cropping region are considered highly or very highly susceptible to wind erosion, with a further 1.7 million ha classed as moderately susceptible[326]. On public land, approximately 1.5 million ha of soil area is considered highly susceptible to wind erosion[327], which is largely accounted for by the National and Wilderness Parks in the Wimmera and Mallee regions. In contrast, 84% of forest on public land is of low susceptibility[328] to wind erosion.

Figure LB5.1 Susceptibility of Victorian soils to soil structure decline, independent of land management
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007



xxiii Exchangeable sodium percentage refers to the proportion of a soil's cation exchange capacity occupied by sodium ions.

Figure LB5.2 Susceptibility of Victorian soils to water erosion
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007

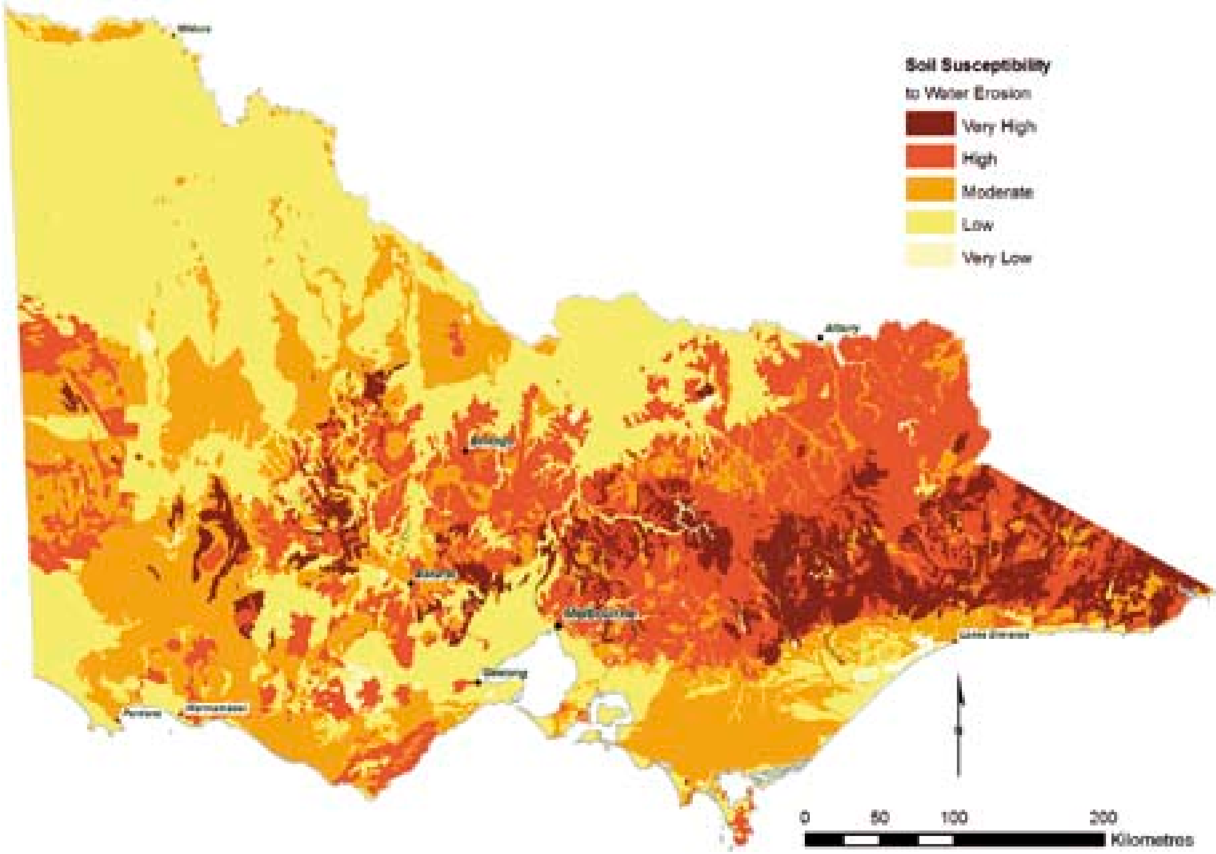
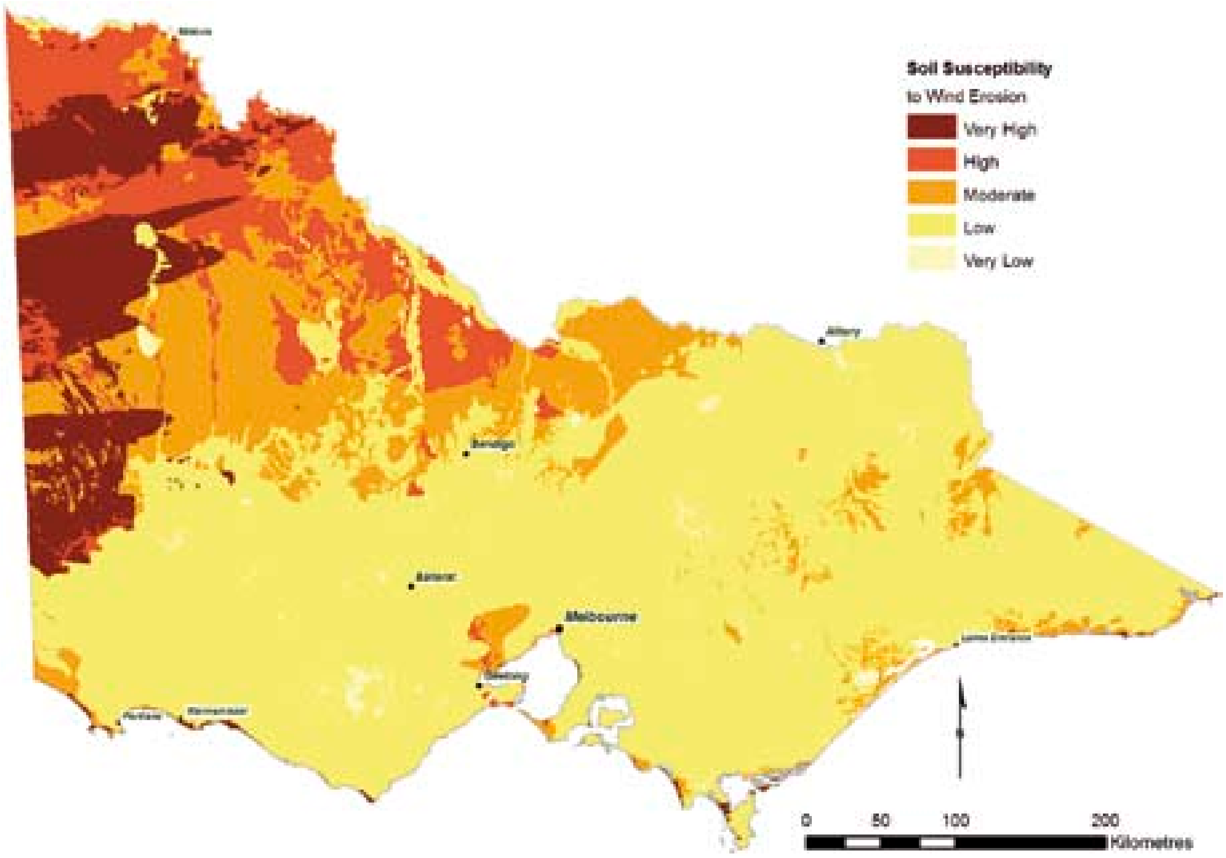


Figure LB5.3 Susceptibility of Victorian soils to wind erosion
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007



Indicator LB25 Occurrence and rate of soil erosion

Water erosion (which can include sheet, rill, gully and tunnel erosion) is the predominant form of erosion in all parts of Victoria except north-western Victoria, where erosion is often driven by wind. Water erosion permanently modifies the landscape and eroded channels remain part of the landscape even after active erosion stops.

The National Land and Water Resource Audit performed an analysis of water erosion in Australia as part of the Australian Agriculture Assessment in 2001. This analysis provides information about the magnitude of changes in erosion since European settlement. The NLWRA estimated that before European settlement the rate of erosion for most of Victoria was less than 0.5 tonnes of soil per ha per year, because of the extensive vegetation cover that existed (see section LB1 Vegetation loss and modification, Figure LB1.14). In 2001, erosion rates for the forested landscapes of Victoria were not significantly greater than the predicted pre-European settlement erosion rates. However, over much of the area with fragmented vegetation, erosion rates were up to five times greater than natural erosion rates. In parts of western Victoria, erosion was significantly greater than the natural erosion rate[329], or up to 12.5 tonnes per ha per year at individual sites. Water erosion becomes a severe issue in the steep, forested public land after extensive bushfires.

The extent of gully erosion in Victoria was mapped in detail in the 1970s and 1980s[330] but mapping stopped in 1982. There is currently no statewide assessment of water erosion. Maps produced from those studies form a baseline from which to assess progress towards control of erosion, and show that the distribution of gullies is closely associated with soil type. The highest incidence of gullying is found on cleared uplands between Seymour and Hamilton, with erosion-prone sodic soils in areas where the average annual rainfall is at least 500 mm[331]. Gully erosion is no longer active in most parts of Victoria[332] owing to the adoption of improved farming techniques and a dramatic reduction of broadscale vegetation clearing (see section LB1 Vegetation loss and modification), although the gullies themselves remain permanent features of the landscape that require ongoing management. Mean annual rainfall well below the long-term average and decreased incidence of rainstorms has occurred in the last 15 years and this has reduced the erosion hazard posed by rainfall since the last statewide report on erosion in 1992.

Wind erosion in the Wimmera and Mallee regions is closely associated with cultivation practices, decreasing in severity when conservation cropping techniques (e.g. minimum tillage, stubble retention) are adopted (see Response Indicator LB26 Adoption of best management practices). There is no statewide monitoring program for wind erosion in Victoria; however, a long-term monitoring program is in place in the Mallee region (see Box LB5.1).

Erosion still ranks as a significant problem on agricultural land in Victoria, with 37% of farm businesses reporting erosion as a land management problem in 2006/2007[333]. It is also a challenge on public land, particularly in the context of fire, which greatly increases the likelihood of erosion (see section LB8: Fire in the Victorian environment). Most Victorian CMA regions have prepared soil health strategies that identify at the regional level areas where soil erosion is a major concern. Much work is being done on developing new approaches (see Box LB5.2).

Photo: Jane Tovey

Box LB5.1 Victorian Mallee Monitoring Soil Erosion and Land Management Survey

Soil erosion is a high community priority in the Mallee region, owing to the environmental and economic impacts on private and public assets. The annual 'Mallee Fallow Survey' commenced in 1978 as a means to assess land management practices and the extent of wind erosion on dryland agricultural land in the Mallee region. The survey is currently conducted three times a year – during summer (February–March), after sowing (June–July) and in spring (October).

The Department of Primary Industries–Farm Services Victoria is engaged by the Mallee CMA to conduct the survey. The 2007/2008 Soil Erosion and Land Management Practices program was funded through the Commonwealth Government's National Action Plan for Salinity and Water Quality and Natural Heritage Trust, and the Victorian Department of Sustainability and Environment.

The survey methodology has been modified on several occasions, most recently in 2005. The new methodology has been implemented since 2007. In-paddock assessments are completed at approximately 160 sites across the Mallee (see Figure LB5.4). The survey measures parameters including actual erosion, soil dry aggregates, groundcover, current land management and the presence or absence of livestock.

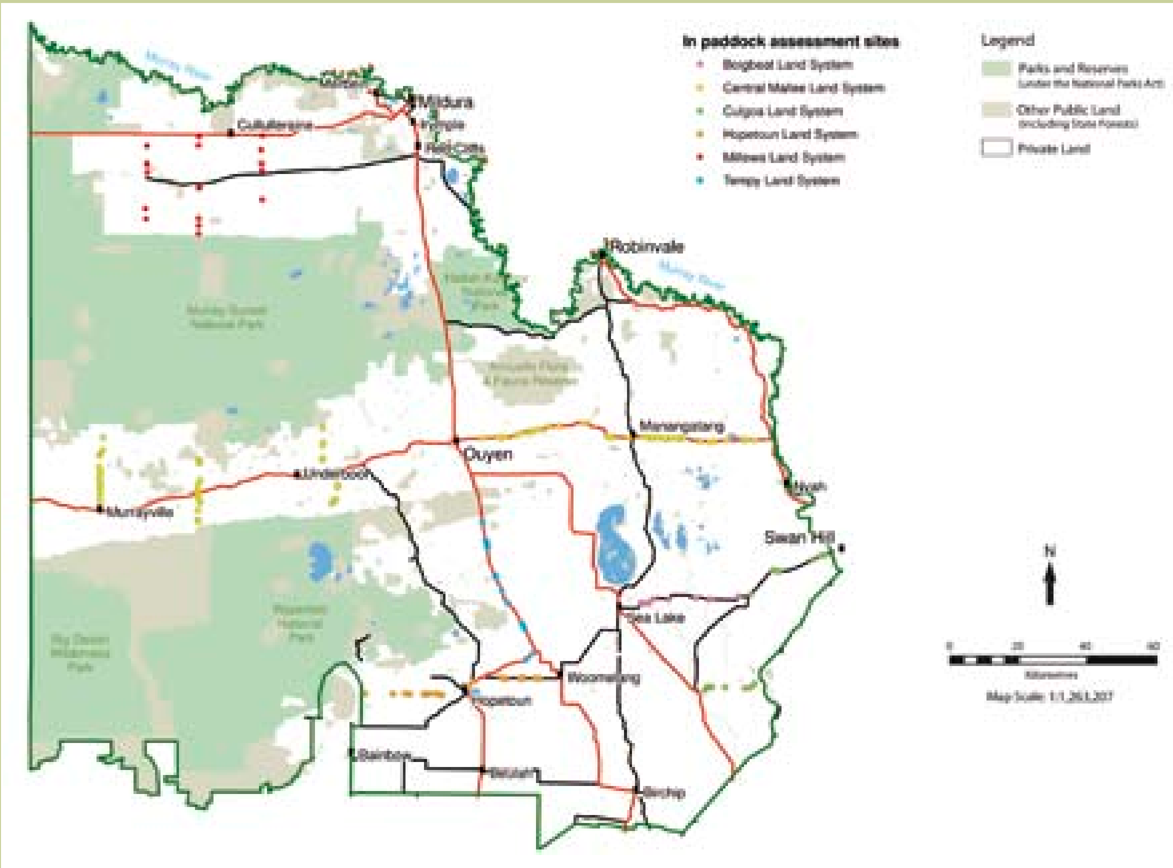
Over the 2007 growing season, approximately 80% of the Mallee CMA region was in crop, compared with approximately 50–60% in previous years, illustrating an intensification of cropping. The percentage of fallow land has declined from approximately 25% to around 10% this decade. The land management measurements from previous surveys and the redesigned survey are comparable.

During the summer 2008 survey up to 62% of the Mallee was observed as eroding, compared with 14% during the same period for 2007. The increase in observed erosion demonstrates an obvious difference in the results with the change of survey methods, but extremely dry seasonal conditions have also contributed. Although widespread changes in land management practices, such as a reduction in fallow land, would be expected to reduce the risk of erosion in the region, overall observed wind erosion events have not declined in recent years.

A direct comparison of data on the area of land eroding from pre- and post-redesign is not possible due to the change in methodology. However, over the next five to ten years the survey will provide more information about erosion trends across the Mallee.

Figure LB 5.4 Location of Mallee soil erosion and land management survey in-paddock assessment sites

Source: Mallee Catchment Management Authority 2008



Indicator LB26 Extent of soil structure decline

The significance of soil structure decline as an environmental issue in Victoria is unclear. Soil structure was assessed at the statewide level in 1991 and, on the basis of local expert opinion, approximately 30% of the State's agricultural land was considered to be severely degraded due to soil structure decline[334]. A component of soil structure decline, soil compaction, was assessed by the ABS for 2006/2007 and 43% of Victorian farm businesses reported soil compaction as a land management issue. The ABS estimated that 1.65 million ha, or approximately 12.5% of Victorian farming land, is affected by compaction[335], suggesting that despite the lack of detailed data, soil structure decline is likely to be a significant issue on agricultural land.

Although a number of indicators of soil structure were identified in 1991, there is no simple, single measure for soil structure and Victoria does not have programs in place to monitor changes in soil structure. Therefore, it is not possible to provide a statewide assessment of Victorian soils that may be undergoing structural decline, or to indicate quantitatively the extent to which structure might have declined under past and current land uses.

Recommendation

LB5.1 The Victorian Government should incorporate within current soil health initiatives a program to ascertain the significance of soil structure decline as a threat to soil health in Victoria.

Indicator LB27 Likelihood of erosion in Victoria's cropping region

Victoria does not directly monitor erosion of soil by water. Erosion events are highly episodic and an extremely large number of observations would be needed to build a regional or statewide picture. However, trends in soil management practices can be used as a substitute for direct monitoring of erosion in cropping soils, as the relationships between management practices, land cover and soil loss are well established[336].

The areas most likely to experience wind erosion as a result of land management are in the western Wimmera and the Mallee. The remainder of the Wimmera and parts of south-western Victoria are estimated to be at low risk of wind erosion.

Conventional cultivation practices (multiple cultivations of soil before the crop is sown) that disrupt soil structure and remove vegetation cover are associated with high likelihood of wind erosion. Conventional cultivation practices, although declining in popularity relative to minimum tillage techniques (see Response Indicator LB26 Adoption of best management practices), are still used over nearly half of the Mallee region[337]. Thus, wind erosion remains a threat to soil condition in north-western Victoria.

Soil organic matter

Soil organic matter, 50–60% of which is organic carbon, has roles in: building soil structure; preventing erosion; increasing soil water-holding capacity; improving soil drainage; improving soil nutrition and restricting nutrient loss; and maintaining soil micro-organism diversity. The stable fraction of soil organic matter (humus) also sequesters carbon in soil, potentially helping to mitigate climate change.

Soil organic matter is an important contributor to soil structure and erosion control because it helps to bind soil particles into larger, stable aggregates. Organic matter and carbon are lost when soils are cultivated and gained during the pasture phase of cropping rotations and in minimum tillage practices, when soils are less disturbed. In the long term, cultivation can deplete soil organic carbon pools by up to two-thirds[338]. Losses of organic carbon from Australian soils of 10–60% have been recorded after 10–80 years of cultivation[339].

Although some information on organic carbon concentrations in Victorian soils is available from routine soil sampling and some broad spatial trends in soil organic carbon levels are apparent, there is no program of routine or systematic monitoring. This precludes the analysis of temporal trends in soil carbon in response to changes in land management.

Box LB5.2 Soil biology: emerging technology

Soil is the medium underpinning all terrestrial ecosystems, but is also a habitat in its own right, supporting a complex mixture of microbial, fungal, invertebrate and vertebrate life forms. One gram of soil can contain up to 10,000 different species[340] of soil animals, fungi and bacteria. Current knowledge of the types of organisms that inhabit soil is extensive, based on many decades of research. However the study of many of these organisms has been limited by the ability to cultivate them in the laboratory, although techniques for cultivating soil microorganisms are improving [341].

Soil organisms perform many functions involved in the provision of ecosystem services by soil. The key functions of soil organisms include:

- decomposition of organic matter and recycling and storage of the nutrients released during decomposition
- stabilisation of soil – fungal filaments and exudates from microorganisms and earthworms bind soil particles into stable aggregates
- reducing erosion and improving infiltration of water and air into soil
- improving root growth and function by providing air- and water-filled pores in soil
- improving water quality by detoxifying and decomposing potential pollutants
- improving plant health by controlling pathogenic organisms and mineralising nutrients to make them more available for plants[342].

Although current knowledge about the types of organisms found in soil and some of the functions that they provide is extensive, information about how the biological component of soil affects chemical and physical attributes is lacking. Understanding of how soil biological functions interact with each other to buffer soil from changes in management and climate is also poorly understood and there are few specific guidelines for managing or monitoring soil biological properties.

Because of these gaps in understanding the complex interactions between soil organisms and their functions in soils, there is currently no standard method for assessing soil biological quality. Worldwide, only 29% of soil monitoring programs measure soil biological data at all, with most relying on chemical and physical indicators of soil quality, which are less sensitive to subtle changes[343]. Victoria currently does not have a program of monitoring soil biological data and it is not possible to assess the biological condition of Victorian soils at a statewide level.

Scientists at the Department of Primary Industries are developing a range of new technologies that will facilitate standard analysis of soil biological quality and monitoring of responses in soil biological function to changes in management and climate. While understanding the details of the relationships between microbial populations, soil management and soil chemical and physical properties is expected to take several more decades, the technology and tools currently under development are expected to guide better soil management decisions by land managers[344].

Recommendation

LB5.2 Victoria has existing strength in soil biology and biotechnology research. The Victorian Government should continue to support this research for the purpose of filling the knowledge gap surrounding the roles of soil biological populations in ecological processes and production systems. The Government should also continue to support farming systems research, in collaboration with regional industry groups, with the aim of developing 'conservation' farming systems suitable for all applications. This research could be supported under the *Land and biodiversity in a time of climate change* Green Paper objective of 'Expanding our knowledge base'.

Pressures

Soil structure

Activities that physically disrupt soil can threaten soil structure. Cropping activities involve multiple operations that can disrupt soil structure (e.g. cultivation, sowing, harvesting). Since 1990 the area of Victoria sown to crops has almost doubled and the intensity of cropping has increased from 15% of farm land to more than 25% (see Indicator LB13 Area sown to crops and pastures, and Figures LB2.6a, b). The resulting pressure on soil structure has been alleviated to some extent by the adoption since the 1980s of minimum- and zero-tillage faming systems that protect soil structure (see Response Indicator LB26 Adoption of best management practices). Conventional cultivation, however, is still practised in parts of the Mallee and Wimmera regions. Conventional tillage was reported for over 850,000 ha in the Mallee region and 735,000 ha in the Wimmera in the most recent Agricultural Census for which data are available[345], compared with zero-tillage, which was reported for approximately 55,000 ha in the Mallee and nearly 200,000 ha in the Wimmera (see also Response indicator LB26 Adoption of best management practices).

Farm traffic is a significant influence on soil compaction. Good soil structure for plant growth is open and loose, whereas good soil structure for trafficability of vehicles and machinery is tight and compact. Uncontrolled traffic can result in compaction over most of the area of a paddock. Axle weights, tyre pressures and soil moisture content are the principal factors affecting compaction. Adoption of controlled traffic cropping, where vehicles are restricted to a defined path and laser guidance of cultivation can reduce this impact.

Burning of crop residues also contributes to pressure on soil structure by removing organic matter from the soil. Although stubble retention has also been widely adopted since the mid-1980s, burning as a method of managing crop residues is still practised. Crop stubbles were burnt on 654,000 ha of Victoria in 2001/2002[346]. Broadscale studies of stubble retention in relation to cropped area are not systematically undertaken, therefore it is difficult to assess the contribution of this technique to alleviating pressure on soil structure.

In addition to cropping activities, livestock can also impart pressure on soil structure. Trampling of soil, especially when wet, disrupts soil aggregates and causes soil compaction. Dryland pasture is a key land use in Victoria, occupying about one-third of the state[347], thus there is widespread potential for livestock industries to degrade soil structure. Victoria's livestock population, however, has declined since the late 1990s[348], largely owing to prolonged drought. While individual instances of overstocking may continue to exert pressure on soil structure, pressure arising from livestock production seems unlikely to increase in the short term.

On public land, activities related to commercial forestry are the key sources of pressure on soil structure. Heavy vehicle traffic over the unpaved roads used during timber harvesting causes compaction. The breakdown of soil structure on forest roads increases the potential for erosion and subsequent sedimentation of waterways. Extensive fire has also had a negative impact on soil condition on public land (see section LB8 Fire in the Victorian environment).

Development of land for residential and other purposes applies strong local pressure to soil structure because the earthworks involved in road building and the preparation of land for building produce severe soil disturbance. Urban and peri-urban growth currently exert strong pressure on native vegetation and biodiversity (see section LB2 Contemporary land use – Urban and peri-urban development), which is potentially exacerbated by soil structure decline at these sites because the loss of soil structure reduces the capacity of soil to support revegetation activities.

In addition to these current pressures on soil structure, projected changes to Victoria's climate (see Part 4.1: Atmosphere, Climate Change) are also likely to indirectly affect soil structure, largely through the impacts of reduced soil moisture on soil biological populations.

Erosion

A large proportion of Victorian soil is naturally prone to erosion because of its soil chemistry, physical properties and topography. In addition, large areas of Victoria have been cleared of native vegetation (see section LB1 Vegetation loss and modification), which promotes erosion by removing the protective cover of the canopy and leaf litter from the soil. Land in Victoria is increasingly used for dryland cropping (see section LB2: Contemporary land use change). This can contribute to erosion if land management is not appropriate by leaving soil bare of vegetation after crop harvest and by physically disturbing soil. Land is also used for other primary industries, including forestry and mining, which contribute to erosion by:

- leaving soil bare of vegetation
- causing physical disruption of soil
- causing local changes in hydrology that can result in landslip.

Climate change is expected to exacerbate existing pressures on erosion by increasing the frequency and severity of droughts, floods and bushfires.

Vegetation cover and primary production

Extensive vegetation clearing in Victoria (see section LB1 Vegetation loss and modification) has contributed to widespread water erosion. Although many of the gullies created by erosion after vegetation clearing are no longer actively eroding, they remain a permanent modification of the landscape and require ongoing management.

Overgrazing can also produce bare soil. In addition, some of the operations used in cropping involve physical soil disturbance, disruption to soil structure and loss of stabilising organic matter. All of these factors contribute to erosion.

The area of land used for cropping in Victoria increased by 85% between 1990 and 2005 (see section LB2 Contemporary land use; Indicator LB13 Area sown to crops and pastures), increasing the pressure exerted on erosion by cropping activities. Cropping techniques that minimise the occurrence and severity of erosion[349] have been developed and have been adopted by Victorian farmers over 0.5–1 million ha (see Indicator LB26 Adoption of best management practices). However, land management practices that contribute to erosion are still in use and may provide economic or operational advantages in some cases. Alternative techniques may be required for specific regions to support the development of sustainable cropping enterprises.

Timber harvesting can be associated with erosion. Victoria's timber harvesting areas are largely located in areas of steep slopes and high rainfall, producing a high risk of erosion if soils are left bare following logging. The scale of the erosion risk associated with clearfelling is unclear, and methods to quantify this risk are being developed by scientists at the University of Melbourne[350].

The unsealed roads and tracks created for timber harvesting activities are a major source of accelerated erosion associated with forestry, contributing 20–60 times more sediment per unit area than undisturbed forest, and about 10 times more than harvested forest areas[351]. Unsealed roads can deliver up to 40% of in-stream sediment from forests. Sediment generation on Victorian forest roads is highly variable[352] and there is a poor understanding of the factors driving this variation.

Mining activities, although not extensive in Victoria, occur throughout the State in areas where deposits of minerals and coal occur. These activities produce intensive physical disruption to soils in relatively confined local areas, which has implications for erosion and water quality.

Climate change and drought

Climate change is likely to exacerbate existing pressures on soil erosion by reducing soil moisture and increasing the occurrence of drought, floods, storm surges and wildfires[353,354] (see also Part 4.1: Atmosphere, Climate Change; Part 4.4: Coasts, Estuaries and the Sea). More frequent occurrence of drought and/or fire can be expected to reduce vegetation cover, increasing the risks of wind and water erosion. More frequent or severe flooding is likely to increase the occurrence of water erosion, especially when floods follow prolonged droughts or fires that have left the soil without adequate vegetation cover. Such a sequence of events occurred in east Gippsland in 2007, when severe winter flooding followed extensive fire in January. Resulting soil loss was severe, as the wildfires had removed most of the vegetation that would usually absorb and slow the flow of water. Although this example is not necessarily attributable to climate change, it indicates the scale of soil losses that can occur under extreme climatic conditions.

Rainfall and drought are important determinants of wind erosion. Nationally, years of low rainfall have been associated with high values of the Dust Storm Index, an indicator of wind erosion[355]. The prolonged dry period experienced over the last decade, especially in north-western Victoria, has heightened the risk of wind erosion. Severe dust storms in western Victoria in April 2008 illustrated that episodic wind erosion can occur when storm events occur during drought, despite the widespread adoption of improved land management practices.

Climate change is also expected to increase the frequency and intensity of wildfires[356,357]. By 2020 it is expected that the number of extreme fire danger days will increase by 5–45% relative to the period 1974–2003. By 2050 the number of extreme fire danger days is expected to increase by 15–25% under a lower carbon emissions growth scenario and by 120–230% under a higher carbon emissions growth scenario[358]. Fire both removes surface vegetation and degrades the physical properties of soil[359], making it less permeable to water and more susceptible to erosion. Fire, therefore, is likely to be a significant pressure on erosion in Victoria's forested areas, which were burned extensively in 2003 and 2006/2007, and which can be expected to be burned more frequently in the future.

Implications

Erosion and water quality

Poor soil structure and erosion are intimately linked and each exacerbates the other. Poor soil structure limits water infiltration and promotes erosion because water travels over the soil surface rather than through the internal pores, carrying topsoil away with it. The breakdown of stable soil aggregates also means that soil particles are more likely to be removed by water or wind, exacerbating the risk of erosion. Erosion exacerbates soil structure decline by removing surface organic matter and biological populations, reducing the ability of soil to form stable aggregates and increasing the risk of further erosion.

Soil lost during erosion events is not readily replaced because soil-forming processes are extremely slow, occurring over tens of thousands of years in Victoria[360]. The National Land and Water Resources Audit[361] estimates that approximately 4.6 million tonnes of sediment per year are transported from the land in Victorian river basins as a result of erosion, representing a substantial loss of fertile soil, nutrients and organic matter from terrestrial ecosystems, and a significant impact on aquatic ecosystems (see Part 4.3: Inland Waters).

Erosion selectively removes topsoil containing nutrients, organic matter and biological populations, threatening the capacity of soils to support plant growth and biodiversity. Loss of surface soil limits delivery of ecosystem services associated with nutrient cycling and decomposition of wastes because many of the species providing these services live in surface soil layers. Soil structure and associated water filtration services are also threatened by loss of the organic carbon and soil organisms in the topsoil.

Implications for natural ecosystems

Soil eroded by water is deposited in streams and rivers either as suspended sediment or on the streambed, affecting water quality and in-stream habitat. Increasing sediment input into Victorian rivers and streams is identified as a key threat to biodiversity in the Victorian *Flora and Fauna Guarantee Act 1988* (see section LB3 Threatened species).

Deposition of the sediment resulting from erosion in waterways has multiple negative effects on streamflow, riparian vegetation, aquatic biodiversity and water quality (see Part 4.3: Inland Waters). Stream clarity is reduced and turbidity increased by sediment, reducing light penetration through the water. This affects the growth and photosynthesis of aquatic plants and algae. Dissolved oxygen levels in water may also be reduced, inhibiting respiration of aquatic organisms.

Sediments can carry nutrients and pollutants from the land, particularly nitrogen and phosphorus, into waterways, where a changed nutrient regime can affect the balance between aquatic species. Water quality objectives for turbidity, phosphorus and nitrogen were met at less than half of the sites monitored for the 2004 Index of Stream Condition assessment and the occurrence of cyanobacterial blooms resulting from excessive nutrient loads has increased (see Part 4.3: Inland Waters).

Where sediments are carried to estuarine and enclosed marine environments (i.e. embayments), they can smother seagrass bed habitats and raise nutrient levels, resulting in disturbance to the marine food web (see Part 4.4: Coasts, Estuaries and the Sea).

Deposited sediments can destroy aquatic habitats by covering the stone and rock streambeds and filling pools. Pools and in-stream debris form important refuges and breeding sites for fish and other organisms, while stone streambeds are ideal habitat for algae[362]. In-stream habitat was poor in 25% of Victorian river reaches assessed in 2004 (see Part 4.3: Inland Waters), reflecting some of the impacts of erosion. Flooding risk is also increased by sedimentation as changes to the streambed produce changes to streamflow.

On-site impacts of erosion are important for native vegetation. Erosion of topsoil can result in loss of seedbanks for native vegetation, limiting the capacity for regeneration. Weed seeds may be deposited with soil from adjacent agricultural or urban land, promoting the spread of weeds into remnant vegetation. In addition, removal of topsoil exposes subsoil layers, which may be hard or impermeable to water, limiting the establishment of seedlings.

Wind erosion has implications for human health due to the impacts of dust storms. Wind-borne dust can have direct effects on human health, causing eye and airway irritation, and potentially triggering allergic reactions and asthma[363] (see Part 4.1: Atmosphere, Air Quality).

Implications for agriculture and soil biology

Agriculture is an important component of the Victorian rural economy and export earnings, contributing $8.7 billion to Gross State Product in 2006/2007, of which $472 million came from broadacre cropping[364]. Possible loss of agricultural productivity arising from declining or poor soil structure and erosion therefore has substantial economic implications for Victoria, and would compromise the Victorian Government's target of $12 billion in food and fibre exports by 2010.

The implications of poor soil structure for agriculture relate primarily to the role of soil in supporting plant growth. Structural properties of soil relevant for agricultural productivity are: infiltration rate and water-holding capacity; penetrability for plant roots and seedlings; and aeration. Plant growth and seedling establishment are limited by degradation of the pore structure because plant roots and seedlings cannot physically push through compacted soils or surface crusts. Waterlogging of poorly structured soils reduces soil oxygen concentration, which inhibits root function and growth. All these effects combine to reduce the agricultural productivity of poorly structured soils. A lack of vegetation cover on poorly structured soils adds to the risk of erosion associated with poor soil structure both by leaving the soil surface exposed to wind and water, and by reducing the organic matter input.

Poor soil structure also has the potential to limit soil biological activity by reducing the supply of oxygen and water to surface soil layers and reducing the physical penetrability of soil. Reduction of soil biological activity is likely to feed back negatively on soil structure, as the exudates from soil organisms are critical for binding soil particles into stable aggregates.

Loss of soil biological activity has further implications for the provision of ecosystem services. Loss of soil biodiversity (see Box LB5.2) reduces the capacity of soil to cycle and store nutrients, and to decompose and detoxify organic wastes. Without these services, the quantity of fertiliser required to restore soil fertility to the levels needed to support agricultural production would increase. Victorian agriculture is already highly reliant on inorganic nitrogen fertilisers, which are energy-intensive to produce and are associated with emission of the greenhouse-intensive gas, nitrous oxide. Approximately 1.1 million tonnes of fertiliser were used in Victoria in 2000/2001[365], and the amount of fertiliser applied to Victorian soils has increased threefold since the 1960s (see Part 4.3: Inland Waters, Water Quality). Increasing use of fertiliser is associated with increased concentrations of phosphorus and nitrogen and decreased water quality in Victorian rivers (see also Part 4.3: Inland Waters).

The primary implications of erosion for agriculture also relate to loss of land productivity. Erosion removes the nutrients and organic matter of soil and degrades soil structure, reducing its capacity to support crop and pasture growth. Additional fertiliser is required to restore fertility to eroded soils; however, the inappropriate use of synthetic fertilisers is associated with high economic and environmental costs. Erosion can also damage fencing, undermine roads and buildings and decrease the storage capacity of water reservoirs. Soil sodicity, a key factor contributing to erosion in Victoria, is estimated to cost the State $342 million per year in lost crop yield (compared with potential yield)[366].

Soil carbon implications

Soil organic matter content, of which soil carbon forms a part, is considered to be an indicator of the ecological and economic sustainability of farming operations[367] because of its contribution to plant nutrition and nutrient cycling, soil structure, erosion control and water-holding capacity. The implications of low soil carbon levels include declining soil fertility and water availability, which in turn impact on crop yields.

The issue of soil carbon also has important climate change implications. Soils, particularly agricultural soils, have been proposed as an important potential sink for carbon as part of climate change mitigation activities because changes to farming systems and land use have the potential to increase the amount of carbon stored in soils[368]. Investment in research and development to resolve some of the technical difficulties related to measurement and monitoring of soil carbon is required before the role of soil as a carbon sink becomes clear. However, given the urgency of developing responses to climate change[369], the possibility of managing soils for carbon sequestration should not be ignored.

Management responses

Declining soil structure and erosion are potentially important forms of soil degradation arising from land use and land management decisions in Victoria. Management of these issues is shared across government, CMAs and private land owners, and effective responses to soil health issues will depend on the development of co-operative partnerships between Government and the community. There are no management responses at a State Government level specifically targeted at soil structure decline or erosion; however, Victoria is currently developing a holistic policy approach to soil health.

Soil health as a reflection of the fitness of soil for specific purposes is an emerging concept, and although some aspects of soil function are relatively well defined, others, such as soil biology, are emerging fields. Because of these knowledge gaps, and because of the wide range of uses and services expected from Victorian soils, management responses need to address the objective of *understanding and improving soil health under a range of productive uses and landscape contexts*. Suitable responses will range from research and development to provision of information about best management practices for soil health, including maintenance of soil structure.

The key management objectives for erosion, *to minimise occurrence and progression of erosion* and *to rehabilitate eroded land*, are also largely addressed through soil health responses and responses aimed at restoring native vegetation (see section LB1 Vegetation loss and modification).

Victorian farmers, through adoption of best-practice cropping techniques such as minimum tillage and stubble retention, are contributing to improvements in the condition of soil resources in Victoria (see Response Indicator LB26 Adoption of best management practices). Their activities are supported by policy initiatives dealing with soil health at Victorian and Commonwealth Government levels.

Response Name
Our Environment, Our Future – Soil Health Initiative

Responsible Authority
Department of Primary Industries/ Department of Sustainability and Environment

Response Type
Strategy/policy

Our Environment, Our Future is Victoria's current environmental sustainability action statement. Released in 2006, it commits the Victorian Government to investment of over $200 million spread over 150 actions. Action 4 of *Our Environment, Our Future* is 'Healthy and Productive Land'. The *Soil Health Initiative* under this action provides $4 million over four years (2006–2010) for the development of a soil health framework. The *Soil Health Initiative* is intended to assist land owners with soil management by providing access to the best available information and management practices to improve environmental services from soil. This goal is consistent with the Victorian Government's stated aim of maximising the value of the services the land produces and its role as a provider of information to communities and individuals about the benefits and impacts of land management practices[370].

Government investment in programs addressing soil health as an integrated concept is a forward step; however, the Victorian Catchment Management Council recently identified soil data quality and soil management as a major weakness for Victoria[371]. The lack of statewide data and the need for soil type benchmarks against which to assess current soil condition indicate that substantial investment in research and data collection is required. Without a substantial increase in the level of consistent statewide soil data collection, appraisal of the effectiveness of Government initiatives will be extremely difficult. The four-year timeframe of this initiative is also potentially limiting because the management of soil for healthy condition under productive use will be an ongoing issue.

Response Name
Healthy Soils for Sustainable Farms

Responsible Authority
Land & Water Australia (Department of Agriculture, Fisheries and Forestry)

Response Type
Process

Healthy Soils for Sustainable Farms is a $5 million initiative funded by the Grains Research and Development Corporation and Land & Water Australia. The program encompasses a wide range of strategic and on-ground projects aimed at providing the best soil management information to Australian farmers and demonstrating best soil management practice. For example, in western Victoria the Birchip Cropping Group is leading a project aiming to:

- obtain the most relevant and useful soil health information and extend this to farmers and advisers through a series of workshops and field days
- improve farmers' capacity to manage soil health issues
- enhance, develop and deliver information packages for farmers
- develop and promote industry-based training packages
- establish demonstration sites highlighting relevant management practices and strategies.

Evaluation of responses to soil structure and erosion

There is a lack of consolidated statewide data on Victorian soils and threats to soil health. It is therefore difficult to assess the significance of these issues, particularly soil structure, and the effectiveness of any responses to them. A lack of up-to-date knowledge and soil type benchmarks against which to assess soil condition was identified by the VCMC as limiting Victoria's ability to manage threats to soil health[372]. It will be essential that future responses include the collection of consolidated statewide datasets for the purposes of empowering landholders to objectively assess soil condition and adopt best management practices, evaluating the success of current strategies, and informing future policy development.

Victoria has no government responses in place that specifically address soil structure decline, and the lack of available soil structure data means that the significance of this issue is difficult to assess. However, the State is developing a suite of responses that address soil health that includes soil structure as an important component. This is an emerging concept that will require investment in research and development of soil health measures. It is not yet possible to evaluate either generally or specifically the effectiveness of soil health responses in relation to soil structure.

As with all soil-related issues on private land, management of soil health is largely in the hands of individual landowners and will be influenced by a range of drivers that will vary between regions and between individual farm businesses. Soil structure can be highly variable both between and within soil types, and mapping this variability at a statewide scale may not be cost effective. However, guidelines relating soil type, soil management and crop type to desirable outcomes for soil structure will assist land managers to identify practices likely to improve soil structure.

The benefits of improved soil structure will flow both to individual landholders (for example, improved agricultural productivity) and to the public in the form of ecosystem services such as water filtration. Therefore, there is a role for government responses that encourage beneficial land management practices. CMAs also have a role in leading community efforts to improve soil health more generally, and most of Victoria's CMAs have either developed soil health strategies or have identified soil health-related goals in Regional Catchment Strategies.

Current responses to erosion on private land are largely based around the adoption by individual land holders of land management techniques that minimise the physical disruption of soil and maximise organic matter input and retention (see Response Indicator LB26 Adoption of best management practices). These techniques have reduced erosion in Victoria; however, the potential remains for significant episodic erosion events to occur during wind or rain storms. Adoption of improved management by land owners is the most appropriate response to erosion; however, this can be limited by the capacity of individual land owners to implement changes. Financial constraints and other barriers can limit or prevent uptake of new management technology, so there is a role for Government in ensuring that information about readily adoptable and effective management options is available and that supportive policy is in place.

Significant erosion may also occur on public land, especially in the context of bushfire and commercial timber harvesting. Bushfire can increase runoff of soil and nutrients by removing vegetation cover, increasing soil erodibility and depositing a layer of loose, nutrient-rich ash on the soil surface. Effective bushfire management, therefore, is an important component in controlling erosion on public land. Fire prevention activities in Victoria have not prevented two large-scale fires in Victoria's eastern highlands in 2003 and 2007. An increase in planned burning has been recommended to reduce risks of extensive bushfires in the future[373] (see section LB9 Fire in the Victorian Environment for more information on bushfire management in Victoria).

Timber harvesting on public land in Victoria is regulated by the Code of Practice for Timber Harvesting, which contains provisions relating to the protection of water quality, river health and soil[374]. Timber harvesting activities are also regularly audited by the Environment Protection Authority for compliance with the Code of Practice for Timber Production. Nevertheless, unpaved forest roads remain a significant source of sediment.

Overgrazing by kangaroos in the Mallee National Parks is a management issue for Parks Victoria that may also contribute to erosion by preventing regeneration of native vegetation[375].

In addition to physical soil disturbance, the absence of vegetation contributes to erosion and, for this reason, responses that relate to vegetation retention and improvement are also important for erosion control. The direct impacts of the Native Vegetation Management Framework (NVMF) and related initiatives, such as BushTender (see section LB1 Vegetation loss and modification) and EcoTender, on erosion are unknown, but on public land the NVMF has produced a net gain of native vegetation, which is likely to have reduced the risk of erosion. New markets for native vegetation management services, such as BushTender, have potential to add to the suite of erosion control measures available for use on private land.

Integration of government programs with CMA activities and those of individuals and community groups such as Landcare will be needed to maximise information exchange and the adoption of new soil management techniques. Victorian farmers have already shown a strong commitment to soil improvement by adopting soil conservation practices such as minimum tillage and stubble retention (see Response Indicator LB26 Adoption of soil conservation farming techniques). If extension and demonstration programs are adequately resourced, it is reasonable to expect that further improvements to soil health may be possible.

Key response indicator: annual rate of soil loss

Response Indicator LB28 Adoption of best management practices

Extensive land clearing as well as some land management practices have exposed Victorian soils to the risk of soil structure decline and erosion. In response, farming systems that reduce the impacts of agricultural production on soil have been developed. These 'best management' or 'conservation farming' practices include conservation cropping (zero- or minimum-tillage, retention of crop residues after harvest, use of chemical rather than physical weed control), use of perennial pastures in grazing systems, and regeneration of native vegetation and tree planting[376].

The use of zero- or minimum-tillage to prepare for crop sowing is preferred to conventional cultivation because these techniques involve fewer operations that disturb soil. Similarly, use of herbicide rather than cultivation to control weeds between crops is considered good practice because soil disturbance is minimised, although the effects of herbicides on soil flora and fauna and the ecosystem services they provide is unclear[377]. Cropping systems that retain crop residues or stubbles, either on the soil surface or incorporated in the soil, are preferred to stubble burning because crop residues returns carbon to the soil.

Adoption of conservation cropping practices has varied throughout Victoria since the 1980s, when these practices were initially developed[378]. Trends in cropping practices on a statewide basis have included[379]:

- 1980s: A clear increase in use of minimum tillage and a smaller increase in use of direct drilling (sowing seed directly into uncultivated soil); a reduction in stubble burning and a move towards stubble retention or incorporation.
- Early 1990s: Increased use of direct drilling (20% of farmers) and a reduction in use of fallow (period when the soil is left bare of vegetation to conserve soil moisture).
- Late 1990s: Move from direct drilling towards minimum tillage and an increase in use of fallow (22% of farmers); a move from cultivation fallow towards chemical fallow; increases in stubble burning (28% of stubble).

More recent data (see Figure LB5.5) show that although there has been little change in the practice of full stubble retention (i.e. crop residue is left completely intact), the area over which stubble is mulched or incorporated into soil has increased such that by 2001/2002, some form of stubble retention was practised over 1 million ha (approximately one-third of the area cropped). The area over which stubble was removed increased over the same period, reflecting an increase in the area cropped.

Adoption of zero tillage techniques (whereby the soil is not cultivated prior to crop sowing) continued to 2001/2002, but cultivation remained widely practised. The number of cultivations used per year appears to have declined during this period as the area cultivated only once or twice per year increased from approximately 675,000 ha to 1.1 million ha compared with a reduction in area cultivated more than twice per year (see Figure LB5.6). Cropping practices have not been recorded on a statewide basis since 2001/2002.

Although statewide data on the adoption of best management practices have not been updated since 2001/2002, some CMAs conduct regional surveys of land management practice. For example, the Wimmera CMA monitors the uptake of recommended best practice for land management with the results of an annual DPI survey of practices such as stubble retention and maintenance of ground cover along a transect of paddocks. Uptake of best practice is increasing in this region. Since 2001, the area of broadacre farm land under current recommended best practice has increased from 160,000 ha to approximately 200,000 ha, or from 40% to 50% of paddocks surveyed[380].

Figure LB5.5 Victorian stubble retention (a) and cultivation practices (b).
Stubble retained includes stubble left intact, stubble mulched and stubble incorporated. Stubble removed includes stubble burnt, baled and grazed.
Source: Australian Bureau of Statistics Agricultural Survey/Census
Note: the basis for data collection changed from calendar year to financial year after 1999

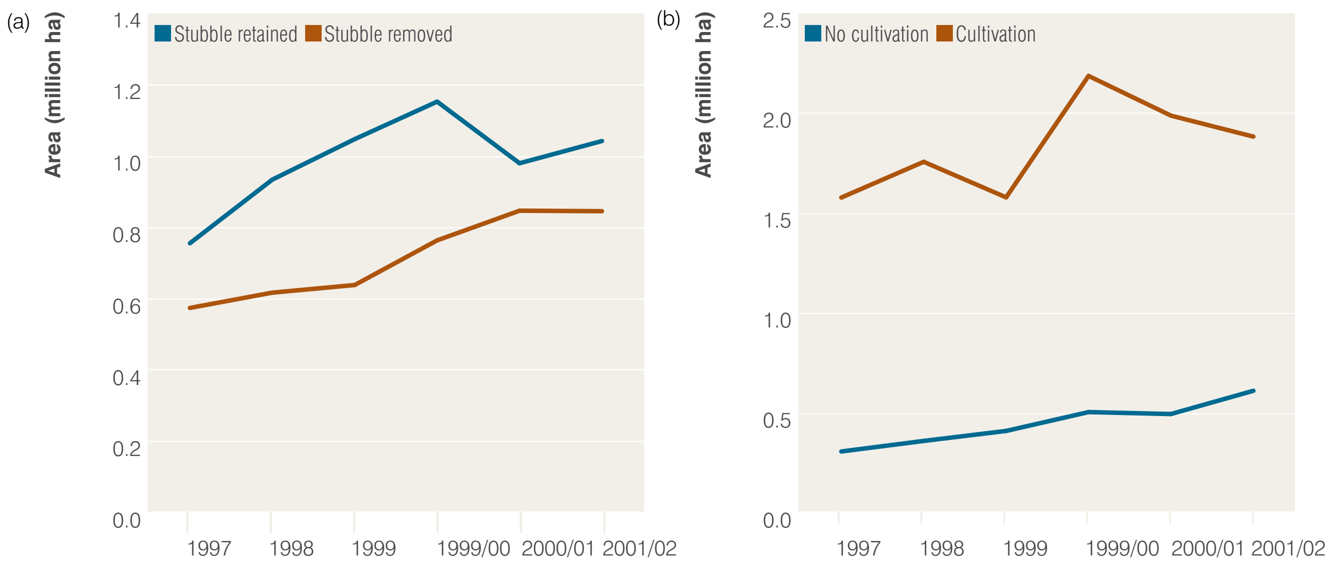
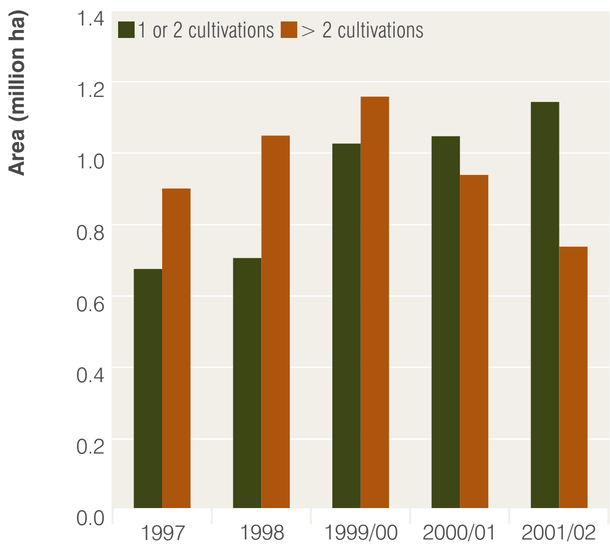


Figure LB5.6 Number of cultivations applied prior to sowing in Victoria 1997–2001/2002.
Source: Australian Bureau of Statistics Agricultural Survey/Census
Note: the basis for data collection changed from calendar year to financial year after 1999



Recommendations

LB5.3 The Victorian Government should co-ordinate with other States to have land management practice monitored in the annual ABS agricultural survey for the purpose of supporting soil health risk assessment and public reporting of these risks.

LB5.4 The Victorian Government should support a 'community engagement' framework for soil health data collection and management at the point that it is most influential in affecting management change in soil health. The Government should co-invest with regional communities and organisations such as cropping groups to benchmark their soil conditions and management regimes against a set of agreed indicators for the purposes of knowledge exchange, learning, target setting and action implementation within stakeholder groups. The investment program could be designed to deliver robust and reliable data about condition and performance over time for public review, assessment and evaluation.

LB5.5 Within the context of a soil health community engagement framework, a key outcome is development of guidelines relating soil type, soil management and crop type to desirable soil health outcomes. The Victorian Government should co-invest with regional communities to develop such guidelines based on data collected within the framework.

LB5.6 The Victorian Government should work with regional cropping groups to identify barriers to adoption of current best cropping practice. Research partnerships should develop and demonstrate alternative farming systems to facilitate uptake of new cropping technology.

For further information

Our Environment, Our Future: www.dse.vic.gov.au/ourenvironment-ourfuture/

Healthy soils for sustainable farms: http://healthysoils.gov.au/

Best land management practice: www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/landuse-best_management

Forest erosion research: www.forestscience.unimelb.edu.au/research/forests_water/projects.html

Code of Practice for Timber Production: http://www.dse.vic.gov.au/DSE/nrenfor.nsf/LinkView/4A25676D00235B544A25679A0014E4D903152A09041FFDBECA25747B000C1C62

LB6 Salinity

Key findings

- Salinity costs Victoria $50 million annually in lost agricultural production and direct costs of salinity are expected to reach $77–166 million by 2050.
- Approximately 240,000 ha of land in Victoria are known to be affected by discharge of saline groundwater; however, mapping of salinity in Victoria is inadequate to provide a comprehensive statewide picture of areas affected.
- Since the late 1990s groundwater depths have stabilised or retreated in response to salinity management and a prolonged period of below-average rainfall. The extent of salinity is also considered unlikely to extend beyond current limits because of reductions in groundwater recharge; however salinity persists and requires ongoing management.

Description

Salt occurs naturally in Victorian soils. It is released from rocks as part of the soil-forming process, has been deposited by the ocean and inland seas in earlier geological time, and is blown from the ocean on to the land, where it has accumulated over time. This salt is washed down through the soil by rain over centuries and is deposited deep in the soil, where it does not affect plant growth. Salinisation of soil occurs when stored salt is brought to the surface by groundwater.

Salinity refers to the presence of salt in soils. It is an issue for land management because most plants tolerate salt poorly and will not grow in highly saline soils (see Table LB6.1).

Salinity occurs naturally, even in healthy catchments, because parts of Victoria, especially the Mallee region, have mostly saline groundwater and large amounts of salt stored in soils. This naturally occurring salinity is known as primary salinity and is not of concern. Vegetation occurring in naturally saline ecosystems, for example saline wetlands, is tolerant to these natural levels of salt.

Secondary salinity occurs when groundwater rises from its usual location deep in the soil towards the soil surface, bringing stored salt with it. As the saline groundwater approaches the surface, salt is concentrated in soil at depths where it can affect plant roots. This form of salinity has been caused by human activities and creates problems because it diminishes the capacity of soil to support plant growth.

Table LB6.1 Classification of soil salinity and plant salinity tolerance by electrical conductivity of soil extract. Note that even the most salt-tolerant agricultural plants are sensitive to salinity levels found in moderately saline soils

Source: Victorian Resources Online, Department of Primary Industries; Agriculture Note December 1997, Department of Primary Industries

(a) Soil salinity classification

Soil salinity class	Electrical conductivity of soil extract (dS/m)[i]	Plant response
Non-saline	<2	No vegetation affected by salinity
Slightly saline	2–4	Salt-tolerant species present; salt-sensitive species show reduction in number and vigour
Moderately saline	4–8	Salt-tolerant species dominate the vegetation; all salt-sensitive species are markedly affected; small bare patches of soil may occur
Highly saline	8–16	Salt-tolerant species dominate over large areas; only salt-tolerant species are unaffected by salinity; large bare saline patches may occur
Extremely saline	>16	Only highly salt-tolerant species survive and even salt-tolerant species may be scattered and in poor condition; extensive bare saline areas occur

(b) Salinity tolerance of selected agricultural plant species

Sensitive	Moderately sensitive	Moderately tolerant	Tolerant
White clover, red clover, subterranean clover, soybean, chickpea	Balansa clover, strawberry clover, Persian clover, lucerne	Sorghum, tall fescue, phalaris, perennial ryegrass, cocksfoot, annual ryegrass, wheat, barley	Sea barley grass, Puccinellia, tall wheat grass, salt bush

[i] Electrical conductivity, a measure of salinity in soil extracts, is measured in units of siemens per metre (S/m). Siemens is the inverse of resistance (measured in ohm).

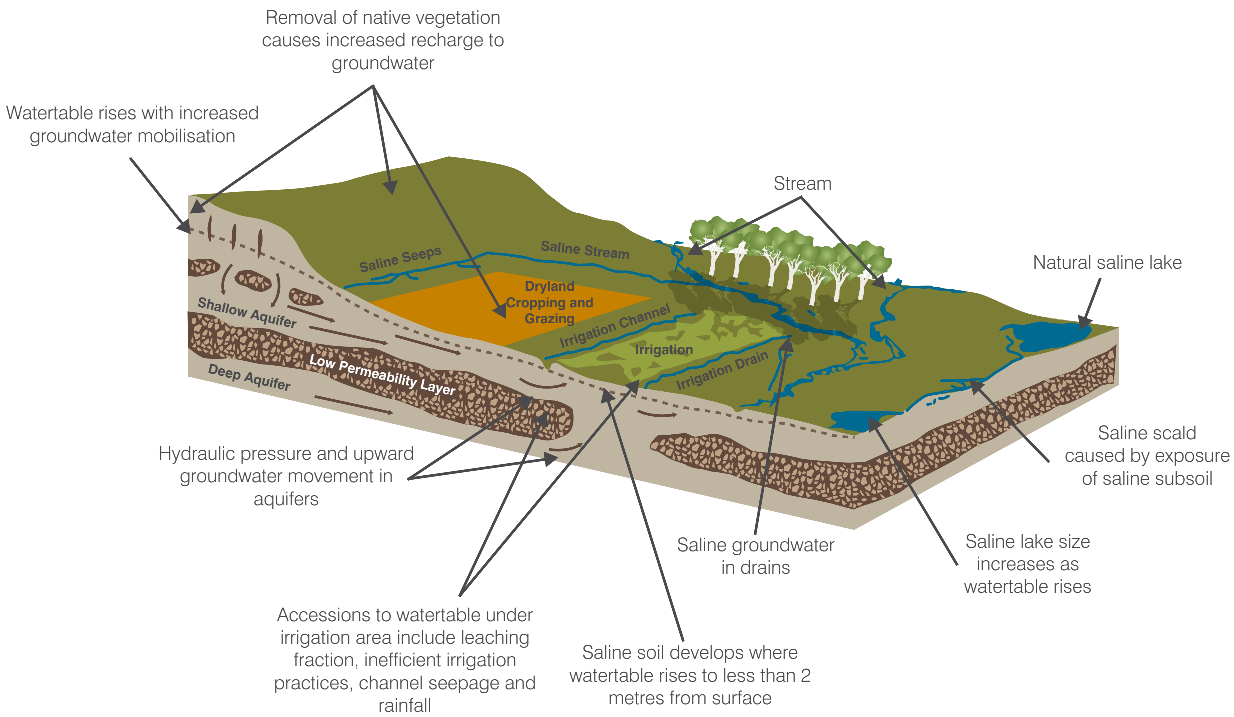
The groundwater system in Victoria is highly complex but, in very general terms, groundwater levels vary with the relative rates of recharge (in-flow of water) and discharge (out-flow of water). When recharge and discharge rates are in equilibrium, groundwater levels are stable, but when recharge rates exceed discharge rates, groundwater levels can rise.

Recharge rates depend on rainfall, application of irrigation water and the use of water by vegetation. When vegetation uses most of the water that falls on the soil (via rain and irrigation), groundwater recharge is slow and in equilibrium with discharge. However, if vegetation uses only a small fraction of rainfall, the remaining fraction either runs off or drains through the soil, increasing the rate of groundwater recharge. If recharge rate exceeds discharge, groundwater level rises.

Victoria's native vegetation includes woody perennial species that are adapted to local rainfall patterns and use rainfall efficiently. There is little drainage under native vegetation and groundwater remains in equilibrium. The broadscale removal of Victoria's native vegetation (see section LB1 Vegetation loss and modification) and its replacement with mostly annual crops and pastures has disturbed the hydrological equilibrium. Annual plants use a smaller proportion of rainfall than perennials; therefore, this fundamental change to the vegetation structure over nearly two-thirds of Victoria has increased groundwater recharge rates, producing rising groundwater and secondary salinity (see Figure LB6.1).

Secondary salinity occurring in un-irrigated areas is known as dryland salinity and that occurring in irrigation areas conversely is irrigation salinity. Irrigation salinity differs from dryland salinity in that the application of excess irrigation water to land contributes to rising groundwater. Both forms of secondary salinity occur in Victoria but irrigation salinity has been recognised as an issue for longer and has been more successfully addressed by improvements in irrigation efficiency and engineering works to divert saline water.

Figure LB6.1 Processes associated with dryland and irrigation salinity
After Simon Kneebone



Salinity severely reduces the capacity of soil to support plant growth. Areas where saline groundwater emerges (known as discharge areas) are characterised by patches of bare soil and sparse salt-tolerant vegetation. Although of low productivity, salt-tolerant vegetation can stabilise erosion-prone groundwater discharge areas and provide biodiversity benefits in salt-affected areas. Saline groundwater discharge is currently known to affect approximately 240,000 ha in Victoria[381].

The land degradation that occurs at discharge sites is a visible indicator of the current impacts of soil salinisation (see Table LB6.1), while trends in groundwater level are important indicators of potential future salinity risk. Shallow or rising water tables indicate areas at risk of developing salinity. Retreating groundwater reflects declining rainfall and improvements in irrigation efficiency as well as the possible impacts of successful land management techniques.

Land salinisation is a long-term, large-scale problem requiring multiple approaches to management. It is a challenge for natural resource management throughout Australia and represents a significant threat to natural ecosystems, agriculture and infrastructure. Land salinity is a national Matter for Target within the National Land and Water Resource Audit[382]. Nationally, costs associated with salinity are expected to increase by 60–70% within a 20-year timeframe[383] while in Victoria, the Auditor-General's Office has estimated the direct cost of salinity in Victoria at $50 million per year, with the potential to rise to $77–166 million per year by 2050[384].

Objectives

- To limit the extent of salinity in Victoria by reducing groundwater recharge; for example, by revegetating critical recharge areas
- To protect and, where necessary, rehabilitate salt-affected land of high environmental value, such as wetlands
- To reduce environmental and economic impacts of salinity
- To improve methods for assessing salinity risk at the landscape scale

Links

See also: Land and Biodiversity – Vegetation loss and modification, Contemporary land use change; Part 4.3: Inland Waters

State

Indicator LB29 Area of salt-affected land

Comprehensive and systematic mapping of soil salinity occurrence in Victoria has not been undertaken at the statewide level so a snapshot of salinity across Victoria is not available. The area of currently mapped saline discharge (both primary and secondary) is estimated at 240,000 ha[385], although the recent Australian Bureau of Statistics Natural Resource Management survey reported a slightly greater area of 268,000 ha, based on estimates from farmers who reported salinity as a land management issue[386]. Salinity has not been mapped for most of the Murray River floodplain or most coastal wetlands[387]. The distribution of salt-affected dryland areas is shown in Table LB6.2. Dryland salinity affects approximately 1% of the dryland agricultural area of Victoria, although there has been a lack of distinction between primary (naturally occurring) and secondary (human-induced) salinity in some assessments, particularly for the Mallee, where up to 90,000 ha of saline sites are thought to result from primary salinity.

Table LB6.2 Regional and total estimates for Victoria of mapped salt-affected dryland areas (data collected 1970–2007)
Source: Reid *et al.* 2008[388]

Region	Mapped salt-affected dryland area (ha)
Mallee	105,000
Glenelg Hopkins	27,435
North Central	27,114
Corangamite	25,162
West Gippsland	24,160
Wimmera	21,789
Goulburn Broken	4,778
Port Phillip	2,890
North East	1,311
East Gippsland	273
Total mapped salt-affected area	239,912

The Department of Primary Industries has identified 120,000 ha affected specifically by secondary salting and considers that the severity of salinity is increasing, particularly in salt-prone areas such as the Kerang district, where 72% of the district is affected[389].

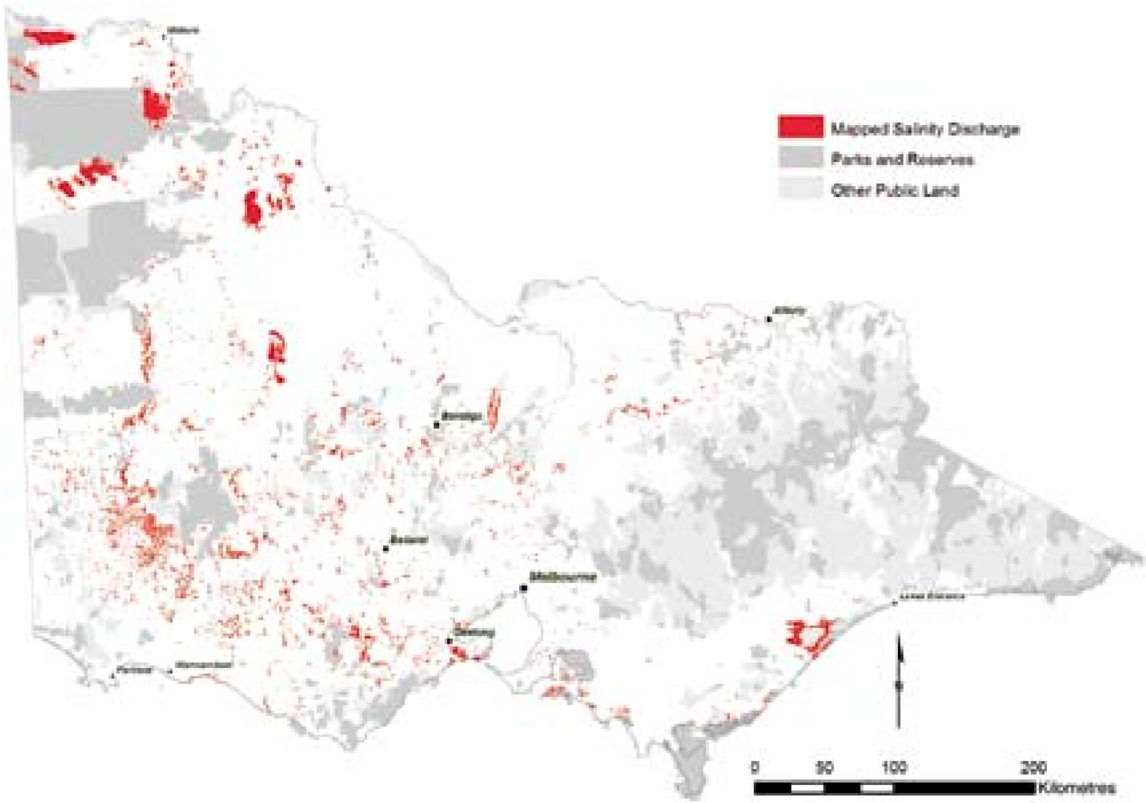
Mapping exercises have generally been driven by local needs and funded by various Victorian and Australian initiatives. Mapping commenced during the mid-20th century with most of the data collected in the late 1980s to mid-1990s; however, the north-west of the State has recently been mapped for the first time. Salinity mapping for many areas of Victoria has not been updated for over 15 years[390] and there is a clear need for comprehensive current information on the extent of salinity in Victoria. The ad hoc nature of the data collection makes it impossible to report on recent trends in salinity extent across Victoria.

Figure LB6.2 shows the distribution of known salinity discharge sites within the areas that have been mapped (see also Table LB6.2). These are focused in the western and northern regions of the State. Western Victoria is more severely affected because clearing of native vegetation and its replacement with annual crops and pastures has been extensive. The landscape in western Victoria is also generally flatter with poor drainage[391].

The Department of Sustainability and Environment estimates that approximately 140,000 ha of salt-affected land is located in Victoria's irrigation districts[392], although the importance of salinity in irrigation areas is declining relative to other constraints, such as water availability. Irrigation salinity has been recognised for several decades in Victoria and a range of measures have been implemented to address it (see Box LB 6.1).

Regional improvements in salinity risk (measured by depth to groundwater) have been achieved by improved irrigation management including whole-farm plans and more efficient irrigation methods, surface water management systems (drainage), groundwater pumping and planting trees. For example in the Shepparton Irrigation Region the Shepparton Irrigation Region Land and Water Salinity Management Plan was implemented in 1991, the area of land with groundwater within two metres of the surface, a depth considered to pose a high risk of salinisation, peaked at approximately 260,000 ha in 1995. Since 1995 the area with shallow water tables has declined to approximately 60,000 ha. This is attributed to investment in improved irrigation management and regional drainage as well as the prolonged dry period experienced since 1996[393].

Figure LB6.2 Known salinity discharge sites across Victoria. Data collected 1970–2007
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007



Box LB6.1 Sustainable Irrigation

Victoria's irrigation sector produces about $2.7 billion worth of agricultural produce annually[394] and underpins the economies of many rural communities, especially in northern Victoria. By the early 1980s, however, serious salinity problems had emerged in the northern irrigation region. Inefficient use of irrigation water was raising groundwater as well as adding to nutrient runoff, waterlogging and soil structural problems.

Since 1990, the Sustainable Irrigation Program administered by DSE has invested in a package of interventions aimed at improving the efficiency of water use to reduce environmental impacts of irrigation and increase economic productivity of irrigation regions (see Table 6.3).

Victoria's irrigation farming communities have made use of these investments and new irrigation technologies in a range of ways to improve irrigation efficiency and reduce salinity. The community of the Shepparton Irrigation Region has reacted aggressively to predictions that without action 65% of the region would have watertables within two metres of the surface by 2020. The response has included implementation of whole farm plans covering over 200,000 ha, installation of over 500 km of surface water management systems and more than 200 groundwater pumps, as well as planting 3 million trees. In contrast, the community of the Tragowel Plains in north-western Victoria has taken a less aggressive approach to salinity. In addition to improved drainage and farm layout, the response in this region has focused on soil salinity mapping to identify the most productive soils and concentrating irrigation water on these areas.

Both approaches have yielded positive results. Water tables in the Shepparton Irrigation Region have retreated to below three metres in most of the area, leaving about 11% of the land with shallow water tables. In the Tragowel Plains, cutting down the irrigation of saline land has reduced the area of highly salinised soil and increased the area of productive soil (see Figure LB6.3).

Table 6.3 Sustainable Irrigation Program outputs 1997–2007 for northern Victoria.
Source: DSE 2008

Outputs	Total
Whole farm plans (number)	4,848
Soil salinity surveys (ha)	203,875
Water re-use systems (number)	3,479
Drains – primary (km)	176
Drains – community (km)	1,289
Groundwater pumps – public (number)	57
Groundwater pumps – private (number)	351
New horticultural development (ha)	22,400
Phosphorus retention (tonnes per year)	350

Figure LB6.3 Improvements in soil salinity levels in the Tragowel Plains area between the early 1990s (left) and early 2000s (right).
Source: Department of Primary Industries 2008
A class soils are the least saline and are suitable for growing most plant species. D class soils are most saline and support little plant growth

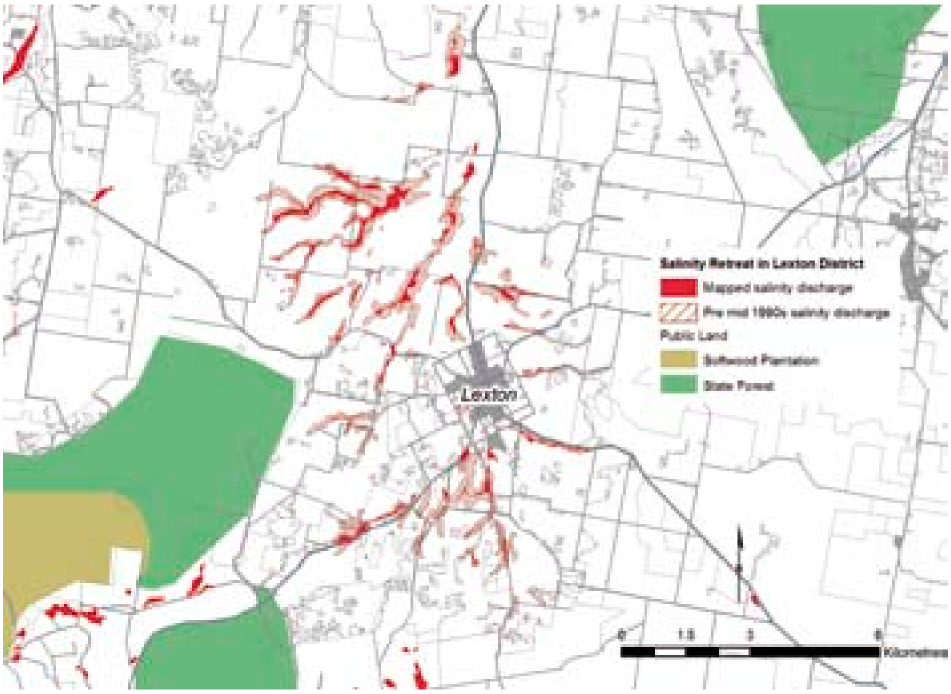
Indicator LB30 Area at risk of dryland salinity

A recent analysis of groundwater trends in key DPI salinity monitoring bores in dryland regions indicates that the spread of land salinisation in Victoria has stabilised and is unlikely to increase further[395]. Climate patterns, specifically rainfall, is the main driver of groundwater trends, and since 1996 Victoria has experienced an exceptionally dry period (see Part 4.1: Atmosphere – Climate Change), during which groundwater levels have generally declined. The climate forecast for Victoria is for lower, rather than higher, annual rainfall; thus, it is expected that the extent of salinity will not exceed the extent reached in the late 1990s. It is likely, however, that there will be resurgences of salinity and the potential for significant movement of salt, including into rivers, in response to sequences of wetter years or flood events, even in the context of a generally drier climate[396].

There is insufficient remapping of salinity to draw confident conclusions about trends in the size and severity of discharge areas, but there are some examples where the combination of reduced rainfall and land management changes have produced contractions in saline discharge areas. For example, around Lexton, north-west of Melbourne, a 73% reduction in the area of land classified as saline was observed between 1990 and 2000 (see Figure LB6.4). Extensive works aimed at combating salinity have been carried out in this region and are likely to have contributed to the improvement, assisted by the lower-than-average rainfall during this period.

The continued presence of salt in the soil and the potential for resurgences of salinity during wetter periods mean that salinity will require continued management for the foreseeable future. Rehabilitation of discharge sites is particularly important to ensure that groundwater levels at these sites do not rise to hazardous levels during natural seasonal fluctuations, i.e. periods of higher rainfall such as winter. Lag times between climate change or management interventions and groundwater responses can be long and, where it occurs, the retreat of saline discharge can take decades; thus, even though the pressure on salinity may have eased, it will require ongoing, long-term management.

Figure LB6.4 Reduction of saline discharge zone near Lexton, Victoria (1990–2000)
Source: Triple Bottom Line Indicators for Victorian Landscapes 2007



The assessment of salinity risk by depth to groundwater is limited in Victoria by the uneven distribution of observation bores, which are concentrated in areas where salinity is known to be a problem. Insufficient information is available from other areas to accurately assess the likelihood of salinity developing.

Recommendations

LB6.1 The Victorian Government should invest in salinity mapping methods research and mapping activity in order to better quantify the area and severity of salt-affected land in Victoria and enable change to be tracked over time. The Government should also invest in research to better understand the hydrological characteristics of Victorian groundwater so as to reliably define future salinity risk for Victoria.

LB6.2 The Victorian Government should ensure that ongoing management of salinity is incorporated into asset-based approaches to land and natural resource management.

Pressures

Processes that raise groundwater levels act as pressures on salinity in Victoria. Broadly, these are vegetation clearing, vegetation water use, irrigation and rainfall. Trends in rainfall for Victoria are discussed in detail in Part 4.1: Atmosphere – Climate Change. Average rainfall in Victoria in the period 1997–2007 was particularly low relative to the long-term average. Retreat of saline groundwater has been observed in some areas during this period. Further reductions in rainfall are forecast for Victoria as a result of climate change, which may reduce the pressure on groundwater recharge.

Extensive historic clearing of native vegetation, particularly in central and western Victoria (see section LB1 Vegetation loss and modification), has disturbed the water balance and contributed to the current extent of land salinisation. Despite the introduction of vegetation clearing controls and legislation to protect native vegetation remnants, native vegetation continues to be lost in Victoria, primarily as a result of gradual declines in vegetation condition (see section LB1 Vegetation loss and modification, Indicator LB11 Extent of native vegetation, Indicator LB4 Quality, condition and fragmentation of vegetation). Continued loss of native vegetation produces ongoing pressure on groundwater levels and salinity.

Irrigation acts as a pressure on salinity in two ways. Firstly, inefficient application of more irrigation water results in drainage to groundwater, raising water tables and bringing stored salt to the surface. This is the same hydrological process that occurs in dryland salinity. Secondly, as the rivers from which irrigation water is drawn increase in salinity, salt is actually being applied to the land in the irrigation water. Extensive networks of groundwater pumps and surface water drains have been installed in irrigation districts to manage the problem, along with changes in farm management and irrigation technology.

The area irrigated in Victoria increased by 25% between 1990 and 2006 (see section LB2 Contemporary land use change, Indicator LB14 Area irrigated) and new irrigation areas are developing, particularly in the west Wimmera and Sunraysia regions. The volume of water applied, however, is declining because of increasing efficiency of irrigation water use and decreasing water availability due to drought (see Part 3.2: Water Resources). Improvements in water use efficiency in irrigated agriculture mean that a greater proportion of the water applied is used for plant growth, with less escaping to groundwater. Severe water shortages resulted in a substantial decline in the area irrigated in 2007 (see section LB2 Contemporary land use change, Indicator LB14 Area irrigated). If this change signals the beginning of a downward trend in irrigated area, as seems likely given rainfall projections, pressure on salinity in irrigated areas may ease further.

Indicator LB31 Area of land sown to annual and perennial species

Replacement of perennial vegetation with annual plants contributes to rising water tables and soil salinisation because annual plant species typically have shallower root systems and shorter growing seasons than perennial plants and therefore use less water[397].

The total area sown to annual grain crops in Victoria rose from 2.3 million ha in 1995 to 3 million ha in 2001. The area sown to annual crops has continued to increase since 2001, reaching approximately 3.6 million ha in 2005 before declining to 3.25 million ha in 2006 (see Figure LB6.5). Approximately 3.4 million ha were sown to annual crops in 2007. It is likely that drought caused the reduction in cropped area in 2006. However, this slight reduction in area is small in comparison with the expansion of Victorian cropping area since 1990 (see section LB2 Contemporary land use, Indicator LB13 Area cropped).

The area sown to annual pasture species remained reasonably stable between 1 and 1.5 million ha over the period 1995–2001. More recent data are not available because since 2001 ABS surveys have not distinguished between sown pastures and grazed native grasslands. When combined with the area sown to crops, the total area of Victoria sown to annual species increased by 26.6% between 1995 and 2001.

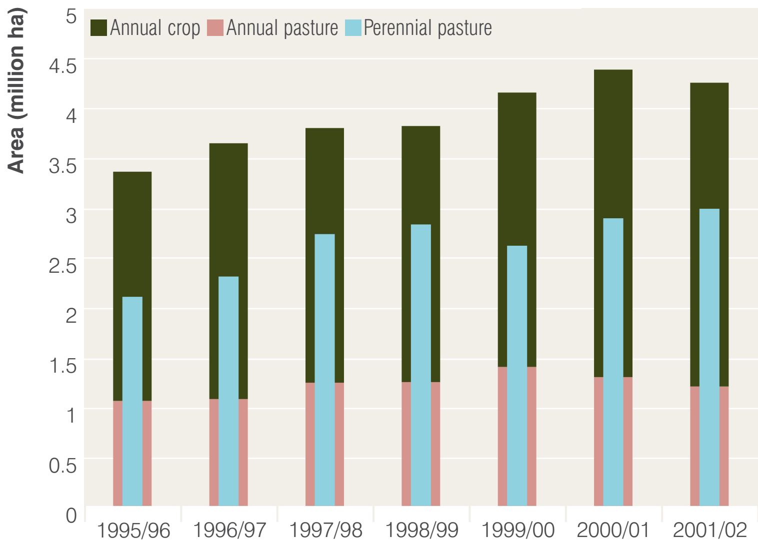
Perennial pasture area increased by approximately 1 million ha over the same period; however, this has not offset the expansion in cropped area. Victoria's agriculture remains skewed towards annual vegetation types, maintaining pressure on groundwater levels. Sowing and management of perennial pastures can be costly and is unlikely to be profitable unless landowners have the skills and commercial drivers to accomplish the transition to higher-input perennial pasture systems. The financial risks involved in establishing perennial pastures are likely to be a barrier to achieving better environmental outcomes[398].

Recommendation

LB6.3 The Victorian Government should continue to invest in the development of readily adoptable and cost-effective perennial-based farming systems for use in areas of high salinity risk.

Figure LB6.5 Area sown to annual crops and pastures and perennial pastures in Victoria 1995–2002

Source: Australian Bureau of Statistics (Crop data Agricultural Commodities, Cat. No. 7121.0; pasture data Agricultural Production)



The trend towards dominance of perennial pastures over annual pastures may help to address salinising processes, especially where annual rainfall is less than 600 mm. In high rainfall areas, however, even perennial pasture systems are unlikely to be adequate to prevent groundwater recharge[399,400,401].

Implications

Salinity produces extensive on- and off-site effects, and has long management timeframes and lasting effects on soil and water resources. The spread of salinity can be rapid (one wet year can cause significant increases or resurgences) but restoration of salinised land is much slower. Improvement over time in the discharge site condition does not directly correlate to reduction in groundwater levels. Achieving significant improvement in the condition of discharge sites generally requires an appropriate vegetation strategy for the discharge area as well as lower water tables. Salinity is a landscape-level problem that requires co-operation between landholders and integration of funding between various stakeholders.

Salinity primarily affects the capacity of the land to support plant growth and ecosystem function is threatened wherever excess salinisation of soil occurs. Salinisation of surface water is also an important consequence of rising saline groundwater.

Saline groundwater often emerges at the surface long distances from where water enters the soil (recharge area), as Victoria has complex regional groundwater systems. Saline groundwater may emerge in sensitive areas of remnant native vegetation, arable land, under towns or directly into rivers and streams. Because of the large spatial scale of salinity and the complexity of the groundwater systems affected, many Victorian natural and infrastructure assets are at risk of damage (see Table LB6.2)[402].

Wetlands and surrounding native vegetation are particularly at risk because their low elevation coincides with groundwater discharge areas. Ramsar wetlands are sites of international significance listed under the Convention on Wetlands, to which Australia is a signatory. Victoria has 11 Ramsar wetland sites[403] and five of these (45%) may be at risk of damage from salinity and shallow groundwater by 2020 (see Table LB6.4).

Table LB6.4 Victorian assets at risk of damage from salinity and shallow water tables
Source: National Land and Water Resources Audit 2001

	Year	
Asset at risk	2000	2020
Agricultural land (ha)	555,000	1,170,000
Perennial vegetation (ha)	6,200	11,830
Length of stream or perimeter of wetlands (km)	10,121	18,146
Ramsar wetlands (number)	4	5
Towns (number)	10	21
Roads (km)	3,896	8,054
Railways (km)	131	303

Impacts of salinity on terrestrial systems

As most plants have evolved in the absence of salt, the majority of plant species (both native and introduced) are unable to grow in saline soils; therefore, salinity results in declining condition of native flora and loss of agricultural productivity. Up to 346 rare or threatened plant species and 485 rare or threatened animal species are recorded in areas that are predicted to have shallow water tables by 2050[404]. These populations are at risk either directly as a result of elevated soil salinity in the case of plant species, or indirectly owing to degradation of habitat in the case of native fauna. Four to eight per cent of all records of threatened flora in Victoria are predicted to be located in shallow water table areas by 2050, along with 9–17% of all threatened fauna records. Some species are at risk of statewide extinction, with all records for 13 plant species lying in areas projected to have developed shallow water tables by 2050[405].

The National Land and Water Resource Audit assessed the implications of salinity for biodiversity and found that:

"More threatened species are currently associated with shallow water table areas in the Wimmera region than elsewhere in the State. The greatest long-term threat to such species appears to be in the Goulburn-Broken, Glenelg-Hopkins and Corangamite regions. Over 20% of these regions' threatened flora records and over 30% of their threatened fauna records are predicted to be located in areas of shallow water table by 2050 under the worst case trend scenario".[406]

Although the worst-case scenario projected by the NLWRA is now thought to be an overestimate of future salinity extent, substantial threats to biodiversity from the current extent of salinity remain.

Implications for agriculture

The direct impacts of salinity at farm level are loss of production and income. Costs to agriculture associated with salinity were estimated at $50 million per year in 2000[407] and are projected to reach $77–166 million per year by 2050[408]. The value of crop yields lost to salinity in Victoria has been estimated at $18.5 million, or about 1.6% of the total net return from agriculture[409]. Given the high value of horticultural commodities produced in irrigation areas at risk of salinity, substantial costs can be expected to impact this industry. However, there is evidence that water tables have been lowered over the last five years in some Victorian irrigation areas[410]. Extensive engineering works have been undertaken to pump saline groundwater and divert salt from the Murray River. Whole-farm planning has increased the efficiency of irrigation water use, leading to lower water tables in irrigation areas (see Box LB6.1; see also Part 3.2 Water Resources). Further increases in irrigation efficiency appear to be possible[411,412].

Because secondary salinity has arisen due to the removal of woody vegetation from the landscape, a recommended approach to reducing salinisation has been reforestation of groundwater recharge areas. While this approach can be beneficial, planting trees to increase water use can reduce the yield of clean water from reforested catchments. This change in hydrological balance can reduce run-off and actually increase stream salinity by reducing dilution of salty streams with fresh run-off[413]. Given the projected water scarcity for some parts of Victoria, detailed cost–benefit analysis will be required to determine the most appropriate vegetation strategies for addressing salinity[414].

As understanding of secondary salinity has improved, there has been a growing realisation that there will be instances where it is not possible or practical to rehabilitate saline land. Production systems based on salt-tolerant vegetation are being developed for these situations.

Impacts of salinity on freshwater systems

Wetland habitats and species are at particular risk from salinity as a result of stream salinisation and intrusion of saline groundwater. Wetlands in the Goulburn Broken and Corangamite catchments are considered to be most at risk. Many rare or threatened species occur in areas that have or are predicted to develop shallow water tables in Victoria and these species will come under further pressure as a result of loss or change of habitat due to salinity. Salinisation of estuaries (for example, the Gippsland Lakes) is also a risk (see Part 4.4: Coasts, Estuaries and the Sea).

One of the most important implications of salinity in Victoria is salination of the Murray River, particularly the lower reaches. The Murray–Darling Basin is a naturally saline environment because of the saline groundwater systems that drain to the Basin. The hydrological imbalances produced by replacement of native vegetation with agricultural species, along with previous inefficient irrigation practices in the Goulburn-Broken catchment, has brought this salt to the land surface and increased its seepage into the river system[415]. Diversion of the Murray River's flows along its length for irrigation and consumption has reduced flow at the river mouth to approximately 27% of the natural level[416] and has meant that salt has accumulated in the river, its floodplains and wetlands, rather than being flushed to the sea. Many of the impacts of salinity in the Murray River are therefore felt downstream in South Australia, with the health of the Coorong and Adelaide's drinking water quality particularly at risk (see Part 4.3: Inland Waters).

Deterioration of water quality as a result of salinisation of Victoria's major rivers will have significant impacts on towns relying on them for drinking water, as well as for irrigators. Salinity objectives for water quality were met at less than half the sites tested in the 2004 Index of Stream Condition assessment (see Part 4.3: Inland Waters). There are no data on the number of people in Victoria potentially threatened by salinisation of drinking water, but the Avoca and Loddon catchments are identified as those at greatest risk[417]. The Murray Darling Basin Commission (MDBC) has set salt content benchmarks of 800 electrical conductivity units (EC)[xxiv] for drinking water (corresponding to the World Health Organisation limit for safe drinking water) and 1500 EC for irrigation. Some waterways in north-western Victoria already exceed the 800 EC limit[418] and the Avoca River is predicted to exceed the 1500 EC limit by 2050[419]. For more information on the implications of salinity for rivers and streams, see Part 4.3: Inland Waters.

xxiv EC = μS per cm at 25°C

Impacts of salinity on infrastructure

In addition to implications for natural and agricultural systems, salinisation of soil and water has implications for the built environment. Increased salt content of water can corrode pipes, pumps and taps, and increase costs for water treatment. At the same time, high saline water tables affect infrastructure such as roads, bridges, building foundations, footpaths and paving, fencing and railways (see Table LB6.3). This can result from both saturation of the subsoil and penetration of salt water into building materials, and result in substantial increases in maintenance costs incurred by local and State Government authorities.

Management responses

Salinity is a catchment-scale issue and occurs both naturally and in response to land use and management in Victoria. Responses to salinity must distinguish between natural and induced salinity, protect naturally saline environments and address causes and impacts of induced salinity. The whole catchment scale of salinity means that integrated responses from Government, CMAs and individual landholders are necessary to address the key objectives of *limiting groundwater recharge* and *rehabilitating discharge sites*.

The large scale and impact of salinity nationally has produced a substantial suite of responses from government and non-government sectors, and has seen the investment of $1.4 billion nationally through the *National Action Plan on Salinity and Water Quality* alone. Commonwealth funding has been important for the delivery of salinity projects in Victoria, but the State has also developed a portfolio of responses to this large-scale issue.

Response Name
National Action Plan on Salinity and Water Quality

Responsible authority
Australian Department of Agriculture, Fisheries and Forestry/Department of Environment and Water Resources

Response type
Strategy/policy

The *National Action Plan on Salinity and Water Quality* (NAP) has been a commitment by the Australian, State and Territory governments to jointly fund actions tackling salinity and related water quality issues. The Plan committed $1.4 billion over seven years to June 2008 ‘to support actions by communities and land managers in 21 highly affected regions’.

Four of the 21 priority regions for the NAP are in Victoria (encompassing six of Victoria’s 10 CMA regions: Goulburn Broken, North Central, Mallee, Wimmera, Glenelg Hopkins, and Corangamite). Actions supported have included on-ground engineering works, rehabilitation activities, protection of waterways and land and water use changes. NAP funding is jointly delivered at a regional level through the Natural Heritage Trust (NHT) to CMAs for projects identified through the regional planning process.

Since its inception in 2002 the NAP has surveyed over 8 million ha nationally for salinity impacts, has revegetated approximately 44,000 ha and treated close to 57,000 ha for rising groundwater. The key goals of the NAP were to engage communities in salinity management and to enable regional communities to use co-ordinated and targeted action to prevent and reverse salinity. The Plan included targets and standards for salinity, water quality and water flows, and was based on an integrated catchment management approach. Monitoring of outcomes was through the National Land and Water Resource Audit process and the most recent Salinity Assessment was completed in 2001.

The NAP and NHT were reviewed by the Australian National Audit Office in 2007/2008[420]. This review found that despite the extremely high level of investment through the NAP, and the extensive outputs of the regional programs supported by the NAP, there is little evidence to demonstrate that the targets proposed in regional plans are adequate to arrest or reverse the decline in catchment condition arising from salinity. The review also found shortcomings in the use of scientific data to develop specific targets and a lack of relevant monitoring. Therefore, despite seven years of investment, it is not possible to identify the most effective approaches to salinity in terms of value for investment.

From July 2008 the NAP will be incorporated into the new, broader Commonwealth NRM program, Caring for our Country, meaning that Commonwealth funding specifically for salinity activities is likely to be reduced.

Response Name
Salinity Management Framework

Responsible authority
Department of Sustainability and Environment

Response type
Strategy/policy

Victoria’s *Salinity Management Framework* was developed in 2000, following the previous major State salinity program, *Salt Action, Joint Action*. The *Salinity Management Framework* commits the Government to real reductions in the extent and economic impacts of salinity by 2015 and is implemented by the CMAs through a series of regional salinity action plans.

The Framework presents goals and targets for 2005 and 2015 that relate to the coverage of monitoring, identification and revegetation of critical recharge zones, management for agricultural production within the capacity of the natural resource base and participation in Murray Darling Basin salt interception schemes. While some of these processes have occurred, the Framework lacks a reporting function to indicate progress. Thus it is unclear whether or not the targets for 2005 were met or whether the goals for 2015 are on track.

Salinity management in Victoria is largely undertaken by the CMAs and while progress is reported against targets identified in individual Regional Catchment Strategies, there does not appear to have been any evaluation of whether or not the Framework as a whole is achieving the desired outcomes for salinity. The Framework itself has not been updated since its launch in 2000 and there is no indication of adaptation of the Framework to the current understanding of salinity development and impacts in Victoria.

Response Name
Environmental Management Action Planning – Mallee region

Responsible Authority
Mallee CMA and partners

Response Type
Process

The Environmental Management Action Planning (EMAP) program being implemented in the Tyrell Basin and Ouyen regions of the Mallee is an example of a co-ordinated, whole-farm planning approach to the protection of natural resources, driven in part by the threat of dryland salinity to significant native species. The EMAP program involves adoption of more sustainable farm and landscape management for multiple benefits including, but not limited to, salinity mitigation. The program illustrates the growing understanding of the landscape-scale nature of salinity and demonstrates an asset-based approach to management of salinity. Outcomes of the program include on-ground environmental works, changed land management practices and building of community capacity in natural resource management.

The Tyrell Basin covers 394,000 ha of the Mallee and is an area where any future rise of saline groundwater is likely to have significant impact. The region is dominated by private agricultural land but also includes areas of remnant vegetation that contain threatened ecosystems, rare and threatened flora and fauna, and a Wetland of National Significance. EMAP commenced in this region in 2005 with funding from the National Action Plan for Salinity and Water Quality, the National Heritage Trust, the National Landcare Program and the Victorian Government. The program was developed jointly by the Mallee CMA, DPI, the Sunraysia Institute of TAFE, the Mallee Regional Landcare Network, Birchip Cropping Group, Mallee Sustainable Farming and the local dryland farming community. The program is supported by monitoring, modelling and research efforts that have allowed the Mallee CMA to prioritise the land resource assets that are at risk from movement of saline groundwater.

EMAP is delivered to individual farmers and Landcare groups and has attracted a high level of participation. In the four years since EMAP commenced, 200 landholders have participated in the education, training, farm planning and action planning activities, developing whole farm environmental plans for 155 properties and 21 Landcare groups that have joined the group program. Training and education in local natural resource management issues forms the basis of the program. Participants use this knowledge to create property-specific Environmental Plans and Action Plans that protect and enhance assets and minimise threats to those assets. Technical and financial support is provided for on-ground works, which has resulted in an increase in the uptake of grants and incentives and more strategic investment in soils and salinity work. An annual review of outputs and outcomes informs a process of adaptive management.

Participants in EMAP have so far developed whole farm environmental plans for land covering 70% of the Tyrell Basin and Ouyen target regions and have undertaken activities including: soil salinity mapping; fencing of remnant vegetation and revegetation activities; planting saltbush to control saline discharge; and establishment of stock containment areas to reduce erosion risks. Salinity control and soil conservation works have been carried out on over 18,000 ha. Approximately 11% of the land in the target areas has been identified for implementation of farming practices aimed at improving water use and reducing soil erosion potential[421].

This program demonstrates the value of a collaborative approach to practice change and the multiple benefits that can be derived from managing salinity as part of the broader landscape.

Evaluation of responses to salinity

Salinity emerged as a major threat to Victoria's agricultural production and natural ecosystems during the 1980s and, since that time, the State has developed a series of strategies and action plans, each based on the current understanding of salinity at the time of development. These have been highly 'threat-based', focusing on the threat to land and water resources posed by salinity. Understanding of the processes by which salinity occurs and may be addressed have evolved rapidly, largely due to substantial investment by Commonwealth and State Governments in research (for example, the Co-operative Research Centre for Plant-based Management of Dryland Salinity and the National Dryland Salinity Program). However, in Victoria, this has not been matched by acquisition of knowledge about the flow regimes of aquifers and the location of saline aquifers, which is needed to deploy the most appropriate and cost-effective management options.

The acquisition of knowledge about managing salinity has generated a complex array of land management responses suitable for different situations. For example, tree planting and perennial pastures are enshrined in most salinity management plans as a means of controlling groundwater recharge. It is now known the effectiveness of these solutions varies depending on rainfall and position in the catchment. At the property scale, these responses are rarely effective because groundwater systems are highly complex throughout the landscape and extremely large areas of revegetation are required. Nevertheless, revegetation and the adoption of perennial-based farming systems has an important role to play in the management of salinity.

Community awareness of the importance of trees and native vegetation in landscape and hydrological function has been escalated through the activities of Government and the CMAs in response to salinity. It is important to note, however, that placement of trees for maximum impact on salinity but minimum impact on run-off and recharge of good quality aquifers is critical. It will be important to accurately map and understand the hydrological characteristics of Victorian groundwater systems, and to accurately target salinity management activities.

Community activity in response to salinity has also been substantial, with land owners engaged through Landcare and other voluntary activities. The broader community has become involved in programs such as Saltwatch, a community water quality monitoring program. Countless trees have undoubtedly been returned to the landscape as a result of community activities driven by the issue of salinity. Land owner engagement in salinity management is being further encouraged with the development of production systems based on salt-tolerant species for use on saline land that cannot be desalinised; for example, the grazing systems based on tall wheat grass pastures developed through the Sustainable Grazing on Saline Lands sub-program of Land, Water & Wool (a $40 million, five-year partnership between Australian Wool Innovation Limited (AWI) and Land & Water Australia).

Ultimately, however, salinity remains a matter for concern in Victoria, despite the alleviation in groundwater levels that has occurred during the current prolonged drought, because salt that has been brought to the surface by groundwater remains in soils and prolonged periods of low flows have concentrated salt in some of Victoria's most important rivers. It is now acknowledged that it will not be possible to arrest or reverse all occurrences of salinity in Victoria and the management of salinity is likely to become part of a more integrated, asset-based approach to land and natural resource management. Under this framework, investment will be targeted to occurrences of salinity that threaten major natural or economic assets and informed no action or production based on salt-tolerant species may be adopted for others.

Key response indicator: Depth to ground water

For further information

National Action Plan on Salinity and Water Quality: www.napswq.gov.au/

Victoria's Salinity Management Framework: www.dpi.vic.gov.au/CA256F310024B628/0/CAB702DDB11E0B7ACA2572880081F866/$File/Salinity.pdf

Sustainable Grazing from Saline Lands: www.landwaterwool.gov.au/land-water-and-wool/sustainable-grazing-saline-lands/about

Photo: Jane Tovey

LB7 Soil acidification

Key findings

- The cost of lost productivity due to soil acidification to Victoria is estimated at $470 million per year. Productivity declines due to soil acidification also reduce the amount of land that could be used for biodiversity conservation in agricultural landscapes.
- Soil acidification is accelerated by some land management practices and the area of acid soil is increasing; however, Victoria has large areas of naturally acidic soils that can't be distinguished from soils acidified by agriculture.
- The use of acidifying fertiliser is increasing to support the increasing cropping intensity in Victorian agriculture.
- Only 5.5% of the area requiring treatment to restore critical pH levels is sufficiently treated with lime. Current lime use in Victoria is only 7% of the level required for soils to reach pH 4.8 and 2% of that required to reach pH 5.5 on a statewide basis.
- The last statewide assessment of soil pH was made in 1994.

Description

Many Victorian soils are naturally acidic and some soils are becoming more acidic. Acidification of soil is a naturally occurring process. Soil acidification occurs as a result of gradual accumulation of hydrogen ions (H^+) in the soil and the associated release of aluminium ions (Al3+). In undisturbed ecosystems this process occurs over thousands of years but can be accelerated by agricultural practices.

Acidity is measured on the pH scale[xxv]. This scale ranges from zero (strongly acid) to 14 (strongly alkaline). Soils with pH of around 7 are considered neutral. Soil pH varies naturally as a consequence of underlying geology, landform, soil type and rainfall, for example, high-rainfall regions tend to have naturally acidic soil while low-rainfall regions tend to have naturally alkaline soils. Naturally acidic soils occur more widely in central and southern Victoria than in the north-west, where soils are naturally alkaline[422] (see Figure LB7.1).

Most plants grow best in neutral soils (pH 6–8). At pH values outside this range, essential nutrients can be limited and toxic elements can be mobilised. Acidified soils can develop a limited capacity to support agriculture and forestry, and can restict revegetation because plant selection is limited to acid-tolerant species and varieties. Soil acidification causes a slow decline in productivity and is difficult to detect. Although less visible than salinity, the cost of soil acidification to Victoria is estimated at $470 million per year[423], compared with $50 million for salinity.

Accumulation of hydrogen and aluminium ions in soil associated with the soil nitrogen cycle is the primary cause of accelerated acidification (see Box LB7.1). Accelerated acidification is strongly associated with the addition of nitrogen (as fertiliser or symbiotically fixed nitrogen) to soil to support agricultural land uses.

Other side-effects of agricultural production also cause soil acidification. In particular, net loss of alkalinity by removal of agricultural products, for example, grain, meat, wool and milk, causes soil acidification. Accumulation of organic matter can also contribute to soil acidification, although the organic matter also provides benefits for soil health.

Acidified soils are generally treated by application of lime or dolomite, which can be costly, and indeed uneconomic in some circumstances[424]. By the time plant decline is apparent, the possibility of complete soil pH restoration may be limited[425]. However, unmanaged soil acidification can result in sub-soil acidification which is more difficult and costly to address. Adoption of farming systems and practices that are less likely to accelerate acidification, such as the use of perennial species and efficient use of nitrogen fertiliser and irrigation, is therefore desirable.

Box LB7.1 Role of nitrogen fertilisers, nitrogen-fixing legumes and nitrate leaching in soil acidification

Ammonium ions can be added to soil in the form of nitrogen fertilisers or fixed from the atmosphere by legume plants (via the rhizobium associated with legume root nodules). Oxidation of ammonium ions (NH_4^+) to nitrate ions (NO_3^-) by soil bacteria produces two hydrogen ions for each ammonium ion oxidised. These hydrogen ions bind to clay surfaces, displacing calcium, potassium and magnesium ions and also releasing aluminium ions (Al^{3+}). If the nitrate produced is not absorbed by plant roots it is leached beyond the rootzone and into the subsoil, along with calcium, potassium and magnesium ions. The hydrogen ions, along with the aluminium ions that they release from clay, remain to acidify the soil.

Coastal acid sulfate soils are a special case of soil acidification and are discussed in Part 4.4 Coasts, Estuaries and the Sea. No estimate of the extent of acid sulfate soils inland in Victoria has yet been made.

Objectives

- To limit the development of critical levels of acidification (pH less than 4.5) in Victorian soils
- To return acid soils to a pH range capable of supporting acceptable levels of plant productivity

Links

See also: Land and Biodiversity – Contemporary land use, Salinity; Part 4.3 Inland Waters; Part 4.4 Coasts, Estuaries and the Sea

xxv Soil pH may be measured in water or in a solution of calcium chloride ($CaCl_2$). These tests give different results, with pH values measured in calcium chloride approximately 0.7–0.9 pH units higher than those measured in water. Thus, $pH_{(CaCl2)}$ 4.8 is approximately equal to $pH_{(water)}$ 5.5.

State

Soil acidification is becoming more widely recognised as a significant land degradation issue in Victoria. It is specifically relevant to agricultural land uses because acid soils with pH of less than 5.5 can restrict the growth of crop and pasture plants. Also agricultural land uses are most likely to cause accelerated acidification. Almost half of Victorian farm businesses reported soil acidity as a land management issue in 2006/2007[426].

Extent of acid soils

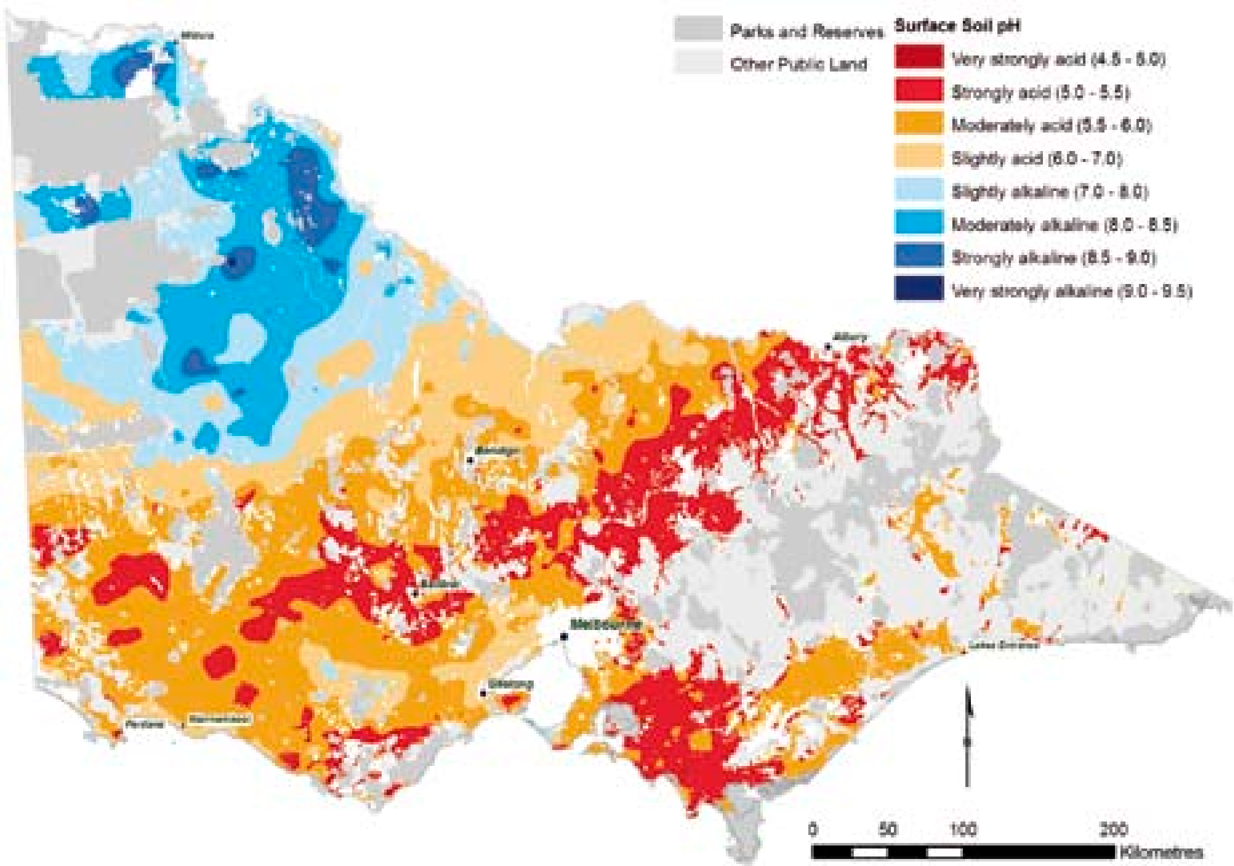
The National Land and Water Resource Audit (NLWRA) estimates that Victoria has 6.5–8.6 million ha of soils with pH($CaCl_2$) (pH measured in a solution of calcium chloride, $CaCl_2$) of 5.5 or less in the top 10 cm, including 4–5 million ha of strongly acidic soils (pH($CaCl_2$) 4.3–4.8)[427]. Of this area, 2.4 million ha also have acidic subsoils. Most of this area, including 23% of Victoria's agriculturally productive soils, is naturally acidic.

Figure LB7.1 shows the approximate distribution of surface soil pH in Victoria, determined from a statewide soil chemistry dataset based on samples submitted from farms, vineyards and orchards between 1973 and 1994. These Victorian tests are performed in water, rather than calcium chloride. This map provides broadscale information about the occurrence of strongly acid soils and may be out of date for some soil types. Nevertheless, this information can be used to direct attention to regions where soil acidity is likely to fall below critical levels for plant growth. Surface soil pH is moderately to strongly acidic in Victoria's Eastern and Western Uplands, the Strzelecki and Otway Ranges and north-eastern Victoria. The acid soil conditions in these areas are known to limit plant production in agricultural industries. In contrast to much of the State, soils in north-western Victoria are generally alkaline (see Figure LB7.1).

Soil pH generally becomes more alkaline at depth. Prolonged acidification of surface soil layers increases the risk of subsoil acidification, which can be difficult to remediate owing to the slow rates of infiltration of neutralising compounds such as lime[428].

Current estimates of soil pH are largely based on commercial soil tests, which are limited by the fact that the location of the sample is not accurately recorded. Therefore, mapping is based on interpolation between nearest locations to soil test sites.

Figure LB7.1 Surface soil pH across Victoria's agricultural soils.
Note: Soil pH data used to create this map were collected between 1973 and 1994
Source: Victorian Resources Online



Indicator LB32 Rate of soil acidification

Soil pH changes with time and is known to have changed as a result of vegetation clearing and modern farming practices. For example, soil pH in north-eastern Victoria declined by approximately one pH unit in the 30–40 years following the introduction of modern agricultural practices[429]. These trends, however, are not captured in current data sets and it is not possible to determine current or historic statewide trends in soil pH from the data available[430].

Rates of acidification vary with crop and pasture rotations; for example, 0.8 pH units over 17 years for a continuous wheat rotation compared with 1.5 pH units over the same period for continuous lupin crops[431]. The NLWRA estimates that in the absence of lime application, up to 13.5 million ha of Victorian soil will have pH($CaCl_2$) of 4.8 or less by 2020[432]. Other estimates indicate that the area of strongly acid surface soil may double by 2050[433]. The CMA regions identified as being most at risk of soil acidification by 2050 are: North East, Goulburn Broken, Glenelg Hopkins, West Gippsland, southern parts of the North Central region and the southern Wimmera[434].

The current data also do not allow distinction between soils that are naturally acidic and those soils in which acidification has been induced or accelerated by agricultural land use. There is a clear need to update soil pH information for Victoria. Any new data collection should attempt to differentiate between naturally occurring soil acidity and soils acidified by land management practice so that resources can be directed towards correcting accelerated acidification. Such an analysis would benefit from the development of soil type benchmarks, as proposed for soil structure analysis (see section LB5 Soil structure and erosion).

Recommendations

LB7.1 The Victorian Government should allocate funding for a comprehensive statewide pH benchmarking program and establishment of long-term monitoring sites in key areas. The findings of such a program should be made widely available to land managers to encourage optimal management and remediation for each soil type.

LB7.2 The Victorian Government should update the soil surface pH map layer to indicate the current soil pH status. This information should be made widely available to land managers to encourage optimal fertiliser management and lime application.

Pressures

While many soils in Victoria are naturally acidic, soil acidification is accelerated by some land management practices. Loss of nitrogen from the root zone by leaching of nitrate through the soil profile is the most widespread cause of soil acidification and, like salinity, is related to drainage of excess water beyond the plant root zone. Thus, there is a strong relationship between salinity and acidity, as they have similar underlying causes and each exacerbates the other. In addition, three other primary causes of induced acidity have been identified[435]:

- removal of alkaline products such as wool, grain, meat and plant material such as hay and wood
- use of acidifying ammonium-based fertilisers
- build-up of organic matter

Inefficient use of irrigation can also contribute to acidification because drainage of the unused water through soil leaches nitrate.

The area of Victoria that is farmed (approximately 13.25 million ha; see section LB2 Contemporary land use change) has been relatively stable since about 1980[436]; however, the intensity of agricultural production from the farmed area has increased over this period (see section LB2 Contemporary land use change, Indicators LB13 Area cropped and LB14 Area irrigated). Increased agricultural productivity has meant that more fertiliser and water have been applied and more products (grain, meat, wool, hay) are removed, all of which contribute to soil acidification.

Vegetation type also influences soil acidification. Perennial plant systems take up greater amounts of water than annual plants, which helps reduce nitrate leaching[437,438]. The area of Victoria sown to perennial pastures has increased in the last decade, but remains less than the area sown to annual crops and pastures (see section LB6 Salinity, Figure LB6.4). Continued adoption of farming systems based on perennial plants is necessary to reduce rates of soil acidification, in addition to the benefits provided by perennial systems for salinity and carbon capture.

Recommendation

LB7.3 The Victorian Government should continue to support the development and adoption of farming systems based on perennial plants in order to address acidification and salinity, and to capture benefits for biodiversity and soil carbon sequestration.

Indicator LB33 Use of nitrogen fertiliser

Some of the changes in farming practices that occurred during the 20th century accelerated soil acidification by increasing the amount of nitrogen added to the soil. The inclusion of pasture and grain legume crops has increased the addition of nitrogen to soils because legume plants are able to biologically fix atmospheric nitrogen. Biologically fixed nitrogen acidifies soil by the same process as fertiliser nitrogen (see Box LB7.1). The introduction of high-value crops with high nitrogen requirements, such as canola, has further increased reliance of Victorian agriculture on nitrogenous fertilisers, which promote soil acidification[439] (see also Box LB7.1). Ammonium-based fertilisers are particularly acidifying.

Fertiliser use in Victorian agriculture was last reported in detail by the ABS in the 2000/2001 agricultural census. In that year approximately 188,500 tonnes of ammonium-based fertilisers were used of a total of approximately 1 million tonnes of artificial fertiliser applied[440]. This represents a significant increase from the average total application of artificial fertiliser between 1991 and 1994 of approximately 625,000 tonnes.

Implications

Acidification affects soil chemistry, limiting the availability of some essential plant nutrients and increasing the soil water concentrations of some toxic elements. Therefore the primary effect of soil acidity is reduced plant growth and vegetation cover. This affects mainly agricultural production but also has implications for management of other forms of environmental degradation. Acidification is linked to a suite of other soil-related land degradation issues such as erosion, salinity and loss of vegetation and soil biodiversity[441]. Declining agricultural productivity arising from soil acidification may have the effect of reducing the availability of land for non-production purposes, such as revegetation and habitat restoration.

Poor vegetation cover owing to soil acidification reduces the effectiveness of erosion control and results in diminished use of water and nitrogen. Excess water and nitrogen either drain to groundwater or run off over the land surface. These effects exacerbate acidification and also contribute to salinity and contamination of surface water.

Loss of plant productivity contributes directly to lost agricultural productivity through reductions in crop yields and pasture biomass. The costs for Victoria associated with accelerated soil acidification are estimated to be $470 million per year, mostly arising from lost agricultural productivity[442]. Acidic soil limits options for managing salinity, as it precludes the use of acid-sensitive perennial plant species, such as lucerne, which feature in most salinity management strategies[443].

In addition to impacts on plant growth, prolonged acidification can cause irreversible damage to soil itself. If soil pH declines below approximately 4.3 in some soils and remains low over a prolonged period, clay minerals decompose. Under these conditions, clay can be lost from the soil[444]. Soil then loses structure and can become hard setting.

Earthworms and other soil organisms are generally sensitive to soil pH and tend to decrease in abundance in acid soils[445,446]. The burrowing activities of earthworms are confined to the surface litter layers in acid soils; thus, the benefits of worms for soil structure and organic matter turnover are reduced in acid soils (see section LB5 Soil structure decline and erosion, Box LB4.2). A secondary effect of the loss of earthworm activity in acid soils is the loss of habitat and food sources for other soil fauna, which feed on the breakdown products of organic matter produced by worms.

Management responses

Soil acidification has been identified as costing Victoria more than salinity, yet Government and community responses to soil acidification have been fewer. Government's capacity to act may be limited because the most effective response to acidification once it has developed to the point where productivity is limited is treatment of the site with lime. This falls within the scope of individual land owners' land management decisions. Thus, management responses addressing the key objectives for soil acidification – *to limit the development of critical levels of soil pH and to return soils to a productive pH range* – are in the hands of individuals. Although it is likely that management of soil acidification will be applied according to the economic circumstances and production objectives of individual farm businesses, considerations of land stewardship and long-term sustainability of production are also likely to influence management decisions.

The key roles for Government in management of soil acidification are the provision of research and development and delivery of information to land managers, to facilitate adoption of best management practices.

Response Name
Environment and Natural Resources Committee *Inquiry on the Impact and Trends in Soil Acidity*

Responsible authority
Parliament of Victoria, Environment and Natural Resources Committee

Response type
Process

A *Parliamentary Inquiry into the Impact and Trends in Soil Acidity*[12] by the Environment and Natural Resources Committee of Parliament was undertaken in 2003/2004 with the aim of reviewing and reducing projected impacts of soil acidification[447]. The inquiry was initiated in response to a DPI report, *The impact of acid soils in Victoria*, and produced 15 recommendations, of which 12 were supported or supported in principle in the Government's response to the Inquiry report. The recommendations not supported related to the role of DPI in negotiating costs of soil testing and reviewing operations of soil testing laboratories. A further recommendation relating to the frequency of surveying of lime producers was also not supported.

A key outcome of this inquiry was the identification of soil acidification as part of a larger suite of issues related to 'soil health'. As a result of the inquiry, the focus of DPI and DSE programs has moved to a more holistic approach to soil condition, incorporating soil acidification. DPI has developed a series of soil health investment priorities that aim to integrate soil health into existing agricultural extension and planning programs.

Response Name
Soil Health Strategies

Responsible authority
Victorian Catchment Management Authorities

Response type
Strategy

The parliamentary inquiry into the impact of soil acidity by the Environment and Natural Resources Committee was instrumental in developing the concept of soil health, meaning the 'fitness' (or condition) of soil to support specific uses in relation to its potential. The soil health concept provides an integrated framework for approaching to soil-related issues, such as acidification, erosion, soil structure decline and fertility, which previously were treated individually.

Soil health as an approach to improving soil management has been embraced by Victorian CMAs, which have developed a range of 'soil health' documents such as Soil Health Strategies and Action Plans. In some cases these are stand-alone documents that articulate investment guidelines, actions plans and targets, while in others the principles have been incorporated into Regional Catchment Strategy targets and actions.

The detail of soil health documents varies between regions depending on the soil-related assets and threats relevant for each region. Common themes, however, include raising community awareness and understanding of soil health issues, community capacity building, the importance of partnerships across State and local governments and the private sectio, and the co-ordination of soil health programs with existing extension and natural resource management programs.

Soil acidification is recognised as an issue in several regions. The investment priority given to acidification depends on whether it is viewed primarily as a limitation on agricultural productivity or whether its broader implications for native vegetation management, soil carbon accumulation and control of salinity and erosion are identified.

It is not yet possible to evaluate the effectiveness of regional soil health programs, although some have defined targets and monitoring protocols, suggesting that evaluation is likely to be possible over the longer term.

Evaluation of responses to soil acidification

The management of soil acidification has, to date, been a matter for private land owners and individual farm businesses involving decisions about lime application. Approximately 445,000 tonnes of lime were applied to Victorian soils over an area of approximately 250,000 ha in 2000/2001[448]. The Australian Agriculture Assessment (2001) indicates that 4.5 million ha would need to be treated with lime to raise the pH of existing acid land to the critical value of 4.8, while 6.5 million ha would need to be treated to raise pH to 5.5[449]. At the rate of lime application recorded in 2001 (approximately 0.4 million tonnes per year), it is estimated that it will take 15 years to raise soil pH to 4.8 on a statewide basis and 59 years to reach pH 5.5. Lime application in Victoria, therefore, is substantially less than the level needed to restore soil pH to critical levels.

The NLWRA estimated that, nationally, only 4% of acid soils could be profitably treated, but that treatment of this responsive area could be expected to provide large financial benefits to farmers[450]. In the current period of prolonged low rainfall, returns on this investment may not be realised and lime application is likely to be limited by the low cash reserves of many farm businesses.

Acid soils can produce offsite effects on waterways and biodiversity. For these reasons there is a role for government responses that encourage behaviour change in individual land owners. The recognition of soil acidification as part of a suite of soil health issues, and a change in focus of government agencies towards a holistic approach to soil management, has been an important outcome of the investigation of acid soils in Victoria. This approach is beginning to be implemented with the development by DPI of of the document *Soil Health: Priorities for Action* (see section LB5 Soil structure and erosion) and a policy framework for soil health. It is too early to evaluate the effectiveness of these initiatives.

Catchment Management Authorities are also developing soil health strategies to provide information and training for land owners and to help implement on-ground works to address soil issues. For example, the Corangamite CMA *Soil Health Strategy* was launched in November 2007. These strategies will need to be integrated with those of government agencies and with the planning activities of local governments to achieve maximum impact.

Key response indicator: To adequately assess progress on this issue within the context of the natural variability in soil pH in Victoria it would be desirable to have soil type benchmarks for pH. In the absence of such benchmarks, the area of soil below the critical $pH_{(water)}$ of 4.8 (or $pH_{(CaCl2)}$ 5.5) could be used as an indicator. Currently this is 4–5 million ha.

Trend: unknown, but projections indicate substantial increase in acidification by 2020 if no remedial action is taken.

For further information

Soil acidification: http://www.parliament.vic.gov.au/enrc/inquiries/soilacidity/

Department of Primary Industries: http://www.dpi.vic.gov.au/DPI/nrenfa.nsf/childdocs/-80E62E2EAB672EE24A256B520005A0AF-7C866D87F6E182014A256B52000B09C0?open

The impact of acid soils in Victoria: http://www.dpi.vic.gov.au/DPI/Vro/vrosite.nsf/pages/soil_mgmt_acid

LB8 Fire in the Victorian Environment

Key findings

- Climate change is forecast to substantially increase the fire risk in Victoria, with the number of very high or extreme fire danger days across south-eastern Australia expected to increase by up to 25% by 2020 and up to 230% by 2050.
- Victoria has experienced a high frequency and severity of fires in the last decade, including major bushfires in 2003 and 2007 that each burnt in excess of 1 million ha. Some species have undergone marked declines and have large amounts of habitat have been lost following these large-scale fires.
- Fire regimes in Victoria have been altered in response to demand for fire suppression to protect human life and property. Inappropriate fire regimes (too much or too little fire) threaten the persistence and condition of some species and ecosystems. Human sources of ignition account for at least 70% of individual fires on public land in Victoria.
- Uncertainty exists over optimal levels of planned burning in Victoria for ecological benefits and protection from wildfire.

Description

Southern Australia, including Victoria, has one of the most fire-prone environments in the world owing to its particular combination of climate, vegetation and topography. Wildfire is a normal feature of the Victorian environment and plays a key role in the regeneration and regrowth of many plant species. Fire stimulates regrowth from existing plants as well as the release and germination of seeds. While many species require periodic exposure to fire to stimulate regeneration, the appropriate timing and intensity of fire varies between plant communities. In general, grasslands and heathlands require more frequent burning than eucalypt forests to maintain diversity and community structure[451]. The sequence of fire events is referred to as the fire regime.

Aboriginal people used fire extensively for a variety of reasons, but most importantly to control the distribution, diversity and relative abundance of plant and animal resources[452]; however, there are few records of specific fire events prior to European settlement. European settlers used fire to clear land for settlement, mining and agriculture. Major wildfire events have been recorded at variable intervals since European settlement of Victoria, most notably in 1851, when 5 million ha were burnt, 1939, 1983, 2003, 2006 and 2007.

As Victoria's population has increased and more people live in close proximity to forested and other fire-prone landscapes, the focus of land managers has been the suppression of wildfire to protect human life and assets, and the management of fuel loads. These changes to the frequency and intensity of fire have impacts on ecological processes.

All fires – wildfires and planned fires – as well as the absence of fire, have ecological outcomes. The challenge for land managers is to balance the control and prevention of wildfires and associated dangers of loss of life and asset damage with the requirement of many ecosystems for regular burning. However, ecological fire regimes must be based on knowledge of species' responses to the various aspects of fire, such as season and frequency of burns, fire intensity and landscape coverage[453,454]. It is only since the introduction of the Code of Practice for Fire Management on Public Land in 1995 that Victoria has had a scientifically based framework regulating the prescribed use of fire to achieve ecological as well as social and economic outcomes[455].

Fire frequencies that are too high or too low threaten Victoria's biodiversity by changing the structure of plant communities. The ideal interval between fires for any given plant community is determined by the time taken by each species to reach maturity and set seed and the time to extinction in the absence of fire[456]. If fire is too frequent, species that are not able to reproduce may be lost from the community. If the interval between fires is too long, species that depend on fire for regeneration may die out[457]. Ideally, periodic fires burn patches within the landscape, producing heterogeneity in vegetation age and structure. Multi-aged forests are considered most valuable for providing the habitat requirements of Victoria's native animal species[458], and therefore fire regimes that promote spatial variation in vegetation structure are desirable. The patches of remnant vegetation in peri-urban areas are too small to support the mosaic of fire regimes needed to produce this spatial heterogeneity.

Intensity of fire also affects ecosystem function. Many forest species have mechanisms for regenerating after fire; however, trees may be unable to regenerate after very intense fire and some tree species are sensitive to fire. Severe fire can sterilise soil and change its chemical and physical composition. The recent prolonged period of low rainfall and sequence of warmer summer temperatures (see Part 4.1: Atmosphere, Climate Change) have produced two very severe and extensive fires in Victoria's alpine region in rapid succession (2003 and 2007). Climate change is expected to further increase the frequency and severity of fire in Victoria.

This section examines the impact of fire on native vegetation and terrestrial biodiversity mostly in the context of Victoria's areas of largely intact native vegetation.

Objectives

- To balance the protection of life and property with the ecological requirement of many ecosystems for fire
- To improve understanding of biodiversity responses to fire and develop optimal ecological burning regimes
- To limit the risk of wildfire and associated damage to life, property and natural assets

Links

See also: Land and Biodiversity: Impacts of climate change on land and biodiversity; Part 4.1 Atmosphere: Climate Change; Part 4.3 Inland Water.

State

Indicator LB34 Area of native vegetation burnt in planned fires and wildfires 2001–2007

Planned fire

Victoria has approximately 8.9 million ha of public land, mostly in parks, reserves and State forests. Fire is one of the tools used by the Department of Sustainability and Environment to manage this land. Planned fire is used to manipulate fuel loads and to achieve ecological outcomes, such as desirable vegetation composition and structure.

Since 2001, 483,369 ha out of a total of 10.3 million ha of native vegetation remaining in Victoria have been burnt in planned fire events. In most years the area burnt has been in the range 20,000–75,000 ha, but in 2004 and 2005 over 100,000 ha were burnt (see Figure LB8.1) in response to recommendations from the *Report of the Inquiry into the 2002–2003 Victorian Bushfires*[459]. This report indicated that maximal use should be made of opportunities for planned burning to reduce fuel loads in Victorian forests. The current annual target for planned burning in Victoria is 130,000 ha[460], or approximately 1.5% of Victoria's public land.

The forest types burnt most by planned fire events were Eucalypt forests and woodlands, especially Eucalypt Mallee Woodland (60,035 ha), Eucalypt Tall Open forest (95,993 ha) and Eucalypt Medium Open forest (224,793 ha) (see Table LB8.1). Eucalypt forest types dominate Victoria's forests and have a number of mechanisms for regrowth and regeneration after fire.

Wildfire

Victoria has a history of large-scale wildfires, especially since European settlement (see Figure LB8.2), including fires that burnt 5 million ha in 1851 and 1.5 million ha in 1939. The 30-year average number of wildfires (unplanned bushfire) prior to 2006 was 510 per year, which burnt an average of 126,724 ha per year[xxviii,461]. Wildfires in the alpine region of eastern Victoria in 2003 burnt nearly 1.12 million ha, mostly in parks and forests on public land[462] (see Figures LB8.3, and LB8.4). Over 100,000 ha of private land were also burnt[463]. The other major fire to affect Victoria in 2002/2003 occurred in the Big Desert National Park and burnt 181,400 ha. More than 3,000 individual fires occurred throughout Victoria in the 2002/2003 bushfire season.

In the 2006/2007 bushfire season more than 1,000 wildfires burnt an area in excess of 1.2 million ha[464] (see Figures LB8.2, LB8.3, LB8.4), again mostly in the alpine area but including a large fire in the Grampians area of western Victoria. The magnitude and severity of the fires in 2003 and 2007 are consistent with previous observations that severe drought conditions produce increased forest fire activity[465].

As for planned fire events, the most affected forest types during wildfires were Eucalypt Woodland and Open forests (see Table LB8.1), reflecting the dominance of these vegetation types in the alpine area.

Figure LB8.1 Area of native vegetation burnt in planned fire events in Victoria between 2001 and 2007
Source: Department of Sustainability and Environment 2007, unpublished data.

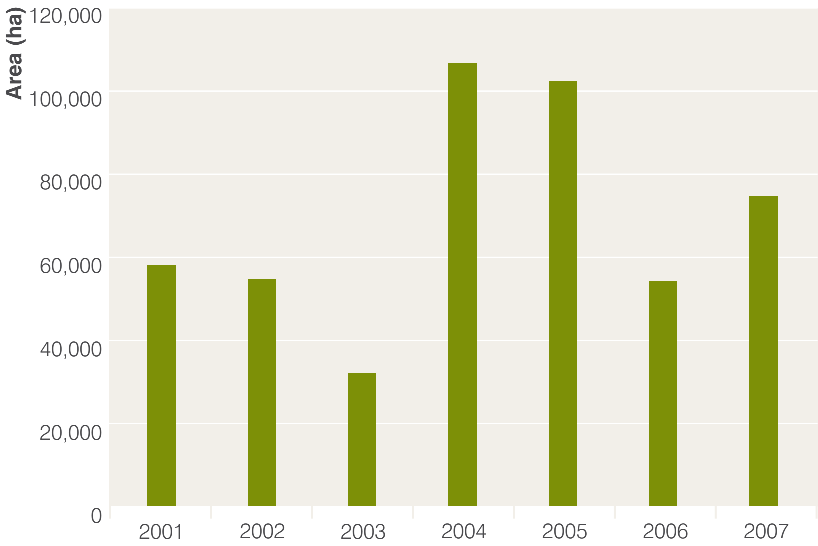


Table LB8.1 Native vegetation burnt in planned fire and wildfire events between 2001 and 2007 by forest type.
Source Department of Sustainability and Environment 2007, unpublished data

Forest type	Planned fire: Total area burnt (ha)	Planned fire: % of burnt area	Wildfire: Total area burnt (ha)	Wildfire: % of burnt area
Eucalypt Low Closed	717	0.15	6,866	0.25
Eucalypt Low Open	2,580	0.54	44,326	1.59
Eucalypt Low Woodland	2,177	0.45	5,567	0.20
Eucalypt Mallee Woodland	60,035	12.54	219,027	7.88
Eucalypt Medium Closed	6,239	1.30	36,468	1.31
Eucalypt Medium Open	224,793	46.97	1,153,131	41.48
Eucalypt Medium Woodland	41,018	8.57	310,392	11.16
Eucalypt Tall Closed	4,837	1.01	52,215	1.88
Eucalypt Tall Open	95,994	20.06	582,675	20.96
Eucalypt Tall Woodland	3,468	0.72	29,536	1.06
Acacia	4,384	0.92	11,941	0.43
Callitris	1,304	0.27	9816	0.35
Casuarina	152	0.03	277	0.01
Melaleuca	816	0.17	1,860	0.07
Rainforest	419	0.09	569	0.02
Plantation[xxvi]	1,056	0.22	12,079	0.43
Other[xxvii]	28,609	5.98	303,304	10.91
Total	478,596	100	2,780,049	100

xxvi Plantation includes hardwood, softwood and mixed plantations.

xxvii Other includes non-forest vegetation, vegetation for which no forest type data was collected and other forest types.

Figure LB8.2 Area burnt in significant Victorian wildfires[xxix]
Sources: Esplin B, Gill AM, Enright N. 2003. Report of the inquiry into the 2002–2003 Victorian bushfires. Report to Department of Premier and Cabinet, Commissioner of Emergency Services, Victoria; Ministerial Taskforce on Bushfire Recovery. 2007 Report from the Ministerial Taskforce on Bushfire Recovery.

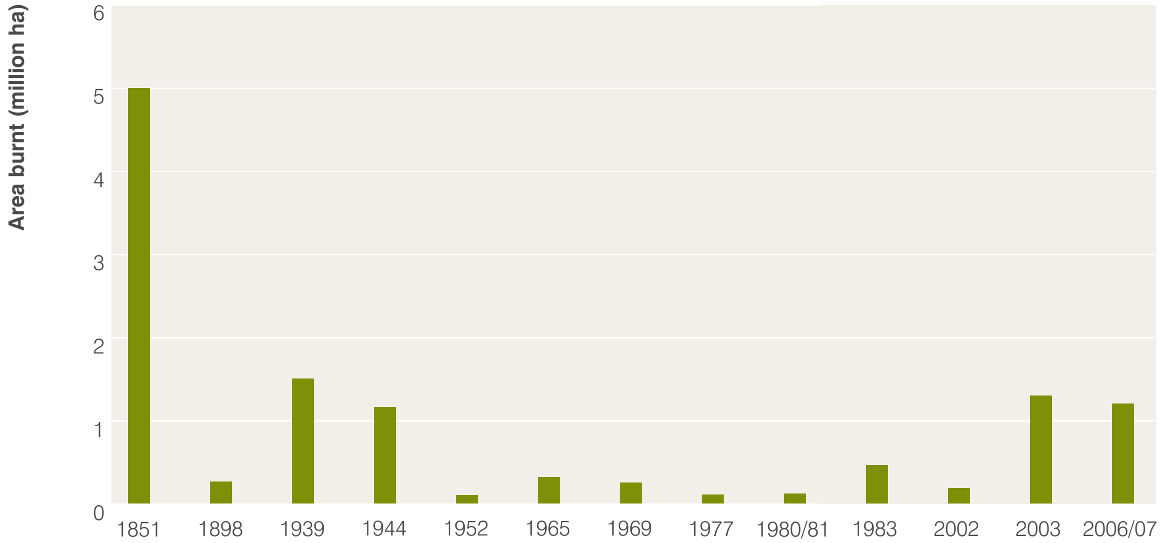


Figure LB8.3 Area of Victorian native vegetation (all vegetation types) burnt in unplanned fire events between 2001 and 2007.
Source: Department of Sustainability and Environment 2007 unpublished data

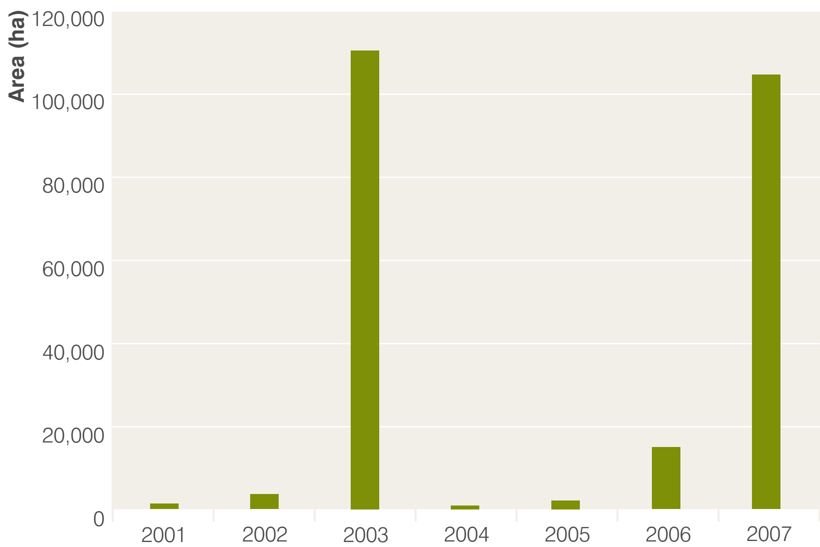


Figure LB8.4 Major wildfires in Victoria between 2002 and 2007
Source: Department of Sustainability and Environment 2007

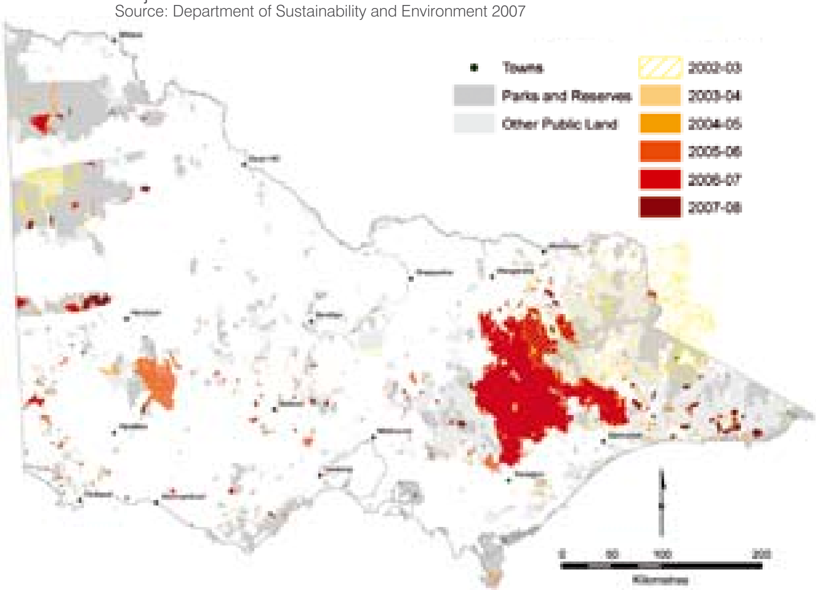


Figure LB8.4 shows the spatial distribution of fires between 2002 and 2007 and highlights the extent of the 2002/2003 Alpine fires and 2006/2007 Great Divide fires compared with other fires that occurred in the same period. A combined area of approximately 2.3 million ha was burnt in these two fires[466]. Of particular significance is the area of overlap between the 2003 and 2007 alpine fires. The repeated burning of this area of 145,000 ha[467] in only four years has implications for the survival of forest species that regenerate from seed, such as Mountain Ash (*Eucalyptus regnans*) and Alpine Ash (*Eucalyptus delegatensis*), which dominate Victoria's eastern forests[468]. These species require up to 20 years without fire to reach reproductive maturity[469], therefore repeated short-interval burning is likely to result in loss of these seeding species from the forest and their replacement with species that resprout quickly from burnt trunks or from roots after fire, such as some *Acacia* species.

xxviii This figure may be skewed by the large area burnt in 2002/2003.

Pressures

The frequency of wildfire has increased with Victoria's growing population. Human sources of ignition account for at least 70% of individual fires on public land in Victoria, with lightning accounting for most of the remainder[470]. Some forms of human ignition, for example sparks from machinery and vehicles, are likely to increase with the growth of population in peri-urban areas.

Climate change is expected to increase the frequency and severity of fire in Victoria (see Part 4.1 Atmosphere: Climate Change). The numbers of extreme fire danger days are projected to increase by 5–40% by 2020 and 15–230% by 2050 across south-eastern Australia[471]. Melbourne is expected to experience around 15 very high or extreme fire danger days per year by 2050, compared with the current average of nine days per year[472]. More frequent drought conditions may also increase the severity of fires[473]. Departure of fire frequency from ecologically appropriate intervals is detrimental for vegetation structure as regeneration may be prevented or reduced. Weeds may become established as vegetation structure is degraded.

Recommendation

LB8.1 The Victorian Government should formulate a response in preparation for the increased risk of fire that is arising from climate change.

Indicator LB35 Actual fire regimes compared to 'optimal fire regimes'

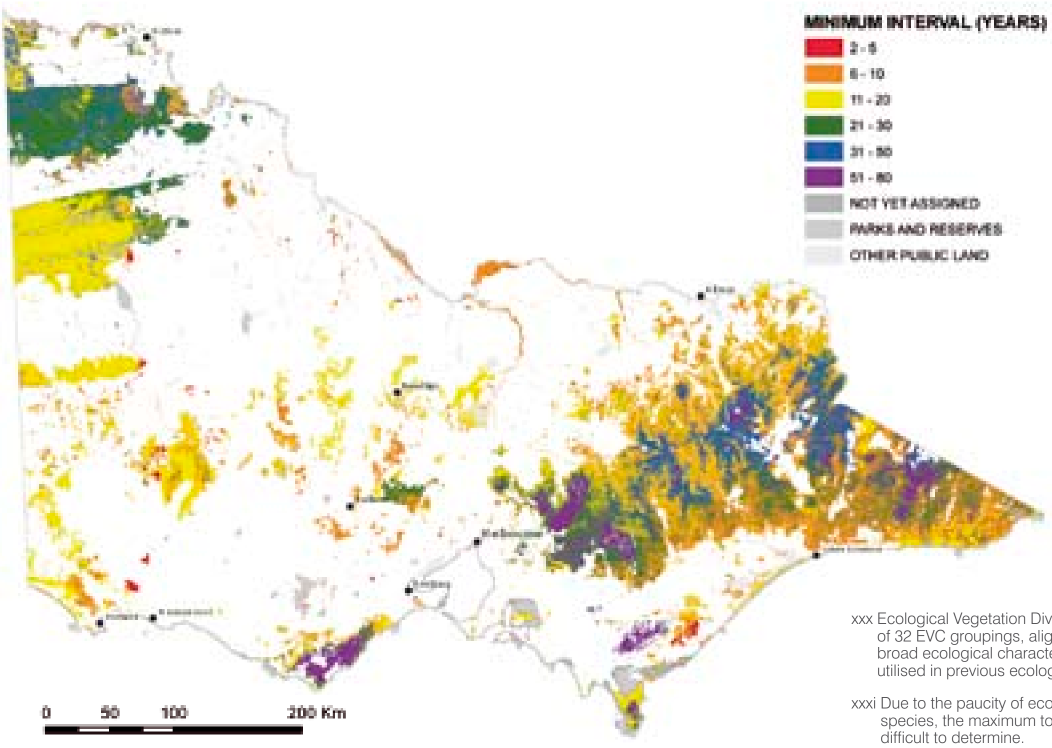
The Department of Sustainability and Environment is currently developing criteria for appropriate ecological fire regimes for native vegetation in Victoria. This is a complex task requiring ecological understanding of flora and fauna responses to fire across a wide range of environments.

Although currently in draft stage, once finalised, these criteria will provide a useful indicator for documenting the extent of vegetation where the existing fire regime departs from ecologically appropriate parameters, and may therefore be of ecological concern. Preliminary minimum Tolerable Fire Intervals (TFI) for Ecological Vegetation Divisions (EVDs)[xxx] following low- and high-intensity burns are presented in Figures LB8.5 and LB8.6. Once finalised, TFIs are intended to be applied at the finer scale of EVCs.

The minimum TFI refers to the minimum inter-fire period required to allow all species within the EVC to reach reproductive maturity. This is set by the species which takes the longest time to reach maturity. These species are sensitive to too-frequent fires[474]. The maximum tolerable fire interval refers to the maximum inter-fire period within the EVC beyond which species may become locally extinct. This is set by the species with the shortest time to local extinction.[xxxi] These species are sensitive to long periods without fire[475]. The minimum and maximum tolerable fire frequencies are then used to determine the fire cycle for an EVC. The fire-cycle is the mid-point between the minimum and maximum inter-fire periods. This concept allows some communities (or segments of communities) to remain unburnt for very long periods of time, while others may be burned several times in the same period, but the community composition overall will be maintained and structural diversity should be maximised.

Tolerable fire intervals relate only to the requirements of vegetation (EVCs) and do not account for the habitat needs of animal species. A number of fauna groups are not necessarily correlated with EVCs[476] and therefore their habitat requirements may not be met by fire regimes optimised only to vegetation groups. The ecological requirements of these groups and potentially other animal species will need to be built into future ecological fire regimes. Ecological burning programs must have a strong scientific basis demonstrating effectiveness in suppressing wildfire and benefits for biodiversity.

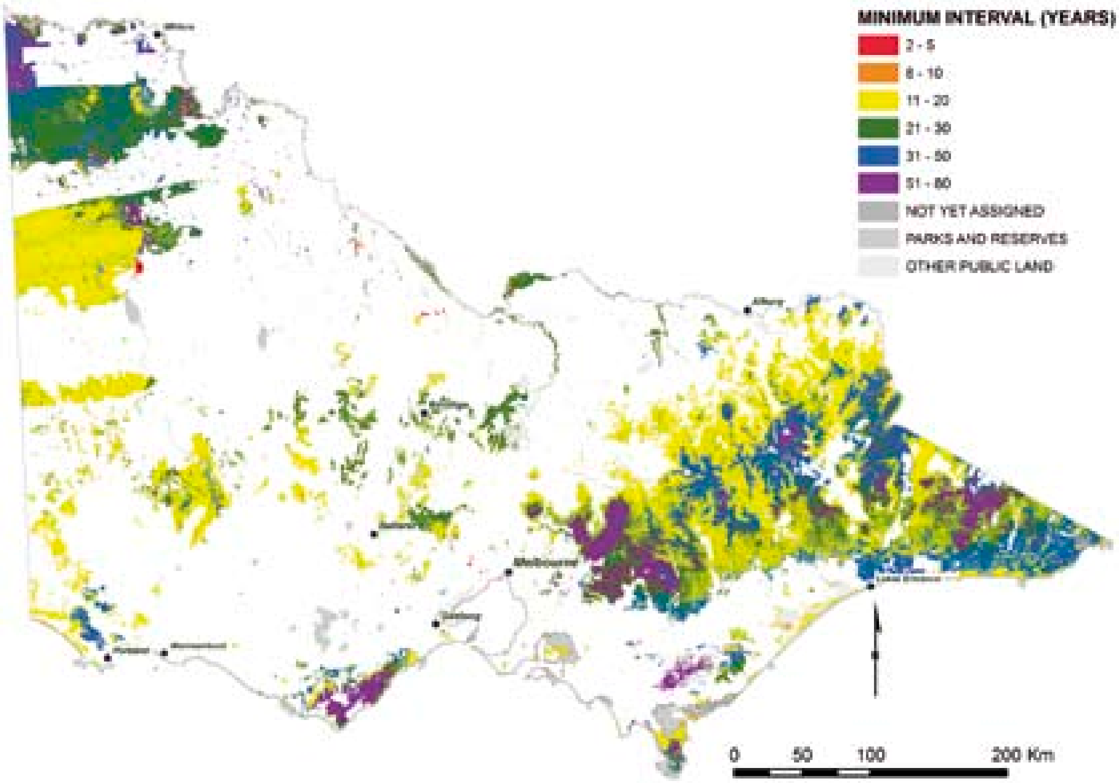
Figure LB8.5 Draft minimum recommended interval before fire following a low-intensity fire in native vegetation on public land
Source: Department of Sustainability and Environment 2008.



xxx Ecological Vegetation Divisions are an existing set of 32 EVC groupings, aligned on the basis of similar broad ecological characteristics, which have been utilised in previous ecological projects.

xxxi Due to the paucity of ecological information for many species, the maximum tolerable fire interval may be difficult to determine.

Figure LB8.6 Draft minimum recommended interval before fire following a high-intensity fire in native vegetation on public land.
Source: Department of Sustainability and Environment 2008.

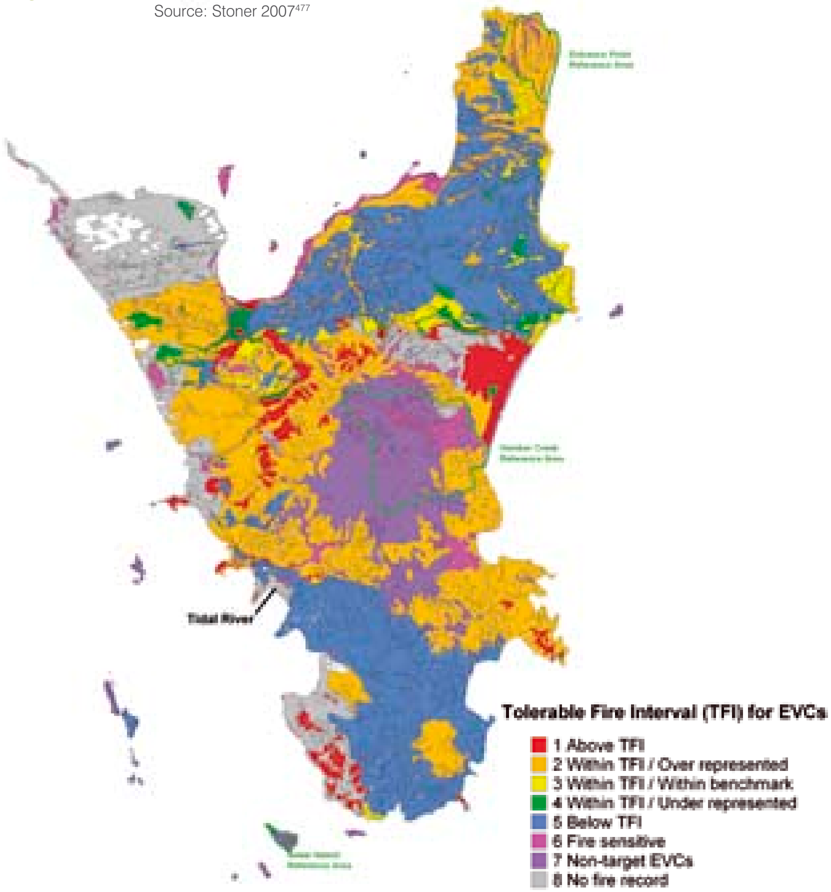


Recommendation

LB8.2 The Victorian Government should continue to invest in research to incorporate the requirements of animal species into research on ecological burning, and develop an ecologically based program of planned burning that accounts for the regeneration requirements of plant communities and habitat needs of fauna that is relevant for public and private land tenures. Funding should also be allocated for the extension of Tolerable Fire Interval analysis to all Victorian Bioregions.

At Wilsons Promontory, the proportion of EVCs falling within, above and below TFIs has been calculated (see Figure LB8.7, Table LB8.2). Although nearly 36% of Wilsons Promontory fell within the minimum and maximum TFIs, most of this vegetation was over the benchmark for that age-class;[xxxii] that is, the period since the last fire has been longer than desirable and thus, that vegetation potentially requires an ecological burn. Another 30% of the region is below the desirable inter-fire period and should be protected from fire (see Table LB8.2). Only 5% of vegetation is considered to be above the tolerable fire interval and thus considered to be a high priority for an ecological burn.

Figure LB8.7 Wilsons Promontory National Park Tolerable Fire Interval Status[xxxiii]
Source: Stoner 2007[477]



xxxii The benchmark is considered to be the desirable range for actual age-class distributions (±50% of the theoretical 'ideal' value).

xxxiii TFI status: 1 Above TFI = priority candidate for ecological fire; 2 Within TFI/Over represented = potential candidate for ecological fire; 3 Within TFI/Within benchmark = not a priority for ecological fire; 4 Within TFI/Under represented = retain, no ecological fire; 5 Below TFI = protect from ecological fire; 6 Fire sensitive = priority for protection from fire; 7 Non-target EVC = fire tolerant, but not targeted due to management constraints; 8 No fire record = no recorded fire event (pre-1951).

Table LB8.2 Area of EVCs within Tolerable Fire Interval (TFI) classes in Wilsons Promontory National Park
Source: Stoner 2007[478]

TFI Status	Area (ha)	%
non-vegetation	1,567	3.3
1 Above TFI	2,307	4.8
2 Within TFI / Over represented	14,662	30.5
3 Within TFI / Within benchmark	1,620	3.4
4 Within TFI / Under represented	956	2.0
5 Below TFI	14,032	29.2
6 Fire sensitive	2,052	4.3
7 Non-target EVCs	5,226	10.9
8 No fire record	5,601	11.7

Implications

Implications for forest structure

Fire is a normal and necessary occurrence in Victorian forests and, while it may produce a temporary loss of vegetation, the regeneration stimulated by fire is necessary to sustain forest structure. Victoria's Mountain Ash and Alpine Ash forests require fire for regeneration, as only fire can create the right conditions for germination of seeds of these species. Regeneration of this forest type begins soon after fire; therefore, fire can be positive for forest diversity and productivity.

Ecological changes do, however, arise from inappropriate fire regimes. The focus on fire prevention and asset protection since catastrophic Victorian bushfires of the early 20th century has meant that many vegetation classes are burnt too infrequently to stimulate adequate regeneration[479]. The lack of regeneration in these ecosystems provides the opportunity for invasion by weeds that are less reliant on fire and produces other changes in plant community structure. Where fuel-reduction burning is carried out regularly, fire may be too frequent, threatening the persistence of species that regenerate from seed and require many years without fire to reach maturity.

The post-fire composition of forests depends on the capacity of plant species to regenerate after fire. Frequent fire will favour those species that can resprout from burnt trunks, at the expense of those species that regenerate from seed and require a relatively long fire-free period to reach seed-bearing maturity. Infrequent fire will favour species with competitive, rapidly growing seedlings that can take advantage of the ecological gap created by the fire. In Mountain Ash forest, very infrequent fire (more than 200 years between fires) results in gradual succession to mid-storey wet forest species or rainforest because Ash forests are totally dependent on fire to stimulate seed germination. Without fire the old-growth Ash trees eventually die and are replaced by rainforest species, which occur only in the prolonged absence of fire. This process takes several centuries after the last fire and seems less likely to occur if climate change increases the frequency and intensity of fire, as expected.

Implications of fires for biodiversity

The frequency of fire in Victoria's forests has implications for biodiversity because of the effects of fire on forest structure and habitats for forest-dwelling species. Mountain and Alpine Ash are the dominant canopy species in Victoria's wet eucalypt forests. Trees of these species generally do not survive and resprout after bushfire. Instead, the heat of the fire stimulates shedding of seeds stored in capsules in the canopy and germination of seeds in the soil. The historical average interval between fires in Victoria's Ash forests is estimated to be 37–75 years, with an average interval between high-intensity fires of 107 years[480]. More frequent burning threatens the survival of Ash species because of the time taken to reach seed-bearing maturity, and can be expected to produce changes in the dominant forest species.

Native grasslands generally require frequent fires to maintain a diversity of plant species and habitat for fauna reliant on an open grassland structure. Burning of native grassland in small reserves now surrounded by factories and residential development in Melbourne's western suburbs is becoming increasingly problematic due to its proximity to these structures. The lack of fire or other means of biomass removal in grasslands west of Melbourne contributes to the pressures of urban expansion on the habitat of the threatened Striped Legless Lizard (*Delmar impar*). In other parts of the State, such as at Terrick Terrick National Park, native grasslands managed for conservation are often grazed by sheep to maintain the desired structure and may not be as frequently burnt as they may once have been (see section LB1 Vegetation loss and modification, Box 1). The implications for biodiversity of using grazing in the absence of fire to maintain native grassland structure are not fully understood.

To the east of Melbourne the urban *Eucalyptus* woodland habitat of the Eltham Copper Butterfly (*Paralucia pyrodiscus lucida*) requires periodic high-intensity burning in late summer to stimulate regeneration of the sole plant species on which the butterfly larvae feed. The small remaining habitat areas, however, are surrounded by housing, so opportunities for burning are constrained by the need to protect homes from fire[481]. As for urban grasslands, the ecological burning of small remnant reserves in urban areas is likely to become an increasingly important issue.

Recommendation

LB8.3 The Victorian Government should review current ecological burning guidelines to account for the limitations on burning of small remnant vegetation patches in peri-urban areas, especially in light of rapid peri-urban development in Victoria.

Intensity, frequency, scale and patchiness of fire, and subsequent predation all impact on the responses of individual animal species and populations to fire. Much research is still required, particularly in two areas: mechanisms and interactive effects at the community level, and the importance of scale, patchiness and fire interval in determining mortality, emigration and the desirable properties of fire mosaics for different taxa[482].

The impact of the extensive wildfires of the last decade on individual species is likely to be varied and is the subject of ongoing research[483]. For many species, the impacts can only be assumed based on life history traits, and, even with initial monitoring, it may be too early to determine these impacts.

Some species, including a number of rare plant species such as the Buffalo Sunray (*Leucochrysum albicans* var. *buffaloensis*), Catkin Wattle (*Acacia dallachiana*) and Shining Westringia (*Westringia lucida*), may be favoured by recent fires in the Alpine area, which are likely to have triggered seed germination[484]. For other threatened or restricted-range species the alpine fires are likely to have had a negative impact, including the Mountain Pygmy-possum (*Burramys parvus*), Spotted Tree Frog (*Litoria spenceri*), Alpine Water Skink (*Eulamprus kosciuskoi*), Alpine She-oak Skink (*Cyclodomorphus praealtus*), and Alpine Bog Skink (*Pseudomoia cryodroma*)[485]. Over 80% of the habitat of the Mountain Pygmy-possum is thought to have been affected by the 2002/2003 Alpine fires[486].

Surveys for some significant species have indicated marked declines. For example, it is estimated that the Spot-tailed Quoll (*Dasyurus maculates*) has declined by 35–50% in the upper Snowy River area in eastern Victoria as a result of the 2002/2003 wildfires. This area is the stronghold for this species in Victoria[487].

Many forest species, such as possums and owls, nest in tree hollows, the availability of which is strongly influenced by fire and tree age. In Victoria's Central Highlands, much of the forest was last burnt in 1939. The trees surviving this fire have provided tree-hollow habitat since that time but are now collapsing due to age. The formation of tree hollows takes at least 100 years for small hollows and 200–400 years for the larger hollows used by owls and Leadbeater's Possum. Because the regrowth forest is not yet old enough for the trees to have developed hollows, the number of tree hollows in this forest is declining, limiting habitat for species that depend on hollows for dens and nests, such as Leadbeater's Possum and the Powerful Owl (*Ninox strenua*). It is expected that existing hollow-bearing trees will collapse before recruitment of the next generation of hollow-bearing trees begins. Very sharp declines in populations of hollow-dependent forest species are expected as a result[488]. The loss of hollow-bearing trees is listed as a threatening process under the *Flora and Fauna Guarantee Act 1988*.

Besides the physical impacts of fire itself, fire prevention and control measures can also potentially have an impact on biodiversity. For example, the permanent Strategic Fuel Break Construction around Melbourne's water supply catchments will extend to around 600 km and clear an area of around 1500 ha. This includes 350 km of breaks prepared as part of the suppression of the Great Divide Fire 2006/2007 and around 250 km of additional breaks to be constructed[489]. In addition, the 2003 wildfire resulted in the construction of 6,000 km of containment line to a range of standards[490]. Such disturbance can lead to weed invasion in areas previously relatively undisturbed and can facilitate movement of feral animals. Fire breaks also restrict the movement of native animal species by creating open spaces that increase the risk of predation. The construction of firebreaks leaves soil bare and at risk of erosion and compaction. Vegetation removal for the construction of the Strategic Fuel Break is to be carried out in accordance with the Native Vegetation Management Framework and vegetation offsets will be provided.

Bushfire-fighting foams are used extensively during bushfire suppression efforts in environmentally sensitive areas. The impacts of these foams at the species or ecosystem level are unclear; they appear to have negligible impacts on soil invertebrates and native plant growth[491,492] but toxicity to fish is concentration-dependent and varies with formulation[493].

Implications of fire for water quality and river health

Wildfires have important implications for river health and water quality because of their impacts on vegetation cover and soil structure. Fires increase the risk of erosion and change surface hydrology by removing surface vegetation. The predominant issue for water quality following bushfires is sediment deposition. Large sediment slugs can be deposited in rivers when rain follows a bushfire. Vegetation is removed by the fire and the bare soil is highly susceptible to erosion. Large amounts of soil and ash are washed into rivers with subsequent rainfall events, dramatically reducing water quality (for more information see Part 4.3 Inland Waters). The severe flooding and erosion that occurred in Gippsland following the 2006/2007 fires have been attributed in part to the effects of the fires[494]. The impact of ash and sediment on water quality can also mean significant additional water treatment costs.

Bushfires can have short and long-term impacts on water yields and quality. Immediately after a fire, water yields may increase, through increased runoff and lower absorption rates, however, water quality will be significantly lower, with greater sediment loads. Five –ten years after a fire in wet forests, such as Melbourne's catchments, water yields will drop below pre-fire levels as the regenerating forest absorbs more water, through increased growth rates. Water yields will fall by as much as 50% for up to 30 years as the regenerating forest matures, and may take over 100 years to reach pre-fire levels. Water quality will improve as the forest regenerates, with the re-growth providing greater filtration.

The 2006/07 Great Divide fires directly threatened the Thomson Reservoir, which provides 60% of Melbourne's water.

Implications for human settlements

Fire in Victoria has historically claimed lives and destroyed private property including houses, fencing and livestock. The numbers of fatalities and homes lost in the 2003 and 2007 bushfires were many times smaller than in the large fires of the 20th century but nevertheless, the loss of life and property has significant and long-lasting social and economic impacts, as described by the 2007 *Report from the Ministerial Taskforce on Bushfire Recovery*. In addition, nearly 18,000 ha of pasture and 1,400 ha of crops were destroyed and nearly 2,000 km of fencing and 220 farm buildings were lost. Over 1,700 animals were killed or had to be put down[495].

Recommendation

LB8.4 The Victorian Government should investigate options to limit further housing development in fire-prone areas to reduce the potential for loss and damage as Victoria's fire risk increases. This should be achieved by altering planning policy for fire-prone areas.

Much of Victoria's critical infrastructure, such as gas pipelines, powerlines, telecommunications and transport networks, is located in or crosses through remote and forested areas. Loss of or damage to this infrastructure is extremely costly. The loss of power across much of Victoria that resulted from the shorting of major high voltage powerlines by smoke from the 2006/2007 Great Divide fires is estimated to have cost Victoria $500 million in a single day.

Fire also has a significant effect on air quality – it is a major contributor to summer smog and particle pollution, adding to the costs and impacts of air pollution on human health (see Part 4.1 Atmosphere: Air Quality).

Management responses

Current government responses to fire management have been developed following several large bushfires over recent years. It is acknowledged that climate change is likely to increase the severity and incidence of bushfire in the future[496]. It is therefore imperative that vegetation is managed to reduce the risk of major uncontrolled fire. A part of this activity should be improving public understanding of the issues relating to planned burns and an approach to planned burning that achieves a mosaic of fire histories throughout the landscape. However, while planned burning is an important component of the Victorian Government's management of fire, the impacts of planned burning on biodiversity are uncertain. The impacts of planned burning on reducing the fire risk are also uncertain and variable. The repeated burning of 145,000 ha in the Alpine area in 2003 and 2007 shows that even recently burnt areas may be at risk of uncontrolled fire.

The key objective of management responses to fire is to limit the risk of wildfire and associated damage to life, property and natural assets. A supplementary objective is to reduce the risk of long-term reduction in diversity of vegetation.

Response name
Conservation, Forests and Lands Act 1987 and Forests Act 1958

Responsible authority
Department of Sustainability and Environment

Response type
Legislation

The Department of Sustainability and Environment uses a suite of legislative instruments to protect public land from wildfire. Regulations provide a framework to control the use of fire and activities known to cause fire, and prescribe the conditions under which planned fire may be used. DSE enforces fire protection legislation focusing on direct contact with the community. The *Conservation, Forests and Lands Act 1987* provides for the *Code of Practice for Fire Management on Public Land*, which defines the framework for integrated management of fire in Victoria.

The Secretary of DSE has a duty under the *Forests Act 1958* to carry out proper and sufficient work for the prevention and suppression of fire in every State forest and National Park and on all protected public land. Fire restrictions are in force all year round in State forests and National Parks. DSE liaises with the Country Fire Authority (CFA) and municipalities regarding introduction and lifting of fire restrictions for areas outside State forests and National Parks. To facilitate this, authorised DSE officers have broad-ranging powers including:

- power to direct the owner/occupier of property near the boundary of State forest, National Park and protected public places to remove fire hazards
- power to direct neighbours to conduct fire prevention or control works within 50 m of the boundary with public land
- extensive powers under the *Country Fire Authority Act 1958* to take whatever action is necessary to suppress wildfire
- to order the extinguishment of any fire within 3 km of public land.

Response name
Fire restrictions

Responsible authorities
Country Fire Authority and Department of Sustainability and Environment

Response type
Process/function

The Fire Danger Period is declared by the Country Fire Authority (CFA) when the risk of bushfires is high due to hot weather and dry vegetation. The Fire Danger Period covers the Country area of Victoria (the part of Victoria that lies outside the metropolitan fire district) but does not include any forest, National Park or protected public land.

Restrictions are applied by the Department of Sustainability and Environment at certain times to lighting fires in Fire Protected Areas (properties within 1.5 km of a park, forest or public land in areas of Gippsland, north-east or far south-west Victoria). Total Fire Ban Days are declared by the CFA in consultation with the Department of Sustainability and Environment. Total Fire Bans are declared only on days when the danger of fires occurring is extremely high and when fire would be expected to develop rapidly and be extremely difficult to control.

Response name
The Code of Practice for Fire Management on Public Land

Responsible authority
Department of Sustainability and Environment

Response type
Process/function

The *Code of Practice for Fire Management on Public Land* provides the framework for the integrated management of fire and fire-related activities on public land in Victoria. The purpose of the *Code of Practice for Fire Management on Public Land* is to promote the efficient, effective, integrated and consistent management of fire and fire-related activities on public land for the purpose of protecting human life, assets, and other values from the deleterious effects of wildfire or inappropriate fire regimes, and to achieve management objectives through the definition and application of principles, standards and guidelines in conjunction with the Victorian community. The Code recognises the use of land adjoining public land and the need for the integrated management of risks and impacts between both public and adjoining private land.

The first Code, developed in 1995, was the first of its kind in Australia and was described as "demonstrating industry best practice"[497]. The Code is reviewed every 10 years to ensure that it is informed by the latest research and information. The current Code incorporates up-to-date fire management science, including the effects of fire on biodiversity, covers integration with fire protection on private land and addresses some of the recommendations from the Inquiry into the 2002–2003 Victorian Bushfires conducted by the Victorian Emergency Services Commissioner[498].

The Code sets standards for fire prevention by use of planned burns. This involves controlled use of fire during periods of low bushfire risk. These burns are carried out to achieve not only fuel reduction but also flora and fauna management, including aspects of commercial forestry. Such burns are usually carried out in autumn or spring, when temperatures are lower and fire behaviour is more predictable. It is often very difficult to reach the total target area for planned burns, as the combination of factors needed to ignite planned burns fall within a very small window of opportunity. Burns are carried out in consideration of a range of social, environmental and economic factors and are a primary tool used to reduce the risk of uncontrolled wildfire.

The Victorian Environment and Natural Resources Committee of Parliament recommended in June 2008 that the extent of planned burning be increased from the current target of 130,000 ha to 385,000 ha annually (5% of public land) to reduce the risk of future large-scale wildfires in Victoria[499]. The impacts of such a change on biodiversity are unknown and should be evaluated during the development of an ecological burning framework. The total proportion of land burnt in planned burns and wildfires should also be considered. At present, approximately half of all public land in Victoria has been burnt within the last five years, so a rapid expansion of planned burning is likely to take Victoria's flora and fauna beyond its ecological tolerance of fire, especially for those species requiring longer fire-free periods.

An increase in planned burning is also likely to reduce air quality (see Part 4.1 Atmosphere: Air Quality).

Planned burns are also used for ecological purposes (see Indicator LB39 Area of native vegetation burnt in planned fires and wild fires; Indicator LB40 Actual fire regimes compared to 'optimal fire regimes') and Victoria is currently developing criteria for appropriate ecological fire regimes for native vegetation. The development of Tolerable Fire Intervals is the first attempt to provide a scientific framework for ecological burning in Victoria but incorporates only the requirements of vegetation types. The draft Tolerable Fire Intervals do not include consideration of the requirements of animal species living within the EVCs.

There is no framework in Victoria for co-ordinating planned burning on private land, and land holders are responsible for any fuel-reduction burning on private land. Permits are required for such burning during the Fire Danger Period.

Recommendations

LB8.5 The Victorian Government should include in its response to the increased risk of fire, review of key fire management documents such as the *Code of Practice for Fire Management on Public Land* to consider and incorporate the potential impacts of climate change on fire.

LB8.6 The Department of Sustainability and Environment should continue to work with the community and other stakeholders such as the CFA and Department of Human Services in rural Victoria and urban centres to manage fire and educate the public about the risks of bushfire and the benefits of planned burns.

Response name
Inquiry into the 2002–2003 Victorian Bushfires

Responsible authority
Emergency Services Commissioner

Response type
Process/function

In response to the 2002–2003 bushfires the Premier established the *Inquiry into the 2002–2003 Victorian Bushfires* in April 2003. The Inquiry was led by the Emergency Services Commissioner, assisted by two independent experts. The purpose was to look into all aspects of the preparations for, and response to, those fires and identify opportunities to further improve Victoria's fire management capability for prevention, mitigation and response. The Report of the Inquiry was publicly released in late 2003. The Government accepted the recommendations and work is under way to ensure their implementation.

One project resulting from the Inquiry is the Wildfire Asset Identification and Consequence Evaluation Project. This work has mapped the consequences of wildfire on assets in a uniform way across the State of Victoria and is expected to provide a useful tool for planning fire prevention and management. The project was funded as a result of recommendations arising from the *Report of the Inquiry into the 2002–2003 Victorian Bushfires* and is an initiative resulting from the Fire Safety Victoria strategy developed by the Office of the Emergency Services Commissioner (OESC) in partnership with a range of stakeholders.

Evaluation of fire responses

The last decade has seen a dramatic increase in the number, size and severity of bushfires in Victoria. The fire events of 2003 Alpine Fire, 2006 Grampians Fire and the 2006/07 Great Divide Fire are all evidence of this increasing fire risk, which is further compounded by climate change. Similar trends are being experienced in other parts of the world. The changing environment and increasing risk requires a comprehensive review of existing and future land and fire management strategies to position the government and Victorians to meet future bushfire challenges.

The recent Inquiry[500] into the 2002/2003 bushfires has resulted in a reassessment of the effectiveness of Victoria's fire management. Whilst some aspects of the management regime were found to be effective, the Inquiry found that improvements could be made, particularly in light of the greater understanding that followed from the Alpine and Great Divide fires.

The legislative framework for managing fire in Victoria is comprehensive and well integrated. It covers both wildfire prevention and provides a system that enables standards and guidelines to be implemented for a range of management tools, including planned fire for both fuel reduction and ecological purposes. This system involves several public agencies, including DSE, the CFA, DPI, Parks Victoria and others, who work together through the Networked Emergency Organisation, which works under the *Australasian Interagency Incident Management System – Incident Control System*. Fire and emergency management are controlled through a state-of-the-art Emergency Coordination Centre located at the DSE Head Office in Melbourne.

The CFA also plays a major role in fire management on private land as well as being part of the NEO. Most of the CFA's activities involve responding to incidents and suppressing fires. The Authority also plays a major role in delivering community awareness, education and information programs as part of the Fire Ready Victoria strategy, a joint initiative of the CFA, the Department of Sustainability and Environment, the Department of Human Services and the Metropolitan Fire Brigade.

Victoria's bushfire agencies are very successful at first attack fire fighting, keeping fires to small sizes and limiting their impact. An unintended consequence of this success is that large amounts of natural fire (lightning initiated fire) have been stopped, resulting in a build up of unnaturally high fuel loads. A Victorian Bushfire Strategy is under development, which will position Victoria's bushfire management agencies to effectively manage risk in partnership with the community.

Key response indicator: Once tolerable fire interval (TFI) criteria are finalised it will be possible to use the percentage of EVCs within TFI upper and lower bounds as an indicator of effective ecological management of fire. Presently, area of native vegetation burnt in planned fires provides the best indication of response activity.

For further information

Fire management on public land: www.dse.vic.gov.au/dse/nrenfoe.nsf/Home+Page/DSE+Fire%7EHome+Page?open

Fire restrictions: www.cfa.vic.gov.au/

Code of Practice for Fire Management on Public Land: www.dse.vic.gov.au/DSE/nrenfoe.nsf/LinkView/8D9507CD764EAA3D4A256823000529DE065947154164141D4A256DEA0013F7A3

Office of the Emergency Services Commissioner: www.oesc.vic.gov.au/

LB9 Impacts of Climate Change on Land and Biodiversity

Key findings

- Climate change is progressing faster than expected and will exacerbate existing pressures on Victoria's native vegetation resulting from past clearing and current land uses, altering the distribution and structure of vegetation communities and habitats. Efforts to reduce greenhouse gas emissions may have both positive and negative impacts on biodiversity.
- Ecosystems have a narrow coping range for temperature and projected rates of climate change are very likely to exceed rates of evolutionary adaptation in many species. Vulnerability becomes significant for 1.5–2°C of global warming. Globally, 20–30% of species assessed to date will be at increasingly high risk of extinction as warming exceeds 2–3°C, which is likely given current trends in greenhouse gas emissions.
- The key impacts of climate change on terrestrial systems will be increased incidence and severity of drought and fire, declining water availability, alteration of habitats and interactions between species, and increased frequency of extreme climatic events.
- Climate change further threatens the survival of a number of threatened species, such as the Mountain Pygmy-possum and Helmeted Honeyeater. Small and fragmented populations of flora and fauna and those at the limits of their range are at particular risk but little is known about the adaptation responses of individual species. Modelling to predict impacts on ecological systems is in its infancy.
- Climate change is likely to facilitate the establishment of pest plants and animals and pathogens in areas that previously were relatively unaffected.
- Agriculture contributes 12.9% of Victoria's greenhouse gas emissions and agricultural production is vulnerable to climate change impacts.

Description

Current projections indicate that Victoria's future climate will be warmer and generally drier than during the second half of the 20th century[501] (see Part 4.1 Atmosphere: Climate Change for details). The outcomes of these changes in temperature and rainfall are expected to include: an increase in evapotranspiration, producing drier soils; more frequent and severe droughts; increasing frequency and severity of fire; and declining snow cover. More frequent severe weather events such as storms and flooding are also predicted.

Victoria's climate has warmed by approximately 0.5°C since 1950 and climate change is progressing faster than expected (see Part 4.1: Atmosphere: Climate Change). Natural ecosystems have a narrow 'coping range' for climate change and a limited capacity for adaptation (see also Part 4.1: Atmosphere: Climate Change). They become vulnerable to population decline at 1.5–2°C of warming[502]. The flora and fauna of Australia and Victoria have a high degree of endemism (80–100% in many taxa); that is, many taxonomic groups are found nowhere else. Many species are at risk from rapid climate change because they are restricted in geographical and climatic range. Most Australian species are well adapted to short-term climatic variability but not to longer-term shifts in mean climate and frequency or intensity of extreme events[503]. If the capacity of species for evolutionary adaptation is exceeded and opportunities for migration to a more suitable climate are limited, significant species extinctions are likely.

Victoria's terrestrial systems are vulnerable to the effects of climate change. Due to lack of sophisticated regional models and data that can accurately predict responses, there are considerable limitations in our ability to measure and predict specific impacts on individual species or in particular locations, including rates of ecological change. Little is known about the life history traits of most species and the ways in which species will adapt to climate change[504]. While some of the likely environmental impacts of climate change are understood, considerable uncertainty surrounds which impacts are likely to dominate; for example, which species and ecosystems are likely to be most affected?, at what rate will changes proceed?, and what feedbacks within and between systems are likely?[505] Thus, current predictions are based on specific studies of a small number of species and involve many assumptions. Acting on the basis of these predictions carries significant risk, which must be managed, but the urgency with which responses to climate change are needed means that actions must be formulated from the best information that is currently available.

Climate change will have significant ramifications for a range of species, especially those with small population sizes and restricted distributions, those that rely on continuous habitat for migration and dispersal, and those sensitive to changes in competition. Species reliant on ecosystems that are already stressed due to past clearing, fragmentation and modification are especially vulnerable, as are alpine species. Ecosystems are particularly susceptible when the magnitude or rate of climate change is outside the range of past variations and exceeds the capacity of species to migrate or adapt[506]. Globally, it is estimated that 20–30% of plant and animal species that have been assessed so far face increasingly high risks of extinction as warming exceeds 2–3°C above pre-industrial temperatures[507].

The Victorian Alps are considered to be a 'hotspot' of vulnerability to climate change[508]. The specialised adaptations of many Victorian alpine species, such as the Mountain Pygmy-possum, make them extremely vulnerable.

Soil moisture is heavily influenced by temperature and rainfall and is likely to be a strong indicator of the outcomes of climate change. It is a critical determinant of the provision of ecosystem services because it is essential for the growth of plants and soil organisms. Low soil moisture is likely to limit the productivity of both native ecosystems and agriculture. Victorian agriculture, like that of all Australian states, is vulnerable to climate change because of its reliance on rainfall and irrigation.

The Victorian and Commonwealth Governments have started the process of limiting carbon emissions, for example through the Carbon Pollution Reduction Scheme[509] (see also Part 4.1 Atmosphere: Climate Change); however, a certain level of climate change is now unavoidable as a consequence of past emissions. Therefore, adaptation will be required if Victoria's ecosystems are to become resilient to climate change.

This section identifies the implications of climate change for Victorian terrestrial ecosystems. The implications of climate change for land use in Victoria are discussed but it is not possible to project future land use patterns at a statewide scale. New opportunities and limitations in land use are likely to develop in response to market forces and other pressures in ways that are not foreseeable; therefore, we do not attempt to predict the composition of the Victorian production landscape in a changed climate.

Objectives

- To develop an understanding of the likely impacts of climate change on land and biodiversity
- To reduce greenhouse gas emissions from land-based activities
- To improve resilience of terrestrial ecosystems to climate change
- To increase carbon sequestration (storage of carbon in vegetation and/or soils)

Links

See also: Part 4.1 Atmosphere: Climate Change; Part 4.3 Inland Waters; Part 4.4 Coasts, Estuaries and the Sea.

State

The current state of Victoria's climate is examined in detail in Part 4.1 Atmosphere: Climate Change.

Pressures

The key pressures on terrestrial systems arising from climate change are those identified in State indicators in Part 4.1 Atmosphere: Climate Change - an increase in average annual temperature, especially for minimum temperature; uncertain changes in rainfall but drier conditions projected for most of the State; greater frequency of extreme weather events such as severe storms and floods; greater frequency and intensity of forest fires; sea level rise; and diminished snow cover and duration.

Implications

Climate change has recently been formally linked with observed changes in global physical and biological systems[510], demonstrating that climate change is already affecting global land and biodiversity resources. Implications of climate change for land and biodiversity in Victoria are discussed below.

Land

Long-term changes in temperature, rainfall and evapotranspiration have implications for the condition of land and its capacity to support native and modified ecosystems. Evapotranspiration, driven by the amount of radiant energy absorbed (approximated by sunshine hours), is a key determinant of soil moisture. Rising evapotranspiration and declining rainfall are likely to produce a more arid environment throughout Victoria[511].

Erosion

Soil moisture is a controlling factor in wind erosion and is strongly influenced by rainfall. The frequency of dust storms increases sharply when annual rainfall falls below 400 mm[512,513] because soils are more likely to be dry and readily moved by wind. For this reason, a long-term reduction in average annual rainfall is likely to increase the area of Victoria that is susceptible to wind erosion. Much of north-western Victoria currently receives less than 400 mm of rain per year and is highly susceptible to wind erosion (see Figure LB5.3: Susceptibility to wind erosion). An increase in the area of Victoria receiving less than 400 mm of rain annually will increase the risk of wind erosion and dust storms.

Erosion of soil by water is highly dependent on rainfall erosivity or intensity[514]. Under climate change, Victoria is likely to experience a decline in total annual rainfall and the seasonal pattern of rainfall is likely to change. Rain is expected to occur less frequently but with greater intensity[515,516] and this is likely to increase the risk of erosion, particularly if it falls on sparsely covered ground. Increases in rainfall intensity combined with the predicted increases in the duration of dry periods, which limit plant growth, are expected to raise the risk of water erosion, with implications for terrestrial and freshwater systems (see section LB5 Erosion). Loss of nutrients from soil due to erosion will compound the effects of reduced soil moisture on the soil's capacity to support vegetation.

Soil biology

Soil both contributes to and is affected by climate change through the activities of the biological fraction of soil. Soil microbes play a role in both sequestering organic carbon in soil and releasing carbon dioxide during the decomposition of organic material (crop residues, dead organisms)[517]. Soil is a complex environment encompassing a range of microclimates. While there is good information about the trophic groups of organisms in Victoria's soils and the functions that they provide, there are few details about the responses of soil organisms to specific changes in climate. Unexpected change in soil biological function in response to climate change is a significant risk because of the critical role of soil in delivering ecosystem services such as the decomposition and detoxification of wastes, nutrient cycling, soil structure and water filtration as well as carbon storage and turnover.

Soil carbon

Soils, particularly agricultural soils, have been proposed as an important potential sink for carbon as part of climate change mitigation activities because changes to farming systems and land use have the potential to increase the amount of carbon stored in soils in the stable form of humus. For example, switching from cropping to grazing enterprises can increase soil carbon stocks by 19%, while a change from cropping to plantation or forest can increase soil carbon stocks by 18–53%[518]. Soil carbon is not currently proposed for inclusion in Australia's carbon trading system, mostly due to difficulties with measurement and uncertainty about longevity and stability of carbon in soil. However, given the urgency of developing effective responses to climate change[519], the role of soil carbon sequestration for climate change mitigation needs to be examined in more detail.

Recommendations

LB9.1 The Victorian Government should recognise soil carbon as an important asset and should contribute to the national research effort to understand the behaviour of organic carbon in a range of soils, agricultural systems and environmental conditions with a view to incorporating soil carbon in the Carbon Pollution Reduction Scheme at some future time.

LB9.2 The Victorian Government should support the future inclusion of agriculture in the Carbon Pollution Reduction Scheme.

Vegetation

Health and productivity of all vegetated ecosystems including forests, grasslands and other native vegetation classes, agricultural crops and pastures, horticultural crops and timber plantations are likely to be affected by declining soil moisture and rainfall, and higher temperature.

The limitations imposed on plant growth by soil moisture might be offset to some extent by the fertilisation effect of elevated atmospheric carbon dioxide. Elevated atmospheric concentration of carbon dioxide can stimulate photosynthesis and improve water use efficiency of plants, which can improve growth[520]; however, plants still require enough water and nutrients to support the extra growth. The extent of rainfall reduction will be critical in determining the consequences of climate change for plant growth, but considerable uncertainty surrounds projected rainfall changes for Victoria.

Water and temperature stresses on plants resulting from climate change are expected to increase their susceptibility to pests and diseases and to facilitate the proliferation of weed species adapted to warmer and drier conditions[521].

Impacts of climate change on plant range and growth

The species richness of Victoria's unique flora is threatened by climate change. Victoria has some 3,140 species of vascular plants as well as 900 lichens and 750 mosses and liverworts. Victoria also has a large number of fungi and algae species, many of which are yet to be described. Of the vascular plants, 794 species or 25% of Victorian plant species are listed by DSE as vulnerable, endangered or extinct (see section LB3 Threatened Species). Species considered to be endangered or vulnerable are at risk of being depleted or disappearing from the wild under existing pressures from land use and other sources. Climate change is expected to exacerbate these pressures and may hasten the decline of vulnerable and endangered plant species.

Distributions of native plant species are constrained by temperature, rainfall, soil type and competition with other species. Plant species are generally expected to contract to smaller areas within their current distributions rather than to track moving climate zones[522]. Some *Eucalyptus* species, for example, have ranges spanning less than 3°C in temperature and variation of less than 20% in rainfall[523]. A change in temperature of 2.5–3°C, as projected for most of Victoria by 2070 (under a high emissions scenario; see Part 4.1 Atmosphere: Climate Change), could therefore be expected to render the current ranges of some eucalypt species largely unsuitable. Even if changes in temperature create new possible ranges, these new climatically suitable regions may have unsuitable soil types or may be already occupied by competing species. Conversely, changes in competitive interactions between species may open ecological niches that were not previously available.

Ecologists do not yet have enough information to be able to accurately predict future species distribution and survival. Further research and modelling is needed to be able to produce accurate projections of species distributions and relative abundance under future climate scenarios. Recent research into the effects of elevated temperature and carbon dioxide on species composition of native grasslands in Tasmania suggests that physiological differences between grass species are likely to produce distinct responses to climate change[524].

Seasonal changes in temperature and rainfall distribution within the year are also likely to affect plant development; for example, flowering time is likely to occur earlier under warmer temperatures. Consequences of potential changes in development for the structure of plant communities are unclear, but for nectar- and pollen-feeding birds and insects, the timing of migration will need to change in order to coincide with the new flowering time[525].

Forests and plantations

Like other plant-based ecosystems, the effects of climate change on tree growth in forests and timber plantations will depend on the balance between temperature, soil moisture and elevated atmospheric carbon dioxide concentration. While young forest trees may grow faster under elevated carbon dioxide, it is not yet possible to reliably predict how forest age affects this growth response[526]; thus, outcomes of climate change for forest productivity cannot be predicted with confidence.

Increased frequency and severity of fire is a predicted outcome of climate change that is likely to affect forest ecosystems. Fire risk is likely to increase because of:

- an increase in the number of very high or extreme fire danger days[527]
- reduced decomposition of forest floor litter
- drier, more flammable foliage[528].

Changes in fire regime have implications for forest structure and species composition; therefore, climate change is likely to modify forest dynamics through its impact on fire regime (section LB8 Fire in the Victorian environment). The projected increase in the number of high and extreme fire danger days is likely to limit opportunities to carry out planned burning programs[529], with implications for the ability to manage wildfire and also the ability to achieve desired outcomes of ecological burning programs.

Plant community responses to climate change

Vegetation structure and competitive relationships between vegetation types are expected to change in response to climate change. For example, temperature increases in the alpine region have resulted in encroachment of Snow Gum (*Eucalyptus pauciflora*) into alpine meadows (i.e. elevation of the treeline)[530].

Floodplain vegetation, such as the iconic River Red Gum forests along the Murray River, relies on regular inundation events to maintain tree health and ecosystem function. Predictions of significantly reduced runoff resulting from climate change, and increased pressure on allocating environmental flows through the environmental water reserved due to competing consumptive use, is likely to further threaten these ecosystems, which are already under severe stress from reduced flows resulting from river regulation and water extraction[531].

Climate change impacts on native animal species

There are considerable limitations in our ability to measure and predict specific impacts on given species or in given locations, including rates of ecological change[532]. Nonetheless, due to the high degree of habitat modification over much of Victoria, climate change is expected to produce further pressures on Victoria's native flora and fauna. The rapid rate at which climate change is likely to progress makes it unlikely that plant and animal species will be able to respond by shifting their ranges[533].

Habitat quality and distribution for Victoria's native fauna is likely to change as a result of climate change effects on native vegetation. Existing areas of a species' or population's range may no longer be suitable and the population must respond either by migrating to a more suitable area or adapting to the new conditions within the current range. It is predicted that with an increase in temperature of up to 3°C combined with a decrease in rainfall of as much as 20%, both of which are projected to occur in Victoria by 2070 (see Part 4.1 Atmosphere: Climate Change), the bioclimates of three bird species will disappear from Victoria – the Western Whipbird (*Psophodes nigrogularis leucogaster*), Mallee Emu-wren (*Stipiturus mallee*) and the Helmeted Honeyeater – Victoria's State bird emblem[534,535]. A further seven species predicted to be severely affected are Malleefowl (*Leipoa ocellata*), Red-tailed Black Cockatoo, Orange-bellied Parrot (*Neophema chrysogaster*), Ground Parrot (*Pezoporus wallicus wallicus*), Rufous Bristlebird (*Dasyornis broadbenti*), Regent Parrot (*Polytelis anthopeplus monarchoides*) and Red-lored Whistler (*Pachycephala rufogularis*)[536]. Some of the species considered most sensitive to climate change are the lowland mallee and grassland species, and those with restricted habitats or narrow habitat requirements[537]. However, further research is required to better understand the 'climatic envelope' that species can occupy[538]. Some species may be able to persist under a wider range of climatic conditions than they currently occupy, particularly if competitive interactions with other species change.

Migration of animal populations to more southerly latitudes and higher altitudes is an expected response to climate change; however, in Victoria, the high level of habitat fragmentation over large areas of the State means that opportunities for migration of less mobile species are likely to be limited. For species that already inhabit high-altitude or southerly habitats, opportunities for migration are also limited and these species, such as the Mountain Pygmy-possum, are threatened with extinction[539].

Victoria's future approach to vegetation management will also have implications for climate change adaptation in natural ecosystems. Failure to arrest the current decline in native vegetation (see section LB1 Vegetation Loss and Modification) will produce further fragmentation and further limit migration opportunities, while restoration of vegetation in targeted 'biolink' regions, as proposed in the Victorian Government's Green Paper, *Land and biodiversity in a time of climate change*, may improve habitat connectivity and build resilience to climate change into Victorian ecosystems (see Figure LB9.1).

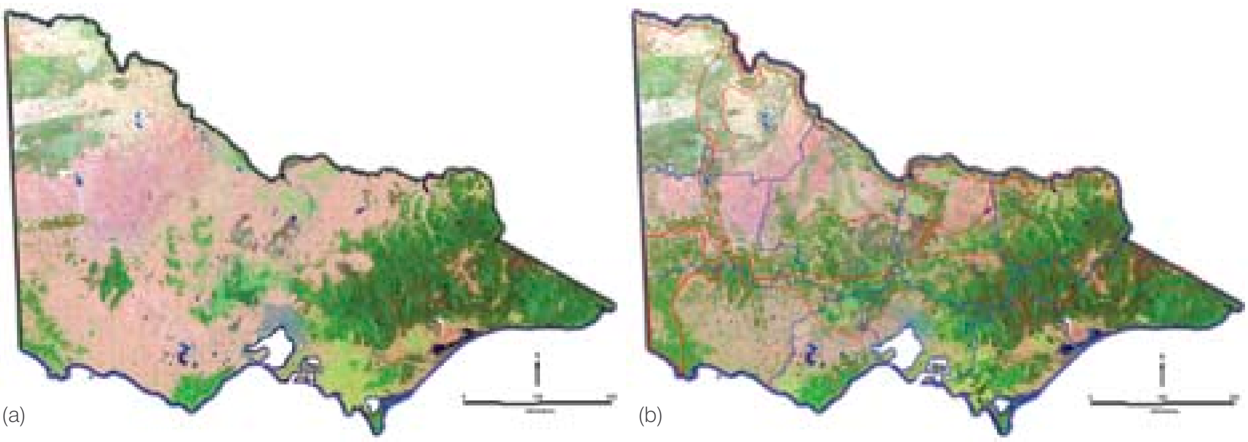
Changes in temperature and rainfall are also likely to affect animal physiology and behaviour, especially in relation to reproduction. This aspect of climate change has not been studied in detail, but a long-term study of the breeding patterns of Sleepy Lizards (*Tiliqua rugosa*) in South Australia[541] has shown that the timing and duration of pairing before mating was affected by temperature and rainfall in late winter and early spring. If effects on mating and breeding times are widespread, climate change will have significant implications for species survival. Climate also plays a role in the timing and success of breeding for Victoria's bird emblem, the critically endangered Helmeted Honeyeater. During the period 1989–2006, the timing of laying became earlier and there was a possible reduction in the mean number of eggs laid per breeding season, corresponding to a reduction in rainfall and mild warming. If these trends continue under projected climate change regimes, there will be increased risk of further population decline[542].

In addition to impacts of climate change on individual species, the interactions between species are expected to be affected. For example, predator–prey, host–pathogen or competitive interactions may be disrupted through changes in the lifecycle or habitat of one of the species. These changes in relationships between species may result in species decline or extinction, depending on the extent of the change. These complex ecosystem-level changes are likely to reduce the capacity of ecosystems to recover following disturbances such as fire (see Box LB9.1).

Little is known about Victoria's invertebrate biodiversity, so it is impossible to estimate how many species may be at risk. Despite Victoria's diversity of invertebrate species, climate change implications for these species have received less attention than those for vertebrate species. In contrast to many plant and vertebrate species, many Australian invertebrate species occupy relatively wide climatic ranges. Nevertheless, modelling studies have indicated that even species with wide climatic ranges may be vulnerable to climate change[543].

Increased threats to species and ecological communities are likely to result in increased costs associated with recovery efforts for those species and communities (see section LB3 Threatened Species and Pest Plants and Animals).

Figure LB9.1 Scenarios for native vegetation coverage in Victoria in 2040 (a) Further fragmentation resulting from continuation of 30-year trend of depletion (b) Revegetation of 40% of each catchment and revegetation of targeted biolink regions
Source: Mansergh *et al.* 2006[540].



(a) (b)

Box LB9.1 Likely ecosystem-wide impacts

In December 2007, at the request of the Commissioner for Environmental Sustainability, ecologists from the Department of Sustainability and Environment held a workshop to identify threatened species most at risk of climate change in Victoria. The ecologists agreed that it is not yet possible to identify such species individually with any certainty; however, it is possible to identify the likely impacts of climate change at an ecosystem level and the traits of species that may predispose them to more severe impacts.

Ecosystem-wide impacts

For terrestrial systems, the changes for broad ecosystems are likely to be:

- more intense and prolonged drought, leading to reduction in primary production of ecosystems
- more frequent extreme fire weather days, likely to lead to more potentially severe wildfires
- reduction or loss of key habitat features such as tree hollows, due to drought and fire
- decline in fire- and drought-sensitive habitats, including rainforest
- reduction or loss of climate envelope for sub-alpine habitats
- changes in distribution of keystone species such as Mountain Ash and other eucalypts – inability to regenerate under changed fire and climate conditions
- development of 'novel' habitats
- emergence of novel pest plants, pest animals and disease, or expansion of existing ones
- developmental changes affecting a range of species.

Characteristics predisposing species to more severe impacts

The following characteristics were seen to limit the capacity of a species to adapt to climate change:

- reliance on complex interactions with other species for reproduction, dispersal or growth (e.g. orchid–fungus, ant–butterfly, pollinators generally)
- reliance on small and/or isolated areas of habitat
- reliance on habitat that is likely to decline under climate change
- reliance on continuous habitat for migration or dispersal
- reliance on 'narrow' food source (e.g. Mountain Pygmy-possum, Bogong Moth)
- reliance on critical environmental cues for migration and breeding
- sensitivity to changes in competition between species
- vulnerability to predation if vegetation structure changes
- small and/or fragmented populations
- low levels of genetic variability
- low reproductive output
- poor dispersal capacity
- complex social organisation
- life history including colonial stages (e.g. colonial breeding sites)
- being already close to ecological limits – such as edge-of-range or disjunct populations.

Risks associated with human adaptation

In addition to the direct threat posed by climate change, the workshop considered the following human responses to climate change may pose further risks to biodiversity:

- changes in agriculture, including spatial shifts and intensification of farming systems
- expansion of bio-fuel cultivation affecting native vegetation and water
- reduction in availability of water for the environment
- greater regulation of water
- increase in fire protection works – fuel reduction and modification, fire breaks
- carbon capture activities that favour monoculture plantings
- loss or reduction of existing conservation programs due to 'new' approaches
- increase in use of pesticides in wetlands to control mosquitoes, especially if the incidence of mosquito-borne human diseases increases.

Climate change in alpine ecosystems

Temperatures in alpine areas of Victoria have increased by 0.7°C over the last 35 years and precipitation has declined[544]. Warming in alpine areas has been greater than the trend at lower elevations[545]. The depth and duration of snow cover has also declined since the 1960s[546,547] and this trend is predicted to continue[548,549]. Under a low climate impact scenario the average snow season length may be reduced by about five days by 2020, with a reduction in maximum snow depth of around 10%, although this is likely to be greater at lower elevations. Under a high impact scenario, the average snow season is likely to be shortened by 30–40 days by 2020. At relatively low elevations, such as Mt Baw Baw, the duration of snow cover is likely to decline by up to 60%[550].

The Victorian Alps (including sub-alpine regions) cover 500,000 ha[551], of which about 180,000 ha is true alpine treeless vegetation[552]. The Alps are inhabited by species that are uniquely adapted to the extremes of the alpine environment and do not occur elsewhere in Victoria. Because of their specialised adaptations, these species are extremely vulnerable to climate change. The alpine region is already very small and is expected to retreat to higher elevations with warming temperatures. Species reliant on this environment will be forced into a diminishing habitat with no alternative refuge. Alpine species are therefore among those most likely to be severely affected by climate change. The decline of these species can be expected to affect the ecosystem processes to which they contribute.

Alpine vegetation

Alpine vegetation is dominated by herbaceous shrubs. Increasing temperatures in the alpine areas will favour further expansion of sub-alpine woodland vegetation into alpine meadows, resulting in an invasion of trees and a decline in the extent of true alpine vegetation[553].

Altered competitive interactions between other alpine plant species as a result of changes in snow cover and hydrology are likely to produce further changes in species composition of alpine vegetation. For example, in the Australian Alps, short alpine herbfield and snowbank feldmark communities are likely to be negatively affected by the declining snow cover, whereas windswept feldmark and heath communities, which are less dependent on snow cover, may benefit[554]. Bogs and fens are likely to vary in area as changes in precipitation, run-off and evaporation alter the competitive ability of plant species within these communities. An increased risk of fire further threatens the vegetation of alpine and sub-alpine regions, which are highly sensitive to disturbance.

Alpine vegetation is especially adapted to the low temperatures and limited growing season that currently inhibit the growth of weedy species. As temperatures become milder, weed invasion is likely to become a more significant threat to alpine vegetation[555]. The combination of more frequent disturbance by fire and less limiting growing conditions may substantially increase the threat of weed invasion of alpine areas.

Alpine fauna

Impacts of climate change on alpine fauna are likely to result directly from changes in temperature and snow cover and indirectly from changes in vegetation composition and structure.

Small mammals that remain active under the snow, such as the Dusky Antechinus (*Antechinus swainsonii*) and the Broad-toothed Rat (*Mastacomys fuscus*) are likely to suffer increased predation under reduced snow cover[556]. For the Mountain Pygmy-possum, which enters a hibernation-like state (torpor) under the snow, a reduction in snow cover will expose the possum to cold temperatures[557], interrupting torpor and life history cycles.

A milder climate is also expected to make the alpine region more accessible to pest animals and predators, reducing the competitive advantages of the native high-altitude species. Reductions in snow cover may advantage some native predator species, such as the Nankeen Kestrel (*Falco cenchroides*), which require snow-free ground for successful hunting.

The changes in habitat structure and the timing of events such as flowering due to climate change means that animals need to adapt behaviour to the new conditions. Generalist species with a range of possible habitats and food sources are more likely to adapt successfully than those that occupy a specialised environmental niche.

Recommendation

LB9.3 The Victorian Government should continue to invest in research aimed at understanding the responses of species to climate change and the requirements for biodiversity conservation in a changing climate. Research findings should inform future responses to climate change but lack of scientific certainty should not be a barrier to implementing broad-scale strategies to improve landscape connectivity in Victoria.

Implications for primary production

Primary production in Victoria is likely to undergo significant changes in order to adapt to climate change. It is difficult to predict how the agricultural landscape might look in the future because adjustment is expected to occur in response to changing climate, a changing regulatory environment and changing market forces. Adaptation opportunities available include the breeding and use of different crop varieties; changes in crop management such as time of sowing, fertiliser application and crop rotation periods; management of soil moisture through weed control and crop residue management; use of water-efficient varieties; and improved use of seasonal forecasting[558]. The scale of adjustment required will depend on the biophysical constraints imposed by the changed climate, the changed policy environment and changes in the demands of the market that will accompany climate change.

The redistribution of primary production enterprises around Victoria is likely to have substantial economic implications for individual businesses, industries and regions depending on the extent to which they are able to adapt to climate change. Changes in land use resulting from climate change are also likely to have social implications as employment opportunities shift between traditional and new industries.

Biophysical implications

Climate change is likely to produce migration of agricultural industries around Victoria and also expansion of some industries out of Victoria as regional climates become less suitable for existing industries but may become more suitable for new industries. The Department of Primary Industries (DPI) has modelled changes in land suitability arising from climate change for several enterprises including cool-climate grapes, productive pastures and blue gum plantations in Gippsland, and apples and pears in the Goulburn Broken region. Projected changes include:

- an increase in the area of Gippsland considered highly suitable for cool-climate grapes of approximately 60,000–137,600 ha by 2050 under high- and moderate-emissions warming scenarios (see Part 4.1 Atmosphere: Climate Change) respectively
- a decline in the area of Gippsland considered highly suitable for high-productivity pastures of approximately 110,000 ha by 2050 under a high-emissions scenario
- declines in the area of Gippsland considered highly suitable for blue gum plantations of approximately 42,000 ha and 54,000 ha by 2050 under moderate- and high-emissions scenarios respectively
- increased suitability for apples and pears over 48–50% of the Goulburn Broken region and decreased suitability over 13% of the region by 2050 under a high-emissions scenario; a southerly migration of the areas most suitable for apples and pears is also projected.

The key biophysical pressures of climate change on agricultural and horticultural plants are the same as those for other plant-based ecosystems: reduced soil moisture availability; increased incidence of pests, diseases and possibly weeds; and increased temperatures[559]. In the case of plant-feeding insects, higher temperatures have the potential to increase the number of generations per year[560] and disrupt the relationships between insects and their natural enemies.

Frost incidence is also relevant for agriculture and horticulture. Frosts are likely to become less frequent[561], which is expected to benefit grain crops in frost-prone areas but is likely to reduce fruit yield and quality for horticultural crops that require chilling to stimulate bud-burst and fruit setting.

Higher temperatures and atmospheric carbon dioxide concentrations are likely to raise crop yields but this effect may be offset by declining rainfall, except in areas currently affected by seasonal waterlogging such as south-western Victoria, which may become more suitable for dryland cropping. Crop growing seasons may be shortened or shifted temporally, requiring adaptation of varieties for earlier or later sowing and a shorter growing period. It is possible that the value of yield increases will be offset by a decline in grain protein content[562], although effective management of soil fertility will help to maintain grain quality.

Climate change impacts on pasture growth are likely to reduce feed availability and quality for livestock industries. Provision of supplementary feed can overcome this problem in the short term, but in the long term, development of more drought-tolerant pasture plant varieties will be needed, along with adaptation of farming practice to match production with feed availability[563]. A reduction in the availability of irrigation water is expected to have particular impacts on the dairy industry, which will need to continue with existing trends towards more efficient use of water[564].

Recommendations

LB9.4 The Victorian Government should undertake a review of current agricultural practices in the State and, based on current climate projections, develop a sustainable, long-term agricultural strategy. This could be supported by extended regional modelling of climate suitability for new and existing enterprises.

LB9.5 The Victorian Government should undertake a comprehensive risk assessment of the impacts of climate change on Victoria's land and biodiversity assets, including agricultural and urban land.

Implications of changed policy environment

The 2008 review of climate change by Professor Ross Garnaut has indicated that in addition to the biophysical effects of climate change on agriculture and forestry, changes in the policy environment will also have implications for agriculture and forestry[565]. The policy of the Commonwealth Government is to reduce greenhouse gas emissions by 60% by 2050, which will create changes in industries that are net emitters of greenhouse gases. Agriculture and forestry are currently being considered for inclusion in an emissions trading scheme[566].

Agriculture is a significant source of greenhouse gas emissions, contributing 15.6% of Australian[567] emissions and 12.6% of Victorian[568] emissions in 2006. This sector, therefore, is likely to come under pressure to reduce emissions and has strong potential to do so. Changes to land use and land management have the potential to create carbon sinks as well as reducing energy use. For example, zero-tillage cropping reduces energy use by farm machinery and can also promote sequestration of carbon in the form of soil organic matter. The opportunity to trade carbon sinks as emissions offsets is likely to lead to management of land for carbon sequestration, either instead of or in addition to production. Australia is in a position to take a leading role in reducing emissions from agriculture and is likely to derive economic benefits from doing so[569].

The impacts of these likely land use changes on Victoria's environment are difficult to assess at this stage; however, they are certain to compound the biophysical pressures of climate change on native vegetation and animal species and will require careful management and planning.

Efforts to reduce greenhouse gas emissions may have both positive and negative impacts on biodiversity and are likely to be major drivers of land use change in the future (see section LB2 Contemporary Land Use Change). Carbon offsetting via re-establishment of native vegetation in regions previously cleared has potential significant benefits for biodiversity by creating new habitat or buffering or linking existing vegetation. However, monoculture plantations of non-indigenous tree species to sequester carbon may have little benefit for biodiversity, particularly if established over naturally treeless native vegetation such as grasslands or in regions suitable for potential future landscape restoration projects. Species-diverse plantings will provide biodiversity benefits as well as carbon sequestration.

The impacts of vegetation established for offsetting carbon emissions on water availability will need to be carefully assessed, given the variable effects of vegetation on run-off (see section LB2 Contemporary Land Use Change) and the high likelihood of lowered annual rainfall and stream flows.

Recommendation

LB9.6 The Victorian Government should ensure that investment in carbon offsets (vegetation planted for permanent biosequestration) provides benefits to biodiversity and native vegetation, for example, by developing mechanisms to encourage biodiverse indigenous plantings rather than monoculture plantings. This could be achieved by broad application of the EcoTender program, with both permanent carbon sequestration and biodiversity gains as targets of management plans.

Management responses

Management responses to climate change in relation to Victoria's land and biodiversity resources need to take account of the fact that land and land-based activities can be both a carbon source and sink, and therefore should aim to minimise greenhouse gas emissions from land and maximise the storage of carbon in plants and soils. Agriculture is Victoria's third-largest source of greenhouse gas emissions behind stationary energy and transport, contributing 12.9% of the state's total emissions in 2005[570]. Responses must address both mitigation and adaptation objectives in order to reduce the ultimate impact of climate change and to facilitate adaptation of land-based systems to climate change. Thus, three key objectives can be identified for responses to the issue of climate change:

- To reduce greenhouse gas emissions from land-based activities
- To improve resilience of terrestrial ecosystems to climate change
- To increase natural carbon sequestration (storage of carbon in vegetation and/or soils).

A key constraint on the Government's capacity to respond to climate change is the high level of uncertainty surrounding both the likely spatial character and intensity of climate change and the life history traits of the vast majority of species. These traits contribute to the vulnerability of species to the impacts of climate change and lack of knowledge impedes the development of appropriate responses. Research, therefore, is an essential response.

Current responses include many individual research programs and projects aimed at improving the knowledge underpinning Victoria's understanding of climate change outcomes and informing policy development surrounding climate change. The Victorian Government's Green Paper, *Land and biodiversity in a time of climate change* (see section LB0 Introduction) draws together the Victorian Government's current land management approaches that aim to improve land and biodiversity resilience to climate change. The resulting White Paper, due for release in 2009, is expected to set the Victorian Government's agenda and guide investment decisions in land and biodiversity management for 50 years, during which time climate change is expected to generate extreme pressure on Victoria's land and biodiversity resources.

The planning system has an important role in facilitating Victoria's adaptation to climate change, particularly in coastal areas. For further discussion of this aspect of planning, see Part 4.4 Coasts, Estuaries and the Sea; Part 5 Living Well.

Response name
Victorian Climate Change Adaptation Program

Responsible authority
Victorian Government (Office of Climate Change, Department of Premier and Cabinet)

Response type
Process

The Victorian Climate Change Adaptation Program (VCCAP) is described in more detail in Part 4.1 Atmosphere: Climate Change - Management Responses.

The key initiatives of VCCAP with relevance for land and biodiversity resources are:

- improving resilience of natural assets to cope with greater threats from bushfire, coastal erosion and flooding
- making agricultural systems resilient to climate change.

The Department of Primary Industries, in particular, has a number of projects under VCCAP investigating the implications of various climate change scenarios for Victorian agriculture and land use suitability. These analyses are intended to improve the economic resilience of Victorian agriculture by identifying strategies and policy plans to enable development of Victorian agriculture in an uncertain future climate. DPI's projects are to be piloted in Victoria's south-west but methodologies are expected to be applicable across the State. It is too early as yet to evaluate the effectiveness of these responses.

Recommendation

LB9.7 The Victorian Government should allocate funding for continued research into technologies for reducing greenhouse gas emissions from agriculture, and should support commercialisation of effective technologies to facilitate rapid adoption by farmers.

Response name
National Biodiversity and Climate Change Action Plan 2004–2007

Responsible authority
Australian Natural Resource Ministerial Council

Response type
Strategy/Policy

Victoria is involved in the ongoing implementation of the National Biodiversity and Climate Change Action Plan, a three-year plan intended to co-ordinate the climate change impacts and adaptation programs of Commonwealth, State and Territory governments. The plan covered three years between 2004 and 2007, and was due for review in 2007; however, a revised plan is yet to be released.

The plan provided a broad framework to support adaptation to climate change across Australia. It includes seven objectives that focus broadly on information gathering and dissemination, minimising impacts of climate change on biodiversity, and incorporating new knowledge into the management of natural resources and land use.

One of the key objectives of the plan was to improve understanding of the impacts of climate change on biodiversity. All states and territories were to identify and address gaps in knowledge and modelling capacity that limited the design and implementation of climate change adaptation strategies. While this goal is undoubtedly necessary if effective strategies and policies are to be developed, it is constrained by a lack of basic biological information about the many species that are yet to be characterised; for example, a large proportion of Victoria's invertebrate species. The workshop conducted by ecologists from the Department of Sustainability and Environment to inform development of this report (see Box LB9.1) indicated that even after the end of the first phase of the National Biodiversity and Climate Change Action Plan, there remains considerable room for improvement in the capacity to predict climate change impacts beyond broad trends. While a great deal is known about some of the species at risk from climate change, little if anything is known about many species, and this lack of basic knowledge may limit the effectiveness of future responses to climate change.

Response name
National Agriculture and Climate Change Action Plan 2006–2009

Responsible authority
Australian Natural Resource Ministerial Council

Response type
Strategy/Policy

The National Agriculture and Climate Change Action Plan provides a nationally co-ordinated policy framework that promotes adaptation of agriculture to climate change and a practical approach to climate change mitigation. This plan, which caters specifically for agriculture, is designed to complement the National Biodiversity and Climate Change Action Plan. The Action Plan identifies four key areas to manage the multiple risks to sustainable agriculture in an environment of climate change:

- adaptation strategies to build resilience into agricultural systems
- mitigation strategies to reduce greenhouse gas emissions
- research and development to enhance the agricultural sector's capacity to respond to climate change
- awareness and communication to inform decision-making by primary producers and rural communities.

The plan includes strategies for each of these areas of focus and identifies actions for each strategy. Implementation of the plan includes an initial review of existing activities in all states and territories and the identification of any gaps in co-ordination that might limit implementation of the plan. A review of the plan's effectiveness in generating actions that are addressing climate change was due in April 2008 but it has not yet been published. As yet there is no indication of the effectiveness of this response.

A potential limitation on the mitigation component of this plan is the current understanding of the nature of agricultural greenhouse gas emissions and the preliminary stage of evaluation of technologies for reducing them. While nitrous oxide emissions may be addressed reasonably readily by the widespread adoption of more efficient fertiliser practices, technology for reducing methane emissions from livestock mostly remains in the research and development phase. Some herd management options such as reducing the numbers of unproductive animals may help to reduce methane emissions in the short term.

Evaluation of climate change responses

Victoria's responses to climate change in the context of land and biodiversity resources encompass both adaptation and mitigation activities. However, because so little is known about the capacity of most Victorian species to adapt to climate change, a vast number of responses will be needed to fill the knowledge gaps. These gaps in knowledge, along with the apparently rapid rate of climate change, create a significant risk that responses will be inadequate. This risk needs to be formally assessed and managed.

Responses addressing adaptation of Victoria's biodiversity and natural ecosystems to climate change are diverse and are not necessarily direct responses to climate change, but are broadly centred on creating resilience by improving the condition of Victoria's ecosystems across tenures and sectors. The recent Green Paper, *Land and biodiversity in a time of climate change*, outlines the Victorian Government's approach to managing climate change in natural systems. While Victoria's reserve system will be an important component of biodiversity conservation, the dynamic nature of climate change means that ecosystem connectivity in the broader landscape will also be critical. The Victorian Government seeks to engage business, the community, the non-government sector and individuals in activities to improve the condition of Victoria's natural resource base and build resilience to climate change.

The Government has an array of existing strategies and policy instruments with which to encourage environmental stewardship, including the Biodiversity Strategy, the Native Vegetation Management Framework and market-based instruments such as BushTender and EcoTender, which can be targeted to improve vegetation connectivity. New markets for carbon offsets also offer opportunities to improve biodiversity outcomes from climate change, and the Victorian Government has a role to play in encouraging biodiverse offset plantings such as those offered by Greening Australia's Breathe Easy program.

Responses aimed at reducing greenhouse gas emissions from Victoria's rural industries are focused on research. DPI is a partner in the Greenhouse in Agriculture research program, led by the University of Melbourne. This program targets nitrous oxide emissions from cropping and grazing enterprises and methane emissions from grazing activities, with a focus on dairy emissions. Research projects are aimed at producing Best Management Practices for minimising nitrogen and carbon losses from farm systems, as well as developing genetics, technologies and management options for reducing methane emissions from livestock. The program includes a communication and extension module, improving the likelihood of adoption of new management techniques and technologies. Provided they are readily adoptable, management-based solutions seem more likely to produce a result in the short term. In particular, reduced reliance of agriculture on nitrogen fertiliser, which is energy intensive to produce and apply, could contribute to a reduction in net emissions from agriculture. A return to legume-based agriculture, where nitrogen is fixed from the atmosphere at small cost to production, could compensate for reduced fertiliser application. Breeding and other genetic approaches may provide long-term options for reducing greenhouse gas emissions from agriculture.

The Greenhouse in Agriculture program also includes research projects aimed at facilitating adaptation of agriculture to climate change, including future land suitability analyses and better greenhouse gas accounting. Accurate profiles of industry emissions will help to prepare agriculture for future carbon accounting.

The Victorian Government announced the $205 million Future Farming Strategy in April 2008. This strategy aims to support adaptation of Victoria's farming sector to climate change and includes $103.5 million for research and development of new crop varieties and improved disease control technologies.

As yet Victoria does not have specific responses addressing the sequestration of carbon in vegetation and soil (biosequestration), but the Green Paper makes reference to using carbon markets for biodiversity and land health. The Victorian Government has the opportunity to influence the design of the Carbon Pollution Reduction Scheme to include agriculture, forestry and other biosequestration activities. This scheme is due to be introduced in 2010.

Victoria has the beginnings of a policy framework to develop an effective response to climate change, as well as a number of the necessary policy instruments. The ultimate outcomes will be dependent on the remainder of the policy development process and the adequate resourcing of both existing and new initiatives. These are yet to be determined.

Recommendations

LB9.8 The Victorian Government should adopt the precautionary principle in relation to climate change impacts on land and biodiversity and allocate adequate funding to address the critical risks.

LB9.9 The Victorian Government should incorporate climate change risk assessments into all government decisions surrounding land and biodiversity.

LB9.10 The Victorian Government should incorporate climate change adaptation responses into the upcoming Climate Change White Paper and climate legislation to ensure that risks are adequately addressed and managed.

Photo: Geoffrey Browne

For further information

Victorian climate change program: www.climatechange.vic.gov.au/index.html

Greenhouse in Agriculture: www.greenhouse.unimelb.edu.au/gia.htm

National Biodiversity and Climate Change Action Plan: www.environment.gov.au/biodiversity/publications/nbccap/

National Agriculture and Climate Change Action Plan: www.daff.gov.au/__data/assets/pdf_file/0006/33981/climate-change-action-plan-2006-09.pdf