Remnant Native Vegetation Investigation
Discussion Paper

FOR PUBLIC COMMENT

June 2010

State Government Victoria

VEAC
Victorian Environmental Assessment Council

WHAT IS THE VICTORIAN ENVIRONMENTAL ASSESSMENT COUNCIL?

The Victorian Environmental Assessment Council (VEAC) was established in 2001 under the *Victorian Environmental Assessment Council Act 2001.* It provides the State Government of Victoria with independent advice on protection and management of the environment and natural resources of public land.
The five Council members are:

Mr Duncan Malcolm AM (Chairperson)
Duncan Malcolm is a former dairy farmer and horticulturalist from east Gippsland, with extensive experience in natural resource management, particularly in the water sector and in coastal management. He has chaired many natural resource management bodies including the Gippsland Coastal Board, Lakes and Wilderness Tourism, Watermark Inc., the Irrigation Association of Australia Ltd and the East Gippsland Catchment Management Authority. He has been a VEAC member since 2002 and Chairperson since 2004.

Mr Barry Clugston
Barry Clugston is a farmer from Stawell in western Victoria, with extensive experience as a land manager with farms and natural ecosystems, particularly relating to biodiversity, salinity and Landcare. Barry is chairman of Grampians Wimmera Mallee Water Corporation and a former board member of the Wimmera Catchment Management Authority and Wimmera Leadership. He is an exhibiting artist and heavily involved in community affairs. Barry is a naturalist who for many years presented a regular wildlife program on ABC radio.

Mr Ian Harris
Ian Harris has had over 30 years experience in the planning and management of land for public use and conservation at both state and local government levels. He has been responsible for on-ground land management in regional Victoria and urban Melbourne as well as statewide policy development and program implementation for national parks and flora and fauna protection.

Mr Ian Munro PSM
Ian Munro is a consultant for the Department of Innovation, Industry and Regional Development (DIIRD), a board member of the Growth Areas Authority and the former Deputy Secretary and CEO, Invest Assist for DIIRD. He has a comprehensive knowledge of government across areas including regional development, infrastructure, technology, the environment, and has chaired or been a member of numerous government expert committees and policy review committees.

Dr Airlie Worrall
Airlie Worrall is a policy analyst by profession and a historian by training. She specialises in rural industry and community policy development. Airlie trained in Australian history at Melbourne University, doing research into 19th century land reform movements and the Victorian wool textiles industry. She has been an academic and an industrial heritage consultant, serving on the National Trust and the Victorian Historic Buildings Council classifications committees. As a policy analyst, she has worked in the Victorian food, textile, wool processing and timber harvesting industries and served as Senior Adviser to several Agriculture Ministers.

HOW TO MAKE A SUBMISSION

Written submissions are invited on this Discussion Paper.

The closing date for submissions is
Monday 30 August 2010.

You may make an online submission via VEAC's website at www.veac.vic.gov.au or send your written submission to VEAC by post, by fax or by email (see contact details). Only submissions sent directly to VEAC will be treated as submissions.

There is no required format for submissions, except that you must provide your name and your contact details, including an email address if you have one. All submissions will be treated as public documents and will be published on VEAC's website. The name of each submitter will be identified as part of each published submission, but personal contact details will be removed before publishing. Confidential submissions are discouraged. If there are exceptional circumstances that require confidentiality, please contact VEAC before making your submission.

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Council members (left to right): Ian Harris, Barry Clugston, Duncan Malcolm (Chairperson), Airlie Worrall, Ian Munro

FOREWORD

The Victorian community has a great interest in, and concern for, our remnant landscapes and native flora and fauna. This is reflected in hundreds of impressive landscape restoration programs and inspirational initiatives in all parts of Victoria, many of them resourced through the voluntary efforts of individuals and community organisations.

Since 2008 when the Government requested VEAC to undertake this investigation into remnant native vegetation outside Victoria's largely-intact landscapes, there has been a substantial increase in emphasis on landscape connectivity and the need to build resilience in the landscape.

The Government's policy direction in the Land and Biodiversity White Paper to build ecosystem resilience and improve connectivity is one expression of this new focus. The increased concern evident in the community about the additional threats that climate change poses to biodiversity is another.

In carrying out this investigation the Council is conscious that there are many agencies and organisations working in this area: scientists, policy specialists, private conservation bodies, naturalists, land owners and land managers, and many experienced and knowledgeable on-ground practitioners. We have taken an approach that tries to build on this experience, and harness the energy and enthusiasm in the broad community. The Community Reference Group for this investigation has provided valuable guidance to the Council in this regard.

We are fortunate in Victoria to have access to considerable expertise on landscape ecology, as well as to spatial modellers who work innovatively with other scientists and policy experts to improve tools for assessment of native vegetation and landscape connectivity. The Council and its staff have been supported in the analysis that provides the basis for this discussion paper by a very constructive collaboration with DSE's research and policy staff, and stimulating discussions with and expert advice from the members of the Scientific Advisory Committee for this investigation.

This is a different kind of investigation for VEAC, in that the Council does not propose to make land use recommendations for the many thousands of individual public land reserves across Victoria. However, the Council believes that it is an excellent demonstration of the way in which VEAC's expertise and focus can be used in collaboration with other organisations. In particular, the investigation utilises VEAC's strengths in bringing together the best science and taking it to the community for input and discussion, before developing authoritative advice for Government.

This discussion paper is deliberately information-rich. Its purpose is to build a clear picture of remnant native vegetation in all its variations across the state as a basis for identifying priorities and the appropriate actions to address them. In its regional consultations, the Council found that there is an appetite for information about native vegetation at a regional scale to inform decisions about what actions, and at which locations, would make the best contributions to the conservation of remnant native vegetation in Victoria. However, the Council is aware that the community is also interested in other specific matters, such as how best to manage small public land reserves within the landscape, and the most effective operation of incentive schemes. We expect to pick up these themes in the final report due in March 2011.

The Council is looking forward to engaging in a discussion with interested groups and individuals during this consultation period.

Duncan Malcolm
Chairperson

Acknowledgment of Country

The Victorian Environmental Assessment Council acknowledges and pays its respects to Victoria's Native Title Holders and Traditional Owners, their rich culture and their spiritual connection to Country. The Council also recognises and acknowledges the contribution and interest of Indigenous people and organisations in the management of land and natural resources. The Council acknowledges that the past injustices and continuing inequalities experienced by Indigenous peoples have limited, and continue to limit, their proper participation in land and natural resource management processes.

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EXECUTIVE SUMMARY

Victoria is the most cleared of all Australia's states and territories, with more than half of the original extent of native vegetation cleared for agricultural and urban development. This inhabited, modified and farmed landscape is as distinctively Victorian as our large areas of natural wilderness.

Victoria's rural and regional areas are a patchwork of developed and agricultural landscapes bound together, visually and ecologically, by remnant native vegetation that links them with more intact natural environments. Vegetation on roadsides and along rivers and creeks, pockets of natural bushland and large solitary trees in paddocks are all critical components of our natural ecosystems, providing habitat for wildlife, and often forming the last strongholds of otherwise depleted local plants and animals.

The Victorian government has asked the Victorian Environmental Assessment Council (VEAC) to investigate remnant native vegetation on Crown land and public authority land outside of largely-intact landscapes across Victoria to identify opportunities for ecological linkages. The terms of reference specify that VEAC release a discussion paper and submit a final report by March 2011.

In total 46.2% of the state has native vegetation cover, a little more than half of which is in the areas outside largely-intact landscapes ('fragmented landscapes'). Fragmented landscapes are the focus of this investigation.

This discussion paper tries to give a clear picture of remnant native vegetation in fragmented landscapes across the state, as well as a discussion of the causes of the observed patterns and threats, as a basis for identifying future directions. VEAC is now seeking comments on this discussion paper. Submissions close on 30 August 2010.

SCOPE OF THE INVESTIGATION

The purposes of the investigation are to:

a identify and evaluate the condition, values, resources and uses of these areas of remnant native vegetation and associated fauna outside largely intact-landscapes;

b assess these areas for their connectivity and contribution to sustainable landscapes in relation to climate change;

c report on the contribution of these areas of remnant native vegetation to biodiversity conservation, recreation activities, community uses, commercial opportunities, services and utilities in the context of improving connectivity with largely-intact landscapes and freehold land; and

d report on opportunities for management to achieve improved ecological connectivity.

The full terms of reference are provided in section 1.3.

Victoria has 28 terrestrial biogeographical regions (bioregions), which are delineated on a landscape scale by characteristics such as climate, geology, natural landforms and vegetation. Given the statewide nature of the investigation, the Council has adopted a bioregional approach, and does not propose to make individual public land use recommendations for the many thousands of public land sites. Council has also decided to present information for remnant native vegetation on both public and private land, in order to provide a context for closer consideration of public land. This approach has the support of stakeholders and the community consulted to date.

CONSULTATION PROCESS

More than 70 submissions were received in response to the Notice of Investigation advertised in February 2009. The submissions can be viewed on VEAC's website.

A Community Reference Group and a Scientific Advisory Committee have been established for this investigation (see appendix 1).

During the preparation of the discussion paper, VEAC also sought input from government agencies, community organisations, landholders, and interested individuals. A series of regional workshops was held in late 2009.

The major issues arising from the consultation to date are provided in section 1.8.2.

LANDSCAPE ECOLOGY AND LANDSCAPE CHANGE

Modification of the landscape by humans for agricultural and other purposes has lead to the immense loss of native vegetation, fragmentation and degradation of habitat, factors implicated in the global decline of biodiversity. Landscape ecology seeks to understand landscape patterns, species assemblages and ecological processes. Within modified landscapes, habitat loss and fragmentation has resulted in populations of plants and animal species existing in discrete places, where previously they may have been substantially connected. Landscapes that maintain or enhance connectivity are thought to be more likely to maintain populations of the various species that once occupied the original landscape.

As well as understanding the patterns and causes of habitat fragmentation, recently there has been a scientific and policy emphasis on maintaining or enhancing ecological processes. This arises from, or has coincided with, an acknowledgement that building ecological resilience will be necessary so that ecosystems have the best chance of adapting to climate change as it occurs. Vegetation loss and fragmentation undermine the resilience of ecosystems. Where ecosystems are degraded, improving and restoring vegetation will improve ecosystem function and contribute to resilience. Australia's biota is already under considerable stress from factors such as landscape degradation and introduced species. Climate change adds a further degree of complexity to the effects of landscape modification and is likely to exacerbate stresses on flora and fauna.

STATEWIDE NATIVE VEGETATION DATA

The importance of vegetation extent and condition as proxies for regional biodiversity status is widely recognised. Management agencies need accurate information on the extent of native vegetation, the level of depletion, and the condition or quality of remnants and how well they are connected. Victoria has excellent information on vegetation extent and is a leader in modelling vegetation condition and aspects of landscape connectivity. The shift from mapping to modelling using current satellite imagery enables regular update of datasets that represent aspects of current native vegetation extent, condition and connectivity.

The current native vegetation extent dataset for Victoria was used as the basis of the analyses carried out for this discussion paper. The current extent of native vegetation in Victoria is 46.2% of the original extent of native vegetation (see section 4.1). This figure is higher than previous assessments because the new extent mapping method is much better at detecting occurrences of native vegetation than the previous mapping available in a statewide coverage, primarily due to the inclusion of grassy native vegetation and structurally modified vegetation. It should be noted that these classes represent native vegetation that is often in a reduced condition.

PUBLIC LAND DATA

An interim, 1:25,000 scale digital spatial layer of statewide public land was compiled specifically for this investigation. While this scale of mapping was not available for some parts of the state, the spatial layer that was used for VEAC's analysis represents a considerable improvement on previously used data. The mapping of road reserves, in particular, is a significant improvement in its own right, but is particularly important for this investigation. It has allowed roadside vegetation to be mapped and analysed at a statewide level for the first time.

The public land spatial layer developed for this investigation has also been used to conduct a stocktake of the area and number of the various categories of public land in the fragmented and largely-intact landscapes (see section 3.2). While public land in fragmented landscapes makes up less than half of the area of public land in Victoria (43%), it contains more than 98% of the individual public land reserves. Furthermore, most of these reserves are isolated and small or very small, posing significant management challenges.

VEAC'S ANALYSIS

The native vegetation extent, site condition and landscape context modelling layers, and the public land spatial layer prepared for the investigation were combined in a Geographic Information System and analysed by each of the 28 Victorian bioregions. The information presented in the discussion paper is the product of considerable summarising of the large and complex datasets on which it is based. There are many possible combinations of factors to analyse further; some additional information is presented on the investigation pages of VEAC's website.

Spatial modelling of connectivity is still in its infancy and remains to be empirically tested in real landscapes. For this investigation, VEAC commissioned DSE's Arthur Rylah Institute to utilise a tool called Circuitscape to analyse 13 vertebrate species across regional landscapes in Victoria. Four examples are presented in section 3.4. The Circuitscape outputs show that a direct route is rarely the most probable passage taken by a given species between patches. Circuitscape models are only one of many potential methods for examining connectivity. However, they provide a glimpse of the multiple pathways for connectivity that are available in the landscape.

STATEWIDE OVERVIEW

Fragmented landscapes make up almost 79% of Victoria but account for only 54% of the current extent of native vegetation. Across fragmented landscapes, remnant native vegetation is divided almost equally between public and private land.

The proportion of native vegetation remaining in the fragmented parts of Victoria's bioregions varies greatly – from less than 16% of the Victorian Volcanic Plain, to 94% in the Highlands – Far East. In terms of the extent of remaining native vegetation, bioregions fall into three broad groupings: most cleared, moderately cleared, and least cleared bioregions (see section 4.2). The 10 most cleared bioregions all have relatively flat terrain, low elevation and fertile soils, and less than 40% of their original extent of native vegetation remaining. As a result, habitat loss and isolation of remnants are likely to be the major cause of biodiversity loss in these landscapes. The 11 moderately cleared bioregions are those with 40-70% remnant native vegetation in their fragmented landscapes, and are characteristically foothills or less fertile flatter country. The remaining seven bioregions have more than three quarters of their original extent of native vegetation left.

Road reserves

The total area of road reserves in Victoria is in the order of 570,000 hectares, most in fragmented landscapes. About 245,000 hectares supports native vegetation (see section 4.2.5). The importance of roadside vegetation in bioregions generally increases as the extent of remnant native vegetation decreases. In the more cleared bioregions, road reserves contain significant proportions of the remaining native vegetation, and particularly high proportions of the vegetation on public land. In these landscapes, roadsides are disproportionately important for the species they support. In four bioregions in the west and north of the state, road reserves account for more than 5% of total remnant native vegetation in fragmented landscapes. Three bioregions have more than 15% of their fragmented public land native vegetation on road reserves.

Vegetation condition

The quality of remnant native vegetation varies widely in different parts of Victoria and is a key factor in its management and its value for conservation of plants and animals. A common pattern across the bioregions is for public land to support vegetation of higher overall site condition than private land (see section 4.2.6). The condition of native vegetation also tends to be better in the less cleared bioregions, but variations to this overall trend have important conservation and management implications warranting specific attention.

Connectivity

Unsurprisingly, there is a clear trend for overall landscape context scores to increase with increasing percent of original vegetation extent remaining in the bioregions (see section 4.2.7). However, the landscape context scores for public land remnants in the most cleared bioregions are significantly higher than for private land, and particularly in the four most cleared bioregions. This is mostly because a high proportion of public land native vegetation in these bioregions is in a small number of relatively large public land remnants.

Numbers of patches

There are some 2.72 million patches of native vegetation in Victoria. However it needs to be noted that the number of patches in a landscape is very dependent on the rules used to delineate patches (see section 4.2.8). The size distribution of patches is highly skewed, with 88% of patches less than one hectare in size, but 68% of the total area of native vegetation in patches greater than 1,000 hectares in size.

SUMMARIES FOR EACH OF THE 28 INDIVIDUAL BIOREGIONS

Section 5.5 provides, for each Victorian bioregion, native vegetation statistics for both public and private land in fragmented landscapes, highlights key findings and briefly describes the major post-European land use activities that have shaped the fragmentation patterns of native vegetation in individual bioregions.

PATTERNS, IMPACTS AND THREATS

The distinctive biophysical attributes of each Victorian bioregion have strongly influenced historical land uses and settlement patterns, which in turn have resulted in particular fragmentation patterns of vegetation. Certain landscapes have been disproportionately cleared or heavily modified for agriculture. The especially high loss of native vegetation from the most productive land is apparent at all scales – from bioregions to vegetation types – and has led to a correspondingly high loss of biodiversity and a high proportion of threatened species in these areas. In the most cleared landscapes within bioregions, the vegetation associated with riparian areas and wetland margins is frequently almost the only remaining local vegetation.

Continued degradation of remaining native vegetation is currently the major threat to Victoria's biodiversity. The incremental loss of small patches of native vegetation and even single 'paddock trees' adds to the loss of habitat and the degradation of landscape processes. DSE estimates approximately 1,600 hectares of woody native vegetation extent and 3,000 hectares of grassy native vegetation extent are being lost annually in Victoria, mostly from private land. Gains in the extent of native vegetation total about 400 hectares of woody vegetation per year. Changes in native vegetation quality, as opposed to extent, account for more than 90% of the statewide overall annual loss of native vegetation. Public land accounts for less than 20% of this loss of quality and more than 60% of the offsetting gains in quality.

There are many dimensions and consequent threats posed to native biodiversity from habitat fragmentation, including changes to fire regimes, climate and the suitability of areas between patches of native vegetation. The complex interaction of ecosystem processes means that the functional status of native vegetation on public land cannot be considered in isolation of the surrounding private land.

Climate change is an additional factor that adds to and interacts with a range of existing stressors that have already contributed to the decline in Australia's biodiversity. These effects will be complex and difficult to predict, but in the future, more native vegetation across the landscape will be needed to develop robust ecosystems so that components may withstand various threatening processes, adapt and sustain themselves under new environmental conditions.

FUTURE DIRECTIONS

Three clear themes emerge from VEAC's work to date on this investigation:

- across the Victorian community there is a high level of interest in, and commitment to, connectivity and the conservation of remnant native vegetation
- there is a large body of scientific theory and analysis related to ecological connectivity, with a significant contribution from Victorian researchers
- there is a large amount of spatially explicit digital information about the landscapes of Victoria that can be analysed to inform decision making.

The challenge is to integrate community support, science and spatial data to set directions for the future.

Nineteen key issues and discussion points are presented in section 7 as a starting point for community response to this discussion paper. Details for making a submission are provided on the inside front cover.

1

INTRODUCTION

1.1 Background to the investigation

Recent assessments conclude that Australia's biodiversity is under considerable pressure from greatly altered landscapes through vegetation clearing, introduced pests and weeds, highly modified and overcommitted water resources, widespread use of fertiliser and other chemicals, changed fire regimes, urbanisation, mining, and over-harvesting.[1]

The statistics are stark for Victoria:

- Victoria is the most cleared state in Australia; about half our original vegetation cover has been cleared including 80% of the original cover on private land.[2]
- One third of Victoria's major streams are in poor or very poor condition. Two thirds of our wetlands have been either lost or degraded and nearly half of our major estuaries are significantly modified.[3]
- The highest number of threatened species in any one region in Australia occurs in north western Victoria.[4]
- 44% of plants and 30% of our native animals are either extinct or threatened.[4]

In its reporting of changes in native vegetation in Victoria, the Department of Sustainability and Environment (DSE) distinguish between 'largely-intact landscapes' and 'fragmented' landscapes (see box opposite and figure 1.1 below). Victoria's *Catchment Condition Report 2007*[3] and the 2008 *State of the Environment*[5] report also use this framework for reporting. DSE report the rate of clearing of grassy native vegetation on private land as significantly greater than the rate for woody native vegetation. While the clearing of native grasslands remains of concern, clearing of native vegetation is no longer the largest source of native vegetation change in Victoria. Recent work undertaken by DSE to provide the first Statewide data-driven model of native vegetation quality has confirmed the magnitude of the chronic loss of quality over a long period.[2]

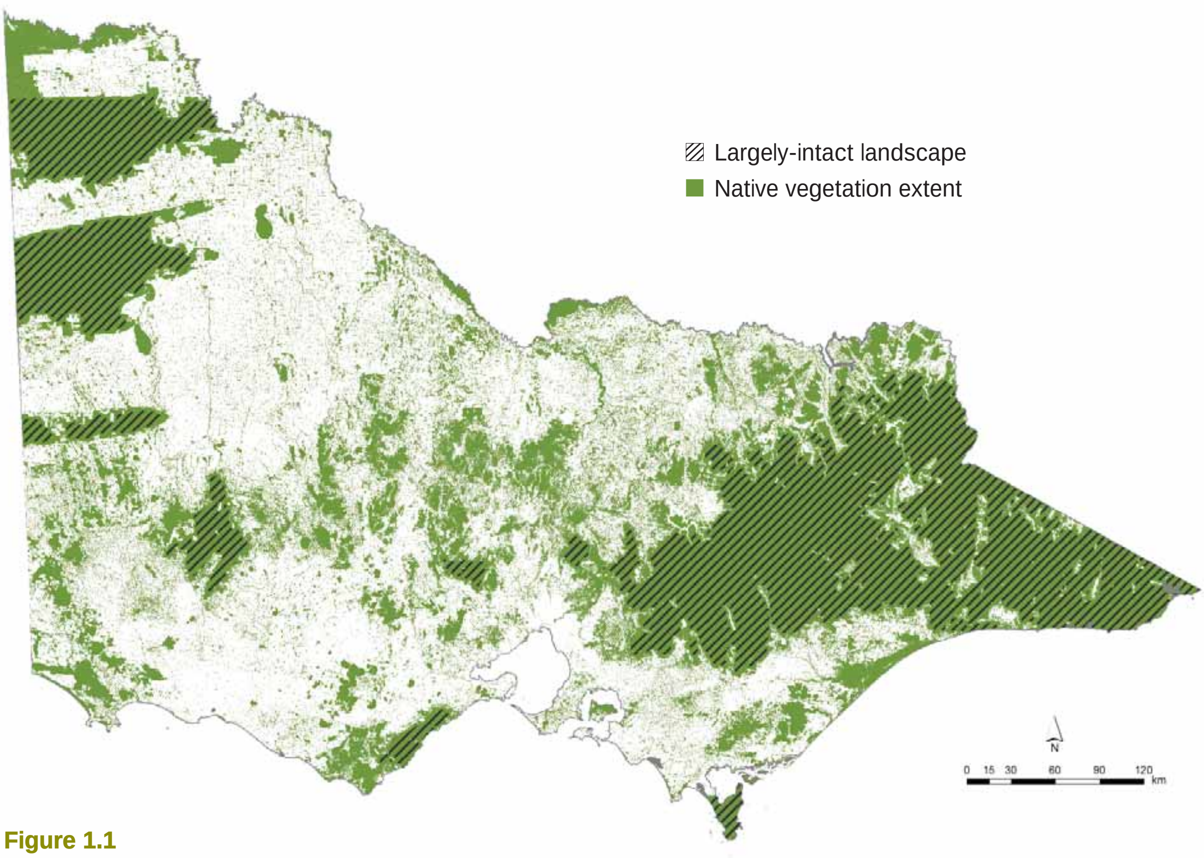


Figure 1.1
Native vegetation and areas considered largely-intact landscapes. *Source: DSE, 2008*[2]

A key finding of the Assessment of Australia's Terrestrial Biodiversity 2008[6] is that native vegetation is a cost-effective and powerful surrogate for biodiversity. The Victorian Environmental Assessment Council (VEAC) has been requested by the Victorian government to investigate remnant native vegetation on public land outside the largely-intact landscapes and to identify opportunities for ecological linkages (see section 1.3 below).

Victoria's *Land and Biodiversity White Paper*[7] released in late 2009, outlines a new goal of building ecosystem resilience and improving connectivity. VEAC will consult widely with interested stakeholders and the community during its investigation, and expects its final report to Government to make a major contribution towards this goal.

The 2009 Victorian Bushfires Royal Commission will conclude during the consultation period for this discussion paper. The outcomes of the Commission and the Government's response will be taken into account in the development of VEAC's final report.

Largely-intact landscapes: defined for the purposes of Net Gain Accounting for the Native Vegetation Management Framework as 'contiguous areas of native vegetation greater than 20,000 ha, with high Landscape Context scores and Site Condition scores that are high (or if scores are not high, this is primarily due to natural or semi-natural disturbances)'; 'underlying stock' of native vegetation is generally considered to be stable; natural or semi-natural dynamics are the dominant drivers. Largely-intact landscapes correspond closely with Victoria's major parks and state forests.

Fragmented landscapes: areas outside largely-intact landscapes where there has been widespread removal and on-going use of native vegetation for economic development. Here, the 'underlying stock' of native vegetation is generally considered to be declining or at risk of decline; degradation and recovery from degradation are the dominant drivers.

1.2 The Victorian Environmental Assessment Council

The *Victorian Environmental Assessment Council Act 2001* (VEAC Act) came into effect on 31 December 2001. This Act repealed the *Environment Conservation Council Act 1997* and established the Victorian Environmental Assessment Council (VEAC) to conduct investigations and make recommendations relating to the protection and ecologically sustainable management of the environment and natural resources of public land.

The current five members appointed to VEAC are Mr Duncan Malcolm AM (Chairperson), Mr Barry Clugston, Mr Ian Harris, Mr Ian Munro PSM and Dr Airlie Worrall. A brief biography of each of the Council members is provided on the inside front cover of this discussion paper. The Council is supported by a small research, policy and administrative staff. The VEAC Act requires the Council to consult with departments and public authorities, and requires departments and public authorities to give practicable assistance to the Council in carrying out investigations. However, VEAC papers and reports are prepared independently.

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

- **a** the principles of ecologically sustainable development;
- **b** the need to conserve and protect biological diversity;
- **c** the need to conserve and protect any areas which have ecological, natural, landscape or cultural interest or significance, recreational value or geological or geomorphological significance;
- **d** the need to provide for the creation and preservation of a comprehensive, adequate and representative system of parks and reserves within Victoria;
- **e** the existence of any international treaty ratified by the Commonwealth of Australia which is relevant to the investigation;
- **f** any agreement at a national, interstate or local government level into which the Government of Victoria has entered, or under which the Government of Victoria has undertaken any obligation in conjunction with the Commonwealth, a State, Territory or municipal council, which relates to the subject matter of the investigation;
- **g** the potential environmental, social and economic consequences of implementing the proposed recommendations;
- **h** any existing or proposed use of the environment or natural resources."

1.3 Terms of reference for the investigation

In July 2008, the Minister for Environment and Climate Change, Gavin Jennings MLC, requested that VEAC undertake an investigation into remnant native vegetation. The terms of reference are below. The terms of reference specify four purposes and also require VEAC to take into account relevant government policies, strategies, programs and plans.

TERMS OF REFERENCE

Pursuant to section 15 of the *Victorian Environmental Assessment Council Act 2001* the Minister for Environment and Climate Change hereby requests the Council to carry out an investigation of remnant native vegetation on Crown land and public authority land outside of largely-intact landscapes* across Victoria to identify opportunities for ecological linkages.

The purposes of the investigation are to:

- **a** identify and evaluate the condition, values, resources and uses of these areas of remnant native vegetation and associated fauna outside largely intact landscapes;
- **b** assess these areas for their connectivity and contribution to sustainable landscapes in relation to climate change;
- **c** report on the contribution of these areas of remnant native vegetation to biodiversity conservation, recreation activities, community uses, commercial opportunities, services and utilities in the context of improving connectivity with largely-intact landscapes and freehold land; and
- **d** report on opportunities for management to achieve improved ecological connectivity.

In addition to the considerations specified in Section 18 of the *VEAC Act*, the Council must also take into consideration relevant State Government policies, programs, strategies and Ministerial Statements, and relevant regional programs, strategies and plans.

The Council is required to consult the community in accordance with the VEAC Act, to release a Discussion Paper, and to submit a Final Report on the results of its investigation. The Final Report must be submitted by March 2011.**

** Largely-Intact landscapes have been defined for the purposes of Net Gain Accounting for the Native Vegetation Management Framework as 'contiguous areas of native vegetation greater than 20,000 ha, with high Landscape Context scores and Site Condition scores that are high (or if scores are not high, this is primarily due to natural or semi-natural disturbances)'.*
*** Originally March 2010*

1.4 Scope of the investigation

Unlike most previous investigations carried out by VEAC and its predecessors, the terms of reference specify that VEAC release a discussion paper and submit a final report, but do not specify that VEAC must release a draft proposals paper. The Council has therefore taken the view that the investigation is statewide and regional in scale, and it does not propose to make individual public land use recommendations for the many thousands of public land sites.

Although VEAC does not expect to make individual public land use recommendations, it has taken the opportunity of this investigation to do a stocktake of public land outside largely-intact landscapes (see section 3.2 table 3.2 for details). Although there are some caveats about use of the data that must be borne in mind, it is immediately clear that while public land in fragmented landscapes makes up less than half of the area of public land in Victoria (43%), it contains more than 98% of the individual public land reserves. Furthermore, most of these reserves are small or very small. Most of this public land is managed by Parks Victoria. An analysis by Parks Victoria in 2003 of the reserves it managed across Victoria at that time showed that more than 90% were less than 400 hectares, with most less than 200 hectares and almost a third less than 10 hectares.[8] There have been changes to public land categories since that 2003 assessment – most notably as a result of the implementation of VEAC and ECC recommendations in the Box-Ironbark, Angahook-Otway and River Red Gum Forests investigation areas – but the broad picture of a large number of small fragmented public land reserves has not changed.

The Council has adopted a bioregional approach for this investigation. Victoria has 28 terrestrial bioregions (or biogeographical regions) across the state. Bioregions are broadscale mapping units that capture the patterns and ecological characteristics in the landscape. In Victoria, native vegetation is classified into Ecological Vegetation Classes (EVCs). There are approximately 300 EVCs statewide. For convenience, similar EVCs have been assigned to 20 simplified native vegetation groups and some of these groups have been further divided, giving a total of 35 sub-groups across Victoria. VEAC has not further analysed or presented data on EVCs for this discussion paper as a considerable amount of information on EVCs (updated in 2007) is available on DSE's website (www.dse.vic.gov.au).

Although VEAC's terms of reference relate only to public land, it is clear that remnant native vegetation on public land cannot sensibly be considered in isolation from remnant vegetation on private land, particularly in fragmented landscapes. Council has decided therefore to present information for both public and private land, in order to provide a context for closer consideration of public land. Consultation on this investigation to date has indicated that there is very strong stakeholder and community support for this approach.

1.5 The structure of this discussion paper

This discussion paper presents information on patterns of remnant native vegetation in fragmented landscapes across the state for both public and private land. The report also describes the factors influencing these patterns and discusses current and future threats, as a basis for outlining possible future directions and opportunities.

- **Chapter 1** introduces the investigation, provides the legislative and policy context, and gives a summary of issues that have been raised in the consultation to date.
- **Chapter 2** briefly summarises the principles of landscape ecology which provide the theoretical basis for considering remnant native vegetation, especially in relation to current threats such as climate change.
- **Chapter 3** describes the native vegetation and public land datasets and the statewide modelling of native vegetation used in preparing the discussion paper.
- **Chapter 4** provides a statewide overview and bioregional comparison of remnant native vegetation in terms of extent, land tenure, site condition, landscape context, and number and size of patches.
- **Chapter 5** presents a brief narrative and key statistics about remnant native vegetation in fragmented landscapes for each of Victoria's 28 bioregions.
- **Chapter 6** discusses the causes of the observed patterns of fragmentation and the impacts on biodiversity, and gives a brief overview of current and future threats.
- **Chapter 7** draws together this information into a consideration of future directions and priorities for action. This chapter is arranged under 19 discussion points which can provide a basis for public consultation and submissions.
- **Glossary** provides abbreviations and technical definitions of terminology used in the discussion paper.
- **References** are arranged numerically in the order of citation in the discussion paper.
- **Appendices** provide more detail on relevant topics including technical information on vegetation modelling used in the analyses commissioned by VEAC.
- **Maps** are inserted in the rear pocket of the discussion paper.

1.6 The investigation process

The process for the Remnant Native Vegetation Investigation is formally specified in the VEAC Act and the terms of reference for the investigation. The process is shown in figure 1.2. There are two submission periods (each a minimum of 60 days) and the investigation is scheduled to be completed by the end of March 2011 when the final report is submitted to the Minister for the Environment and Climate Change.

Over 70 submissions were received in response to the Notice of Investigation. The submissions can be viewed on VEAC's website. These submissions contain much valuable information and perspectives on the investigation, and have formed a major input to this discussion paper and the investigation as a whole. A summary of some of the major matters raised in submissions is contained later in this section.

Figure 1.2
The investigation process and timetable

1.6.1 COMMITTEES

Under section 12 of the VEAC Act, the Council may appoint any committees that it considers necessary. For the Remnant Native Vegetation Investigation, VEAC established a Scientific Advisory Committee. The Scientific Advisory Committee has four members: Mr Rod Gowans (Chair), Dr Sue McIntyre, Dr Denis Saunders and Prof Andrew Bennett. The Committee provides advice to the Council on current scientific research and data, including any gaps in knowledge, related to remnant native vegetation, ecological fragmentation and connectivity; and on techniques and approaches that would assist VEAC in the conduct of this investigation.

Under section 13 of the VEAC Act, a Community Reference Group (CRG) is required to be established for each of VEAC's investigation. See section 1.8.1 for more information about the CRG for the Remnant Native Vegetation Investigation.

1.7 Policy context

There are numerous international, national and state government policies and strategies that inform this investigation. Some of the key strategies and programs are outlined below.

1.7.1 STATE GOVERNMENT POLICIES AND STRATEGIES

Victoria's Land and Biodiversity White Paper 2009

The Land and Biodiversity White Paper[7] is a long-term, strategic framework to secure the health of Victoria's land, water and biodiversity in the face of ongoing pressures and a changing climate over the next fifty years. The White Paper describes a new focus on ecosystem resilience, ecological connectivity and high value asset areas. The White Paper has five inter-related goals:

- To safeguard Victoria's land, water and biodiversity by building ecosystem resilience, maintaining ecosystem services and improving connectivity
- To reform and realign Victorian Government processes and institutions which lead and facilitate the sustainable management of Victoria's land, water and biodiversity
- To increase market demand for land, water and biodiversity outcomes
- To encourage all Victorians to work together as responsive and effective stewards of our land, water and biodiversity
- Building healthy and resilient ecosystems across the landscape

Victoria's Biodiversity Strategy 2010 – 2015 (consultation draft)

Victoria's Biodiversity Strategy[4] implements the White Paper's policy agenda for biodiversity over the next five years in partnership with the biodiversity sector.

The renewed Victorian Biodiversity Strategy makes a shift towards a functional view of ecosystems and suggests that a major gap in our approach is effective forward planning based on the needs of biodiversity. It includes a major initiative for a dynamic spatial biodiversity planning tool (NaturePrint) that will help to identify areas that need ecological restoration if Victoria's conservation objectives are to be effectively and efficiently achieved.

To take better account of both pattern and process in framing policy and program objectives, the strategy recognises the twin drivers for biodiversity conservation are minimising loss of biodiversity and maximising the functionality of ecosystems.

The strategy also provides a list of related state, national and international policies, strategies and legislation.

1.7.2 NATIONAL AND STATE ASSESSMENTS OF VICTORIA'S NATIVE VEGETATION

Native vegetation loss is widely recognised as a major driver of biodiversity decline in Australia. As a result there has been a considerable amount of attention given to assessments of the extent, condition and level of depletion of native vegetation at national, state and regional levels. Many government agencies assess, monitor and report on native vegetation.

In Victoria, at a state level, the most authoritative report is the *Native vegetation net gain accounting first approximation report 2008*[2], utilising DSE's most recent 2004-2005 data and mapping of native vegetation extent. For the first time in Australia, a statewide map of the quality of native vegetation was also prepared based on advanced modelling techniques and site data from surveys and related government programs. Other state level reports such as *Victoria's catchment condition report 2007* or Victoria's *State of the environment report 2008* use these same data and mapping for their assessments.

At the national level, the most recent comprehensive assessment is the *Assessment of Australia's terrestrial biodiversity 2008*[6]. This is an update of the 2002 assessment and utilises data available up to June 2007. Another significant national assessment is *Australia's biodiversity and climate change: a strategic assessment of the vulnerability of Australia's biodiversity to climate change 2009*[1]. Also at a national level, assessments have been compiled and directions established for the level of protection of different ecosystems or vegetation classes in the National Reserve System.[62] National assessments, of course, largely rely on data from state and territory departments and agencies.

More detailed work on native vegetation has been undertaken at a regional level in some parts of the state by other agencies such as Victorian catchment management authorities.

1.8 Community views

During the preparation of the discussion paper, VEAC also sought input from government agencies, community organisations, landholders, and interested individuals.

1.8.1 OVERVIEW OF CONSULTATION TO DATE

The submission process is one of the key methods for VEAC to seek community views on issues and values. VEAC received 73 submissions following advertisement of the Notice of Investigation, including five initially sent for VEAC's Metropolitan Melbourne Investigation but also relevant to the Remnant Native Vegetation Investigation. The submissions came from across the state including rural areas, regional towns and Melbourne. Submitters included statewide and local community conservation groups, local government bodies, catchment management authorities, state government agencies, recreational users groups, business groups, ecological consultants, fire agencies and individuals. Collectively, the submissions are a valuable resource for VEAC, and the Council is extremely grateful to all who took the trouble to contribute to the investigation and make a submission. The submissions can be viewed at VEAC's website (www.veac.vic.gov.au).

In addition to the submission phase, VEAC also received input from the Community Reference Group (CRG) established for the investigation in accordance with section 13 of the VEAC Act (see appendix 1 for the membership of this group). The group was made up of representatives of a broad range of interests related to the investigation, and provides ongoing advice and input to VEAC. The Community Reference Group provided advice on consultation processes and methods for gaining the community's views on remnant native vegetation.
As a result of this advice, a series of community and stakeholder workshops was held in various locations around Victoria in November and December 2009: Benalla, Bendigo, Hamilton, Traralgon, Mildura and Melbourne. In total, about 150 people attended these workshops. Participants were invited to identify what they deemed as the major issues for remnant native vegetation (and why), and propose solutions. Feedback was also sought on VEAC's approach to the investigation as it was at that time.

Submissions varied widely in terms of their geographic scope. Twenty-eight submissions addressed matters at the statewide or more general level, 12 submissions focussed at the level of one or more particular large landscapes or biolinks, 21 focussed on single moderately sized biolinks, and 12 focussed on a single issue or one or a few small areas.

Without exception, submissions recognised the importance of remnant native vegetation for biodiversity or the value of remnants to community users. The majority of the submissions were from conservation groups which applauded the need for an investigation and the opportunity to develop strategically connected landscapes, though the scale of the landscape at issue varied. Twenty percent of the submissions were from local government councils and catchment management authorities. These bodies recognised the importance of conserving biodiversity and the need for a strategic approach to maintaining and improving native vegetation management and restoration. They also raised issues pertaining to the need to improve integrated legislation and management of remnant native vegetation.

Given the wide geographic and conceptual scope of the investigation, a large number of often interrelated themes were covered in submissions. However, few were able to address the difficult task of categorising and prioritising regions, threats and actions at the broadest scales. Despite this, many submissions contended that the functional value of remnant native vegetation on public land cannot be considered in isolation from the context of largely-intact landscapes and remnant native vegetation on private land.

1.8.2 ISSUES AND PROPOSALS

This section summarises the issues and proposals presented in submissions and regional workshops under several broad headings.

Conservation of biodiversity

Most submissions and discussions at workshops acknowledged the value of the biodiversity pertaining to remnant native vegetation and expressed concern at the continued degradation from grazing, feral animals, invasive weeds, firewood removal, incremental clearance and inadequately managed recreation use.

It was recognised that improved management requires substantial increases of resources in terms of funding and personnel. Many practitioners proposed that fencing to exclude stock and the reduction of incremental clearance were two areas that are the most cost effective in terms of outcomes for biodiversity protection and for rehabilitation of native vegetation. In addition, many proposed a significant investment in pest management was required to prevent further degradation.

Several submissions and discussions proposed that there was a need for increased scientific research into the role of remnant native vegetation in ecological function. Other submissions proposed the acquisition of more land to protect biodiversity, notwithstanding VEAC's role being restricted to public land. The conservation of biodiversity is addressed throughout the discussion paper.

Connectivity

Many submissions and discussions supported the terms of reference in improving connectivity in the landscape. However there were few detailed strategic proposals specifying potential areas for connectivity. The extent of community understanding of ecological connectivity varied greatly. The general perception from submissions and discussions was a need for explicit detailed information on habitat restoration and connectivity in a form that is prescriptive and appropriate to the variety of ecosystems within Victoria.

Roadside reserves, riparian zones and crown frontages are landscape elements that act as existing linear connective remnants. Improved management of these areas was thought likely to contribute significantly to biodiversity protection and facilitate connectivity without the need for establishing new connective elements. Roadsides were flagged as a part of the public land estate deserving closer examination, being thought to contribute – in some areas at least – more in terms of significance and extent of remnant native vegetation than generally thought. Riparian zones were cited as an example of the more biologically productive parts of the landscape which were thought likely to deliver greater benefits from investment in their conservation, than most other parts of the landscape.

Riparian and wetland areas

Riparian areas were considered to be valuable elements of the landscape in terms of connectivity, biodiversity and productivity. Protection of riparian zones was considered by some to be a high priority. Fencing, to exclude stock grazing, was proposed as the most cost effective means to improve long-term management and biodiversity protection. Many unique characteristics of wetlands were raised, notably their sensitivity to climate change and resultant recent degradation, their role as aids or obstacles to connectivity of adjoining terrestrial habitats, and the implications for connectivity of their different spatial configurations – e.g. along river floodplains, as more or less discrete large areas of wetlands such the Gippsland Lakes or as large numbers of small scattered ephemeral wetlands often on private land such as in the region around Hamilton. Riparian and wetland areas are discussed further in section 6.2.3.

Recreational uses

Given the statewide scope of the investigation, a wide variety of recreational pursuits are undertaken on public land with remnant native vegetation, including fishing, bushwalking, four-wheel driving, hunting, horse-riding and nature appreciation.

Several submitters were concerned with the potential threat of vehicle activity damaging native vegetation while other submissions were concerned that track access to remnant native vegetation would be restricted. One submission proposed that controlled pest management (hoofed feral animals and foxes) by regulated hunters could be integrated into management planning.

Proposals for specific blocks of public land

As mentioned above some submissions focussed on one or a few relatively small individual blocks of public land – from around one hectare to around 10,000 hectares. Although the investigation is regional and statewide in scale – and therefore will not deal individually with the many tens of thousands of such blocks across Victoria – the intent of these submissions will be taken up at the strategic level. For example, the broader theme that can be drawn from proposals that particular areas become conservation reserves is that of poor reserve system representation and the view that different management regimes may improve habitat quality. At the same time it is recognised that others have expressed their desire to continue existing recreational access to public land.

Public land management

A very common sentiment, particularly from those with extensive on-ground experience, was the need for greater investment in public land management, especially in small blocks and more fragmented landscapes. Several people pointed out that the scale of increase required was at least an order of magnitude greater than savings that could be made from improved efficiency of management, coordination and so on. Many practitioners and others emphasised that inconsistent legislation and policy impaired integrated functional management of remnant native vegetation – particularly in the case of roadsides and riparian areas. They felt an urgent need for clearer responsibility, improved consistency in land-use provisions and increased compliance with and implementation of policy. Many suggested that improvements in this area would lead to significant gains in the conservation of native vegetation.

Framework

Attendees at the regional workshops and several submitters raised many issues relating to a framework for the conservation of remnant native vegetation. These included a need to improve the development, integration and implementation of policies consistently and effectively, to increase the priority of remnant native vegetation in conservation, and to provide funding appropriate to the value of remnant native vegetation in providing ecosystem services. Monitoring and environmental audits based on scientific knowledge were proposed as essential to measure the effectiveness of management.

Areas that were flagged as needing improvement included the provision of facilitators, strategic planning (including whole farm planning), motivational and financial incentives for private landholders, and building on the capacity of Landcare-type groups.

Many parts of the landscape are important to Indigenous people for cultural and spiritual values. The opportunity to engage, consult and provide meaningful roles for Indigenous people was considered important when making planning decisions, in ecological restoration projects and in the protection of remnant native vegetation.

Among the submissions and regional workshops there was a strong emphasis on the need to improve and engage public awareness and education of the role and value of remnant native vegetation to ecosystem services. In particular, the need to engage younger people through education programs was identified.

Data collection and management is important for conservation as it underpins effective decision making. Participants at the regional workshops identified a need to establish an appropriately funded process for data management, storage and coordination. This includes improved communication of data accessibility for agency and private use and cross-agency tenure.

Particularly after being shown VEAC's preliminary analysis of the DSE's 2005 native vegetation assessment data, many recognised its great value and strongly advocated ongoing assessments to track changes and trends, starting within the next year or so if possible.

Fire management

Several submitters and regional workshop attendees highlighted a need for increased scientific knowledge and long-term monitoring of the role of fire in the ecology of remnant native vegetation.

In light of the February 2009 fires, the need for asset and community protection from fire is widely recognised. However, there is a concern that in many instances the removal of native vegetation and fuel reduction burns are emotionally or politically driven, rather than based on scientific evaluation or strategic asset protection. Some participants at the workshops suggested that there is a lack of clearly defined objectives in fuel reduction and ecological burns, and no evaluation of effectiveness. Of particular concern was that the removal of key environmental elements such as fallen timber and hollow bearing trees from roadsides, decreasing their value for biodiversity.

Genetic provenance

It was proposed that remnant native vegetation as a source of genetic diversity is rarely recognised. Using plants of local provenance for revegetation projects and as stock for local nurseries is important because local plants are genetically adapted to local conditions. Planting local plants increases the success of revegetation projects and decreases the risk of the disruption of locally adapted gene complexes.

Climate change

Most members of the community acknowledge that climate change is a globally driven process and mitigating the adverse effects poses many challenges for global and local policy makers. The overwhelming scale of the threat to biodiversity has made some feel that they are powerless to address the problem at the community level. Nonetheless, many felt that maintaining and improving the quality of remnant native vegetation would improve the resilience of native vegetation and the fauna it supports in the face of climate change.

Some submitters and participants at regional workshops considered remnant native vegetation valuable as a source of carbon storage and, therefore, potentially an important contributor to the mitigation of climate change. Furthermore, incorporating carbon sequestration and biodiversity values into revegetation programs (on public and private land) could be an important part of a framework for mitigating climate change.

2

LANDSCAPE ECOLOGY AND LANDSCAPE CHANGE

Modification of the landscape by humans for agricultural and other purposes has led to the immense loss of native vegetation, fragmentation and degradation of habitat, factors implicated in the global decline of biodiversity (see box, right).[9,10] Many landscapes throughout the world are now highly modified with only scattered fragments of native vegetation remaining.[11]

The modification of landscapes influences ecosystem processes, species richness and distribution, as well as altering physical attributes of the environment, ultimately leading to a poorer environment in which all species, including humans, live. Maintaining the integrity of ecosystems is vital if they are to adapt to climate change, if biodiversity is to flourish, and if humans are to continue to receive the ecological goods and services on which we depend for our existence. Services provided by functional ecosystems include clean air and water, carbon sequestration, pollination, biological pest control, raw resources, the prevention of soil erosion and degradation, and recreational opportunities.

Landscape ecology is the study of patterns and processes of species assemblages and their interactions within landscapes.

Classifying the elements and patterns that make up landscapes, and understanding the complex biophysical interactions within the context of whole landscapes, enables scientists and land managers to make informed decisions about effective conservation and land management. The study of landscape patterns, species assemblages and ecological processes is known as landscape ecology. Landscape ecology has its roots in geography and ecology.[13] Landscape ecology is central to effective conservation ecology and the mitigation of adverse environmental effects arising from vegetation loss and degradation caused by human modification to the landscape.[14]

Biodiversity

The term ‘biodiversity’ is often defined as the variety of all forms of life, encompassing genes, species, ecosystems and their interactions. Biodiversity has three main components: composition, structure and function.

- Composition includes the identity and variety of elements within a system. The three levels at which biological variety has been identified are:
  - genetic diversity – the total number of genetic components that make up a species. This includes populations, significant taxonomic units and individuals. At the level of biological populations, genetic variation among individual organisms is a signature of their evolutionary and ecological past, but also a basis of future adaptive evolutionary potential. Species that lack genetic variation are thought to be more vulnerable to extinction from natural and human-induced environmental changes.
  - species diversity – the number of species and their relative abundance.
  - ecosystem diversity – the diversity of ecosystems.
- Structure is the physical organisation or pattern of a system and includes habitat complexity, patch patterns and the elements within a landscape.
- Function involves physical, ecological and evolutionary processes including nutrient cycling, disturbances and gene flow.[12]

2.1 Landscape patterns and processes

Scientists distinguish between pattern and process in conservation ecology. Pattern refers to the spatial arrangement of species and habitats, and process refers to their interactions with each other and the environment.[4] Existing approaches to biodiversity conservation and management have focused on pattern, but recently emphasis has also been given to understanding and protecting ecological processes and a recognition that these processes operate at multiple geographic scales.[15] The emphasis on ecological processes arises from, or has coincided with, an acknowledgement that building ecological resilience will be necessary so that ecosystems have the best change of adapting to climate change as it occurs. A healthy and resilient ecosystem will be better able to cope with environmental fluctuations (including climate change) outside normal ranges.

Removal of large areas of vegetation alters physical processes, including those related to water flux, radiation, wind and erosion. The greatest effect of these changes on vegetation fragments occurs at the boundaries of the fragments. The microclimate at the boundaries differs from the interior of fragments in terms of light, temperature, humidity, and wind speed. In turn, these physical changes affect biophysical processes such as litter decomposition and nutrient cycling, and the structure and composition of vegetation. Land uses in the surrounding environment, such as the use of fertilisers, alterations to drainage patterns and water flows, also have adverse effects on fragments. In particular, grazing by domestic stock markedly alters vegetation fragments by changing the structure and nutrient cycles.[16]

One of the most detrimental impacts on the landscape caused by wide-scale land clearing in southern Australia is dryland salinity. The wide-scale removal of trees has resulted in the rise of groundwater, bringing salts from ancient seas to the surface. Where the brackish water discharges in the landscape it degrades agricultural productivity and native vegetation.[17]

2.1.1 FRAGMENTATION, PATCHES AND THE MATRIX

Vegetation fragmentation is the ‘breaking apart’ of continuous vegetation (figures 2.1 and 2.2). Fragmentation results in the reduction of the total amount of vegetation (habitat loss), the sub-division of vegetation into patches and fragments (fragmentation) and the replacement of removed vegetation with new forms of land use.[11] The intervening land and its associated land use are referred to as the landscape matrix.

Landscape change is not random. The type of land use influences the spatial patterns of landscape change, underlying ecological processes and species distributions in different ways. For example, areas of fertile, low lying land suitable for agriculture are typically targeted for extensive clearing. Remnant vegetation in these areas, if it exists at all, tends to be in small and isolated patches. Steep terrain such as highland slopes or low fertile soils such as mallee shrublands are less suitable for agriculture and tend to support more substantial patches of native vegetation.[10]

Figure 2.1
An agricultural landscape along the Murray River, illustrating large remnants in areas prone to flooding.

Figure 2.2
A modified landscape extensively cleared, containing few remnants. Linear remnant vegetation follows road reserves and drainage lines.

McIntyre and Hobbs (1999) conceptualised a model of landscape change represented by four major stages of landscape condition (figure 2.3).[18] Landscapes can be:

- **intact** – in which landscapes contain most original vegetation with limited clearing;
- **variegated** – in which landscapes are dominated by original vegetation, but include gradients and buffers of modified habitat;
- **fragmented** – contains discrete patches of vegetation in a modified matrix; or
- **relictual** – with little (less than 10%) of the original vegetation remaining, surrounded by highly modified landscape.

Landscape change is a dynamic process. Landscapes are comprised of innumerable configurations along a continuum and consist of a variety of elements such as riparian, granite or wetland areas (figures 2.1 and 2.2). Landscape modification changes the spatial configuration of native vegetation. The extent of modification influences the proportion of edges, size and shape of a fragment. With increasing clearing, the distance between patches increases and landscape connectivity decreases. Furthermore, the quality of the remaining vegetation decreases because of changes in water fluxes, solar radiation and susceptibility to invasion by weeds, grazing by domestic stock and a loss of native biodiversity.

2.1.2 EFFECTS OF LANDSCAPE CHANGE ON SPECIES AND POPULATIONS

Different organisms display diverse and individual responses to landscape modification depending on the scale at which they normally operate and the scale at which they perceive the environment.[19,20,21] For example, a large bird of prey with a large home range and able to fly many tens of kilometres has a radically different response to a plant. The ability to utilise highly modified landscapes (e.g. agricultural pastures), in addition to native habitat, has enabled some generalist species, like galahs, to prosper and expand their ranges. Some species are known as 'edge specialists'; they inhabit the matrix-vegetation boundary and benefit from highly fragmented landscapes.[10] Several species that have flourished in an agricultural matrix have become overabundant and in certain landscapes are considered pests requiring active control measures. In contrast, many other species have specific habitat requirements that restrict them to certain elements of the landscape (e.g. native grasslands or wooded areas), and their ranges have contracted within modified landscapes or have become locally extinct.

Generally the number of species found within an area is proportional to the size of the area and how isolated it is from other core areas. This concept is known as the species-area relationship and is derived from the

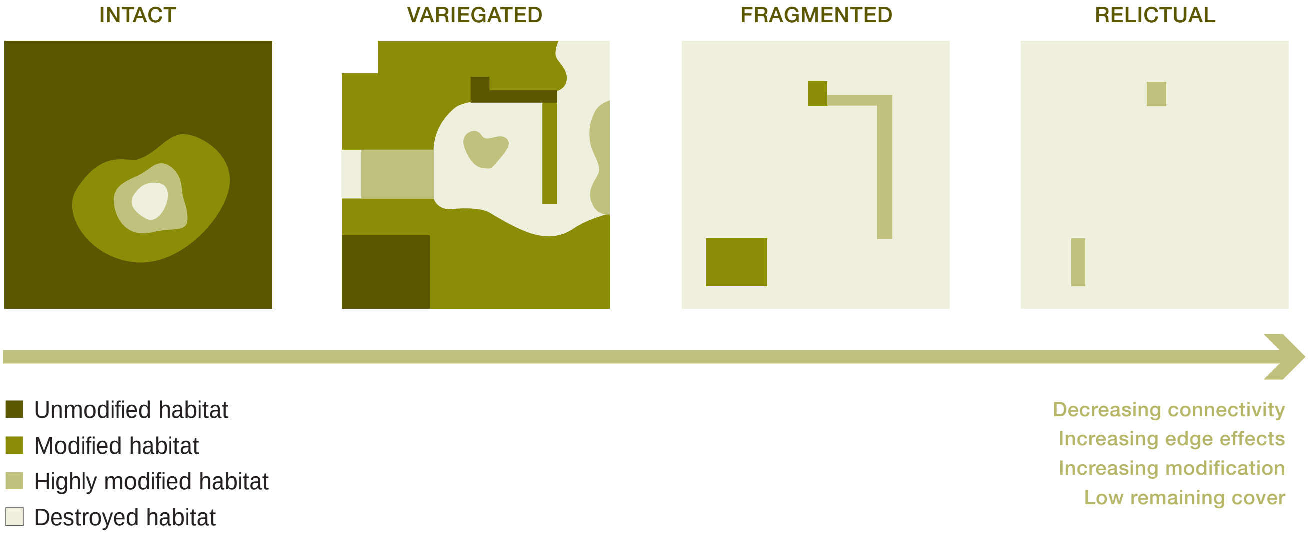


Figure 2.3
Four landscape alteration states (intact, variegated, fragmented and relictual) showing modification of remaining habitat (from McIntyre and Hobbs 1999).[18]

equilibrium theory of island biogeography.[22] The theory postulates a relationship between the number of species found on an island and the island's area and isolation. The theory predicts that the number of species on an island represents a dynamic balance between the rate of colonisation of new species to the island and the rate of extinction of species already present. The analogy between islands in the ocean and vegetation patches in a matrix has formed the basis of landscape ecology. For terrestrial systems, the theory predicts that as the size of a patch decreases, the number of species found will generally also decrease. In other words, as patches become smaller, and more isolated from other patches, the progression of habitat loss eventually leads to species loss.

Landscape change affects animal and plant species distributions and abundance – frequently with adverse consequences.

Within unmodified landscapes, a given species may occur as spatially discrete populations that are functionally connected via the interchange of dispersing individuals. Collectively, such connected populations are known as a 'meta-population'.[23] The characteristic process that defines a meta-population is extinction and re-colonisation of populations. In a meta-population model, local populations are vulnerable to extinction from random processes. However the movement of individuals between local populations 'rescues' failing populations or permits the re-colonisation of patches in which the species previously declined to extinction. A species will thus persist in the regional landscape as long as local population extinction does not exceed re-colonisation.[23, 24]

Within modified landscapes, habitat loss and fragmentation has resulted in populations of a species existing as a series of spatially discrete entities, where previously they may have been substantially connected. In many cases, the spatial isolation of patches and the nature of the intervening matrix restrict the capacity of an organism to move through the landscape. In the absence of landscape connectivity, populations in small patches are vulnerable to extinction.

For species dependent on native vegetation, the clearance of vegetation and replacement with alternative land uses represents habitat loss. Smaller patches become unsuitable for many species because they do not support sufficient resources; for example, suitable nest sites, food and shelter.[25] Smaller patches support smaller populations that are vulnerable to extinction because of natural fluctuations in resources, random changes in population demographics, adverse genetic processes and disturbance events (e.g. fire).[26,27,28]

The presence of a species within a patch does not necessarily equate to a locally viable population. Species may persist within vegetation patches because of immigration of individuals from resource-rich areas outside the patch or locality. These populations are considered 'sink' populations as they are unable to sustain their numbers in the absence of immigration.[29] Such populations are likely to be prevalent throughout highly modified landscapes and mask the true status of populations or species.[24]

Evidence suggests that species loss may take many decades to manifest following fragmentation.[30,31] Local extinction of a species can occur after a substantial delay following habitat loss, fragmentation or disturbance. That a species can initially survive environmental perturbations, but later become extinct despite no additional change to the habitat, is known as 'extinction debt'. Extinction debt can refer to a proportion of populations of a single species or the proportion of all species subject to the given environmental perturbation.[32]

As long as species still persist following environmental perturbations, then there is time to implement counter measures, such as habitat restoration, to prevent extinction. However, extinction debt poses a significant but under-recognised challenge for biodiversity conservation, because the delay between the perturbation event and the demise of a species may take many decades and go unrecognised until near extinction.[33]

Some ecological consequences of past landscape modification have yet to occur. The existence of mature non-reproducing individuals may give the impression of healthy population sizes using assessments based on occurrence or abundance, but in the absence of recruitment they will decline.[34]

2.1.3 DISPERSAL, LANDSCAPE CONNECTIVITY AND CORRIDORS

Landscapes that maintain or enhance connectivity are thought to be more likely to maintain populations of the various species that once occupied the original landscape.[35] Connectivity prevents and reverses local extinctions by enabling the re-colonisation of empty patches. Connectivity promotes the exchange of genes between populations, and prevents the extinction of local populations due to inbreeding depression and random shifts in the demographics of a population (e.g. over-abundance of a single sex).[36]

The ability of a species to disperse between isolated fragments depends on the intrinsic behaviour of the species, its habitat requirements and the nature of the intervening matrix. From the perspective of an individual species, what may constitute connectivity varies greatly. Highly mobile species such as parrots can traverse open areas of agricultural land to feed on patches of suitable flowering eucalypts. However, the same landscape may be impermeable to a small native rodent or ground-dwelling bird that requires dense vegetation as protection against predators. Such species may be unwilling, or unable, to successfully traverse open land to re-colonise new patches of suitable habitat.

Connectivity can be considered in three ways. From the perspective of a single species, connectivity is connectedness between patches of suitable habitat. From a human perspective, connectivity refers to patterns of vegetation. Finally, from an ecological perspective, connectivity may be considered as being made up of ecological processes at multiple scales.[20]

Figure 2.4 illustrates three major types of landscape connectivity.

- **Corridors –** Linear or linear-like features that connect core areas of habitat. The effectiveness of vegetation corridors will be dependent on their width and quality, and is species-specific.
- **Stepping stones –** Like corridors, stepping stones can provide additional habitat to those species that are not area sensitive. Although a small patch may not support the diversity of larger patches, the cumulative conservation value of small patches in the landscape is substantial and studies show that up to three-quarters of native bird species may use patches of less than 1 hectare in some way. [20]
- **Matrix –** In modified landscapes many species use the matrix as habitat. Scattered trees in the matrix are used by bats, woodland birds and reptiles.[20,37] Despite the potential value of the matrix for some species, the matrix will be inhospitable to many other organisms.

Connectivity may also have detrimental effects. Animals carry out an important role in ecosystem processes by carrying and dispersing seeds and facilitating pollination. However, undesirable species can also be dispersed within native vegetation systems by the same mechanisms. Connectivity via vegetation corridors may also facilitate the movement of fire and other abiotic disturbances through the landscape.[38] The design of corridors should also consider the intrinsic characteristics of species and their susceptibility to predation or other inhospitable attributes of the corridor. Furthermore, inappropriately placed corridors may establish new routes for dispersal in previously isolated systems, disrupting local adaptation.[39]

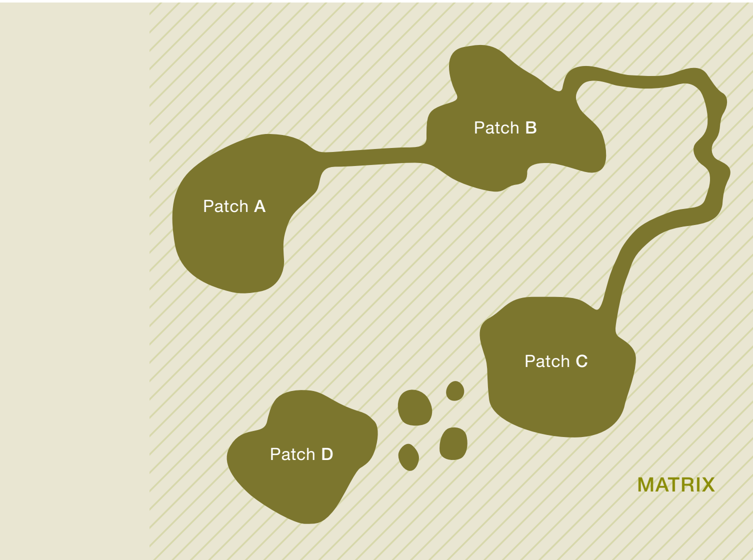


Figure 2.4
Schematic representation of corridor attributes. Corridors may be direct between two patches [A-B], a non-direct route such as along a riparian zone [B-C] or a series of structurally non-connected stepping stone corridors [C-D].

Figure 2.5
Connectivity operates at all spatial scales, from the transcontinental to this lace monitor crossing the Hume Freeway using a bridge provided principally for squirrel gliders.

2.2 Habitat restoration

For the reasons already discussed above, vegetation loss and fragmentation undermine the resilience of ecosystems. Where ecosystems are degraded, improving and restoring vegetation will improve ecosystem function and contribute to resilience.

Given the relationship between vegetation decline and loss of biodiversity it follows that conservation in fragmented landscapes can be enhanced by vegetation restoration. Ecological restoration can be carried out by:

- protecting and improving the quality of existing habitat – particularly core habitat or refugia;
- increasing the amount of habitat and connectivity between fragments. This includes the reduction or elimination of landscape discontinuities so as to reduce edge effects and provide dispersal and migration opportunities for species;
- the restoration of buffer or transitional zones in critical sensitive places such as riparian areas;
- the restoration of wildlife corridors and stepping stone habitat to ensure adequate migration flows within the wider landscape matrix; and
- prevention of further habitat loss.[16,20,40]

Ecological restoration is undertaken at a variety of scales and, for example, may include small areas of less than one hectare, strips of roadside reserves, or large-scale plantings of many thousands of hectares. The importance of restoration and increasing connectivity for landscape-scale ecosystem function has lead many community groups in Australia to working towards rebuilding connectivity on large spatial scales (e.g. Habitat 141 and WildCountry).[41] These projects are frequently referred to as 'biolinks'. Biolinks are defined as "broad geographic areas identified for targeted for action to increase ecological function and connectivity, improving the potential of plants and animals to disperse, recolonise, evolve and adapt naturally".[7] Biolinks do not necessarily aim to establish structurally contiguous corridors of native vegetation, but also involve projects which improve the quality of existing habitat by domestic stock exclusion, weed removal, facilitation of water flows, re-establishment of native vegetation patches, and wetlands restoration.

Detrimental effects of land degradation can be mitigated by habitat restoration.

A key issue for conservation (and hence habitat restoration) is the relative importance of habitat loss versus habitat fragmentation.[42,43] That is, what is the relative importance of *how much* habitat remains in the landscape versus *how fragmented* it is?[10,43] Theoretical modelling and empirical studies suggest that the effects of fragmentation on biodiversity become apparent at about 10-30% of remaining vegetation,[42,43] though species responses are individualistic.[21] Restoration of landscapes containing remnants of native vegetation at these thresholds would need to strategically consider if restoration effort would be best targeted at increasing the size of individual remnants or enhancing connectivity.

Several recent scientific studies into landscape scale restoration of woodland habitats in the heavily fragmented systems of southern Australia has provided insights into how species (particularly birds) respond to spatial and structural aspects of original and restored native vegetation in modified landscapes.[44] The size of patches, total woody cover and structural complexity of vegetation are important elements in local species diversity. Crucially, landscapes comprised of remnant native vegetation are found to support a higher diversity of species, than those with revegetation alone.[45] This work emphasises the importance of protecting extant stands of remnant native vegetation if conservation of a range of species is a restoration goal.

2.3 Climate change

2.3.1 MAGNITUDE

Since 1960 the mean temperature in Australia has increased by about 0.7°C. The summer of 2009-10 was Australia's hottest on record, at 0.2°C above the long-term summer average.[46] The decade 1998-2007 was globally the warmest on record with 2007 being the warmest year on record in Victoria with a mean annual temperature 1.2°C above the long-term average. Predictions on climate change estimate Victoria will warm at a slightly faster rate than the global average, especially in the north and east of the state. By 2030, annual temperatures are predicted to increase by at least 0.8°C with much warmer summers and springs. Inland areas will experience more frequent and intense hot days. Rainfall patterns are expected to change with drier winters and springs and increased intensity in rainfall during summer and autumn. In addition to overall lower rainfall totals, evaporation is expected to increase, exacerbating the overall drying trend.[47,1] These changes will result in an increase in the fire index and a likely increase in the frequency of fires.[48]

Climate change poses complex challenges for conservation of biodiversity.

2.3.2 THE IMPACT ON BIODIVERSITY

Biodiversity has been identified as the most vulnerable global sector to be affected by climate change reflecting the very low adaptive capacity of ecosystems.[49] The threats to biodiversity arise because of changes in the physical and chemical environment which underpin all ecosystem processes; especially CO_2 concentrations, temperature, rainfall and acidity. Individual species will be affected in different ways by these changes, leading to flow-on effects to the structure and composition of present-day communities, and then potentially to changes in ecological processes.

How species may respond to climate change will vary greatly and probably in unpredictable ways because of the complexity of biological systems. Organisms experiencing climate change may disperse from their original location (find a better place) or tolerate the change and remain in their original location (genetic or physiological adaptation). The rate of climate change, the ability of species to disperse, the nature of dispersal routes and the intervening matrix, and the ability of a species to adapt will determine the success of the response by a given species. Individualistic responses by species will mean that communities and ecosystems are likely to change with novel combinations of species almost certainly appearing in the future.[1]

Observed changes in Australian species and communities that are consistent with species responding to a climate change signal include changes in geographic ranges, life cycles, populations, ecotonal boundaries, mass bleaching of coral, and changes in fire regimes. Most of these changes are related to temperature and rainfall, but are difficult to separate from other natural and human drivers of change.[1] Australia's biota is already under considerable stress from factors such as landscape degradation and modification, and introduced species. The legacy of past actions has had a devastating influence on species distributions and abundance. Climate change adds a further degree of complexity to the effects of landscape modification and is likely to exacerbate those stresses.

2.3.3 CONNECTIVITY

A global analysis of biodiversity distributions shows a profound shift in species ranges over a wide range of taxa with movement on average of 6.1 km per decade toward the poles.[50] Predictions of shifts in species ranges to different elevations and latitudes in response to climate change suggest that landscape connectivity will aid conservation of biodiversity. Indeed, the general perception from many participants of the stakeholder meetings and submissions and a review of the scientific literature[51] suggest increased connectivity as a key conservation strategy. However, knowledge of how species will respond to climate change is minimal. For example, it is not known if genetic adaptation or dispersal will be the most important factor in determining the success of a species adapting to climate change. Scientists have also pointed out that, ultimately, conservation is a multi-species enterprise and multi-species responses are not a simple function each individual species' response.[1]

Unfortunately in many cases, improving habitat connectivity will not be sufficient to buffer against climate change. The climate envelope in which species currently exist will either cease to exist at all or shift to regions with unsuitable geomorphology prohibiting the establishment of identical (or suitable) vegetation communities. On the other hand, some species may be able to expand their range by extending into areas where competition is decreased or diseases cannot follow.[41]

2.3.4 MANAGEMENT CHALLENGES

Given the uncertain but inevitable changes to biodiversity from climate change there is a growing awareness that management of biodiversity needs to be reorientated towards an overarching goal of minimising biodiversity loss, rather than concentrating on single species approaches. In this context, two key principles to minimise biodiversity loss are maintaining well-functioning ecosystems and protecting an array of ecological systems.[1] Central to this strategy is to enhance robustness of remaining ecosystems to give them a chance to adapt. Approaches would include (but are not limited to):

- addressing key threatening process leading to habitat degradation
- enhancing protection of an array of ecosystems
- building appropriate connectivity
- developing appropriate fire and other disturbance regimes
- translocating species (assisted migration)
- re-engineering ecosystems
- developing new tools in modelling of climate, vegetation responses, animal movements and genetic adaptation, particularly the need to develop more robust and certain models
- developing policy, decision making processes and adaptive management approaches that incorporate uncertainty.

As the current trajectories for sea level rises are at the upper limit of the projection of the Third Assessment Report of the Intergovernmental Panel on Climate Change,[52] and global temperatures are expected to rise given the current rate of greenhouse gas emission production,[53] the need for planning and implementation for future biodiversity requirements is urgent.

3

STATEWIDE MODELLING OF NATIVE VEGETATION

For effective conservation planning, management agencies need accurate information on the extent of native vegetation, the level of depletion, and the condition or quality of remnants and how well they are connected. This information can in turn be used to infer the significance of remnant vegetation in supporting indigenous biodiversity at landscape scales. Australian federal and state agencies recognise the importance of vegetation extent and condition as proxies for regional biodiversity status, and have instituted policies and requirements to monitor native vegetation at landscape-scales using these two indicators (e.g. DNRE 2002).[54]

A major issue with large-scale (i.e. statewide) assessment of native vegetation extent and condition is that available resources prohibit extensive systematic ground-truthing for accurate assessment. Previously, mapping of the extent of native vegetation in Victoria had been done using a variety of techniques at different times at varying resolutions. Landscape-scale studies of vegetation extent were project based, regional or local, and ad hoc. Tree cover was frequently the parameter used by management agencies and researchers to model vegetation extent at landscape scales. In recent years, the advent of Geographic Information Systems (GIS), combined with sophisticated satellite imagery, advances in statistics and improved computing capacity, has enabled broad-scale models of regional landscapes to be developed. The shift from mapping to modelling using current satellite imagery enables regular update of datasets that represent aspects of current native vegetation extent, condition and connectivity.

Presented below is a brief overview of the spatial modelling employed to assess the extent, condition and connectivity of remnant native vegetation across Victoria. Technical details of the methods are given in appendix 2.

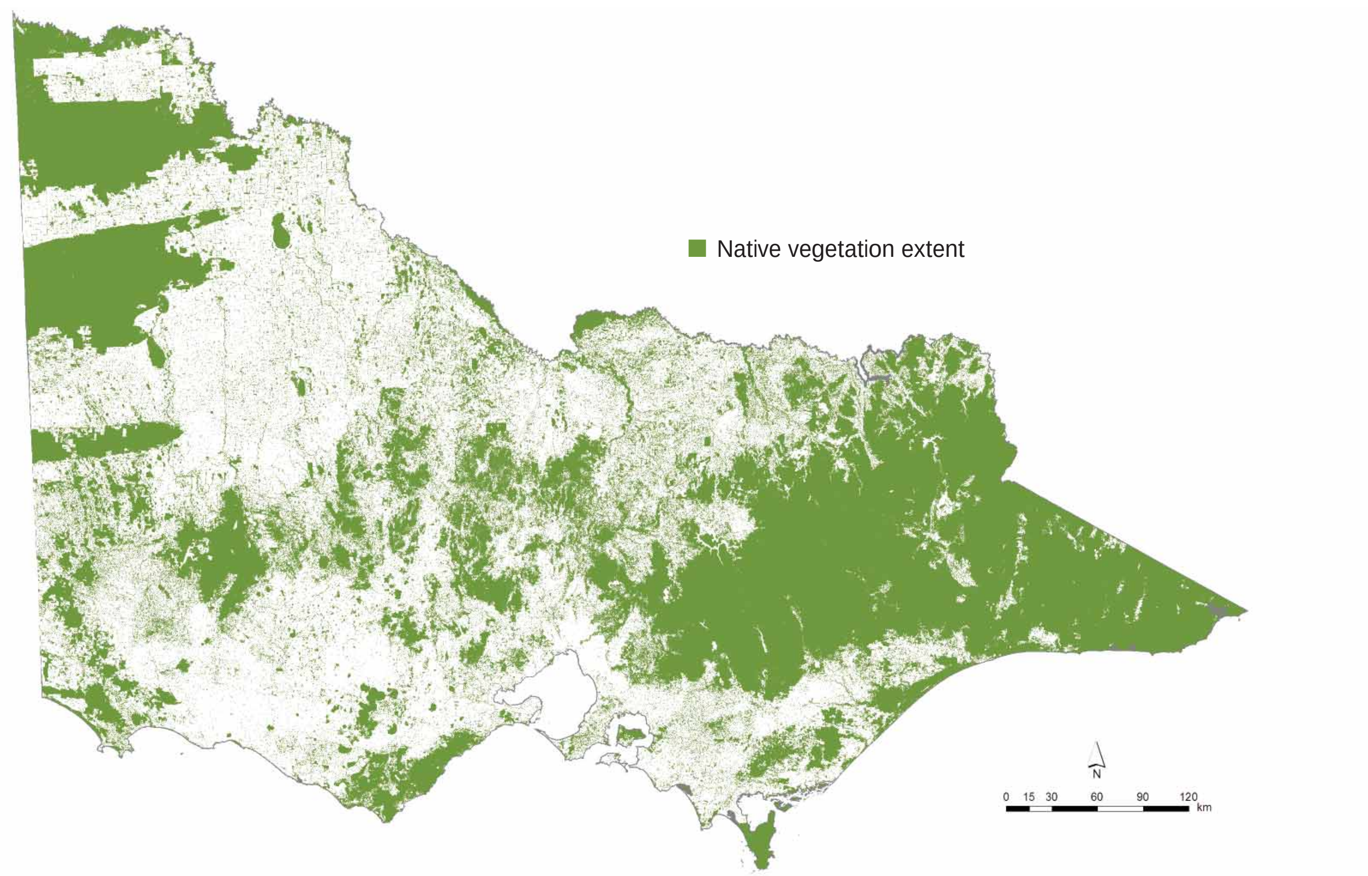


Figure 3.1
Native vegetation extent *Source: DSE, 2008*

3.1 Vegetation modelling

3.1.1 VEGETATION EXTENT

The current native vegetation extent dataset for Victoria (NV2005_EXTENT)[55,56] was used as the basis of the analyses carried out for this discussion paper (see figure 3.1). This dataset represents the extent of both woody and non-woody native vegetation. Prior to the use of the modelling approaches outlined above, mapping non-woody vegetation was incomplete. The new extent mapping methodology is much better at detecting occurrences of native vegetation than the previous mapping available in a statewide coverage, primarily due to the inclusion of grassy native vegetation and structurally modified vegetation, although it should be noted that these classes represent native vegetation that is often in a reduced condition.[2] The extent mapping also depicts a class referred to as "possibly native vegetation", although this is not counted in extent analyses (table 3.3).

The consequence of improved detection of native vegetation is that the estimate of total area of native vegetation is higher than previously reported. This does not however mean that the actual extent of native vegetation has increased. Areas of the landscape which may have previously been classified as non-native vegetation have now been modelled as native vegetation and assigned accordingly. As already mentioned, the increase in extent is because the model now distinguishes native grassy vegetation (where the overstorey trees have been removed), structurally modified native vegetation and smaller clumps of trees.[2] Isolated trees are still currently below the level of detection and are therefore not represented in the vegetation datasets. It is important that this is taken into consideration when comparing published work based on extent data from previous years.

3.1.2 VEGETATION CONDITION

Between 2003 and 2007 DSE staff compiled a database of vegetation condition (see Habitat hectares below) from more than 15,000 field sites across the state. This information was derived from a variety of different research programs and Government incentive schemes. The majority of these field sites were categorised across the landscape by vegetation type, tenure, and patch size, and other data were used opportunistically where available.

These data, in conjunction with other spatial datasets and time-series LANDSAT imagery, were assembled in a GIS environment to develop a statewide predictive model of native vegetation condition. In total 58 variables (GIS and remote-sensed data) including biophysical and spectral data were assembled in the total dataset.

The outputs from the modelling are useful as a broad appraisal of native vegetation condition, but users need to be aware of the limitations. The dataset is designed for use at a broad scale (1:25,000 to 1:100,000) and is not definitive at fine scales. Any actions or interpretation at the site scale should be informed through individual site assessments.

Map A (back pocket) shows site condition across Victoria.

3.1.3 HABITAT HECTARES

"Habitat hectares" is a method developed by DSE to objectively assess the quality of native vegetation at the site level. Habitat hectares is a generic rating of native vegetation condition, which attempts to assess the degree to which the current vegetation differs from a "benchmark" representing the average characteristics of a mature stand of the same vegetation type in a "natural" or "undisturbed" condition.[56,57] Habitat hectares is comprised of two weighted groups of components – seven of which assess the condition at the site, and three which provide information on the landscape context. The components of the habitat score and their relative weightings are shown in table 3.1.

The first group, site condition, describes the retention of characteristics within a site (or conversely the level of disturbance). Each of these components is referenced and scored in relation to a standard benchmark for the vegetation type in question (i.e. notional pre-European settlement condition). The second component relates to the context of the patch or remnant within the landscape. Landscape context describes spatial characteristics of a patch and its surroundings, which contribute to the overall quality of the patch.

Table 3.1
Components and weightings of the habitat hectares score

	COMPONENT	SCORE (%)
Site condition	Large trees	10
	Tree canopy cover	5
	Understorey	25
	Lack of weeds	15
	Recruitment	10
	Organic litter	5
	Logs	5
Landscape context	Patch size	10
	Neighbourhood	10
	Distance to core area	5
	TOTAL	**100**

3.1.4 LANDSCAPE CONTEXT

The context of a vegetation patch within the landscape describes spatial aspects of the patch that make it more likely to sustain healthy native vegetation and suitable habitat for native species. The underlying premise is that larger patches with a smaller edge-to-core ratio, high connectivity and close proximity to other patches are better for biodiversity. In other words, all factors being equal (i.e. patches of the same size and site condition) a patch in a highly connected landscape will score higher for landscape context than an identical patch in a poorly connected landscape.

The dataset developed by DSE assigns a rating of 0 – 20 to a patch based on four patch and landscape metrics: patch size, patch shape, landscape proximity and landscape connectivity. The modelling provides an assessment of landscape context for Victoria at 25 m x 25 m resolution (see appendix 2 for details).

Map B (back pocket) shows landscape context across Victoria.

3.2 Public land mapping

At the commencement of the Remnant Native Vegetation Investigation, the only statewide public land use mapping available did not cover metropolitan Melbourne, was out of date and of insufficient detail to accurately map small parcels and road reserves, which are key focuses for the investigation. To address these deficiencies, DSE compiled an interim, 1:25,000 scale digital spatial layer of statewide public land use for VEAC's Remnant Native Vegetation Investigation. The layer included the most recent information from VEAC's 'RECS25' project and the Angahook-Otway and River Red Gum Forests Investigations, and some mapping for the current Metropolitan Melbourne Investigation current to September 2009.

However, in some parts of the state – particularly Gippsland and much of the southwest – only relatively old 1:100,000 scale mapping was available. In addition, the inner area of metropolitan Melbourne could not be included in the interim layer, although there is little public land in this area. Accordingly, data for these areas need to be treated with some caution, particularly in more detailed analyses, but the scale of inaccuracies is negligible at the statewide level.

Nonetheless the spatial layer that was used for this analysis represents a considerable improvement on previously used data. The mapping of road reserves, in particular, is a significant addition (over half a million hectares) in its own right but particularly important for the Remnant Native Vegetation Investigation. It has allowed roadside vegetation to be mapped and analysed, where previously this was not possible using the 1:100,000 data. DSE and VEAC are currently developing a full 1:25,000 scale statewide public land use layer called PLM25.

The public land spatial layer developed for this investigation has been used to conduct a stocktake of the area and number of the various categories of public land in the fragmented and largely-intact landscapes (see table 3.2). There are a number of qualifications around these figures and these are noted at the end of the table.

Through its regional and special studies, investigations and reviews over the past 40 years, VEAC and its predecessors, the Land Conservation Council (LCC) and the Environment Conservation Council (ECC), have established and applied a consistent set of approximately 20 public land use categories, as appropriate to each investigation area. Government-approved LCC, ECC and VEAC recommendations for public land provide a framework for use and management of all public land across Victoria, except in metropolitan Melbourne, inner Geelong and a few small regional urban areas. DSE, Parks Victoria, Committees of Management and others manage public land in accordance with the uses, and public land use boundaries, specified by past VEAC, ECC and LCC Government-approved recommendations.

Table 3.2

Extent of terrestrial public land use categories in Victoria

CATEGORY	FRAGMENTED LANDSCAPES		LARGELY-INTACT LANDSCAPES		STATEWIDE	
	Total area (ha)	Count	Total area (ha)	Count	Total area (ha)	Count
Wilderness Area	767	3	199,932	3	200,699	3
National and State Parks	739,992	68	2,207,973	25	2,947,966	69
includes Lake Tyers State Park and Castlemaine Diggings National Heritage Park, excludes amendments associated with VEAC River Red Gum Forests Investigation						
National Parks Act schedule 3 or 4 park or reserve *includes coastal parks*	129,605	22	10,486	6	140,091	22
Regional Park *includes metropolitan parks and Phillip Island Nature Park*	55,742	69	3,854	4	59,596	69
Forest Park	42,950	2	5,120	1	48,070	2
Nature Conservation Reserve *includes wildlife areas where hunting is not allowed*	229,528	479	28,269	25	257,797	489
Coastal Reserve *includes minor port and coastal facilities*	15,102	78	41	2	15,142	78
Historic and Cultural Features Reserve	11,917	150	26,910	21	38,827	160
Natural Features Reserve – Wildlife Area *hunting allowed*	67,749	204	6,262	1	74,011	204
Natural Features Reserve – Bushland Area	43,700	1,578	9	2	43,709	1,579
Natural Features Reserve – Streamside Area	6,459	257	35	1	6,494	258
Natural Features Reserve – Stream Frontage & Stream Bed and Banks *'remnant' stream frontages previously estimated at 87,608 ha[97]*	113,800		20,469		134,268	
Natural Features Reserve – other *includes cave reserves, natural and scenic features areas, geological and geomorphological features areas, lake reserves, highway parks, River Murray and Gippsland Lakes Reserves*	113,800	301	20,469	26	134,268	316
Community Use Area	36,570		4,637		41,207	
Alpine Resort	118	1	10,050	6	10,168	6
State Forest *includes plantations, hardwood production areas and uncommitted land*	1,278,735		2,282,332		3,561,067	
Earth Resources	14,912	17	5,981	2	20,893	17
Services and Utilities – Road *includes unused roads previously estimated at 122,490 ha[98], and roadside conservation*	555,830		12,261		568,091	
Services and Utilities – Water and Sewerage Services	29,988		881		30,870	
Services and Utilities – other	2,524		729		3,253	
Water Production	83,013	12	215	4	83,228	13
Uncategorised Public Land	81,036		626		81,662	
Other	76,412		244		76,656	
Public Land subtotal	**3,730,247**		**4,847,786**		**8,578,033**	
Commonwealth Land	56,632	22	0	0	56,632	22
Private Land *includes (+/- public) land not required for public purposes*	14,045,420		18,535		14,063,955	
Total	**17,832,299**		**4,866,321**		**22,698,620**	

Notes:

1. *These figures were compiled from three sources: DSE's Parks and Reserves spatial layer for the first 11 categories, the 1:25,000 interim spatial layer compiled by DSE for the Remnant Native Vegetation Investigation for roads and DSE's PLM100 spatial layer for all other categories. The PLM100 data were compiled for use at 1:100,000 scale or smaller which excludes or inaccurately estimates many small Crown parcels.*
2. *Many of the figures in this table – albeit covering a relatively modest total area – are based on imprecise and incomplete mapping and attribution of categories to areas, especially for the following categories:*
   - *stream frontages and stream beds and banks: mapping has been based on standardised buffers (generally 20 metres) along each side of some permanent waterways, rather than on actual boundaries of frontages, beds and banks*
   - *community use areas: most prevalent in urban areas, there are a large number of small Crown land blocks used as recreation reserves, public halls, local parkland or by government agencies such as the Department of Education for schools, that were not included in the mapping used here*
   - *service and utilities: as with community use areas, many Crown land blocks used by government departments have not been included (e.g. courts and police stations under the Department of Justice, or housing under the Department of Human Services); in this category there are also many blocks owned by public authorities – such as water authorities, VicRoads and VicTrack – that have not been included.*

   Much more reliable figures should be available in 2011 as a result of projects currently under way: the VEACRECS25 compilation of statewide 1:25,000 scale public land use mapping, DSE's PLM25 spatial layer using the VEAC data, and VEAC's Metropolitan Melbourne Investigation. In the meantime, the data in this table should be treated as indicative only.
3. *Counts are not given for categories in which they would be misleading – where many small blocks are missing (Services and Utilities, Community Use Areas, Uncategorised Public Land, Other) and where blocks are highly contiguous (State Forest, Stream Frontage and Stream Beds and Banks, Roads, Water and Sewerage Services, Private Land).*

3.3 Statistical analysis of GIS modelling

Native vegetation in Victoria is often considered in terms of the biogeographical region (bioregion) in which it occurs. Bioregions are a landscape-scale classification of the environment using a range of attributes such as climate, geomorphology, geology, soils and vegetation. There are 28 bioregions identified within Victoria (figure 3.2).

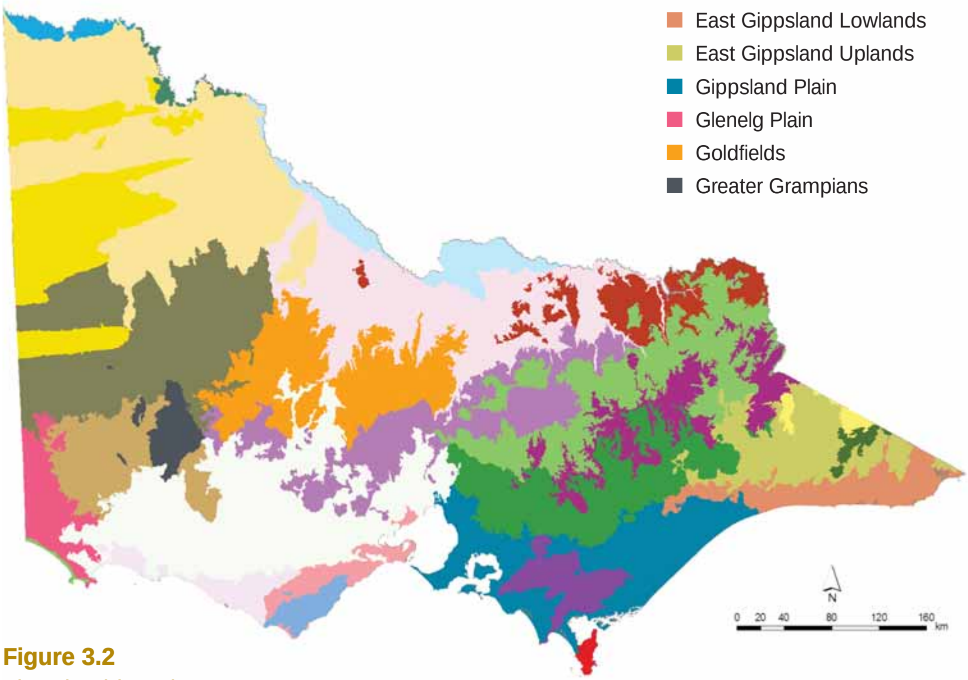


Figure 3.2
Victorian bioregions
Source: DSE 2010[4]

The site condition and landscape context modelling layers, native vegetation extent and the public land spatial layer prepared for the investigation by DSE were combined in GIS and analysed by each of the 28 Victorian bioregions (figure 3.3). The resolution of vegetation condition and landscape data are at 25 metres. The PLM25 layer was available in polygon format, and to allow the best possibility for capturing and maintaining data throughout the spatial analysis, the PLM25 was converted to a raster dataset with a 10 metre resolution for the whole state, and the other data were re-sampled to a coincident resolution prior to a spatial 'combine' process. Basic descriptive statistics were calculated (e.g. total hectares, relative proportion of the extent of native vegetation, means and medians). Each bioregion was assessed for the distribution of site condition and landscape context scores based on the modelled vegetation categories (table 3.3). The results are presented in sections 4 and 5.

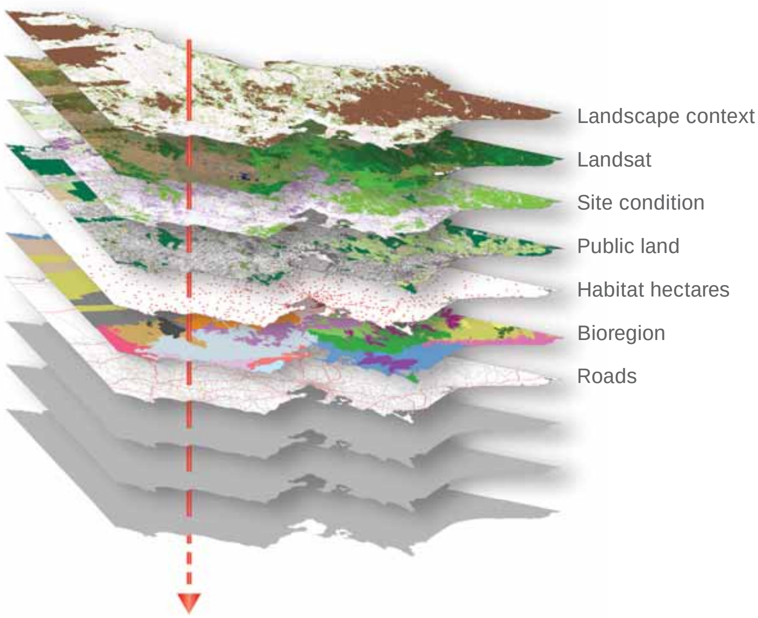


Figure 3.3
Diagrammatic scheme of the data layers used in GIS analysis

Each 25 m x 25 m pixel (represented by the red arrow) contains information on the attributes of each of the 58 input layers.

Table 3.3
Modelled vegetation categories contributing to the native vegetation extent used in the statistical analysis of remnant native vegetation

CATEGORY IN DATASET	CONTRIBUTING MODEL OUTPUTS	INCLUDED IN ASSESSMENT	ASSESSMENT CATEGORY
Wetland habitat	Wetland cover	Yes	Wetland habitat
Highly likely native vegetation – grassy	Highly likely native grassy cover	Yes	Grassy – highly likely
	Herbaceous wetland cover		Wetland habitat
Highly likely native vegetation – woody	Highly likely – dense native woody cover	Yes	Dense woody – likely
	Highly likely – less dense native woody cover		Less dense woody – likely
	Highly likely – sparse native woody cover		Sparse woody – likely
	Disturbed natural (sand dunes etc)		Dense woody – likely
	Woody cover fire scars		Dense woody – likely
	Woody wetland cover		Dense woody – likely
Highly likely native vegetation – structurally modified	Structurally modified – highly likely native woody cover	Yes	Structurally modified – woody
	Structurally modified – highly likely native grassy cover		Structurally modified – highly likely grassy
Possibly native vegetation	Likely native grassy cover	No	
	Structurally modified – likely native grassy cover		
Unlikely to support native vegetation	No native vegetation	No	
Exotic woody vegetation	Urban tree cover	No	
	Windbreak tree cover		
	Plantation tree cover		
Artificial impoundment	Artificial impoundment cover (man-made dams, reservoirs etc)	No	

Source: Native vegetation extent dataset. Information sheet No. 3 www.dse.vic.gov.au

3.4 Connectivity modelling

Understanding ecological processes that depend on connectivity requires quantifying how connectivity is shaped by landscape features. Tools that do this can aid managers in effective decision making for conservation. Utilising the powerful computer processing capacity now available, researchers are able to investigate theoretical aspects of animal movements, and predict and quantify connectivity across landscapes. Spatial modelling of connectivity is still in its infancy and remains to be empirically tested in real landscapes.

One approach to connectivity modelling is through the use of 'Circuitscape' software.[58] Concepts and algorithms from electrical circuit theory (resistance and conductivity) have been used to predict ecological connectivity in landscapes.[58] The underlying premise of Circuitscape modelling is that heterogeneity in the landscape (different vegetation types or topography) influences differences in movement probability by a given species along specific pathways. The electrical conductivity in Circuitscape is analogous to the probability of movement of plants or animals. Using this theory Circuitscapes can be used to suggest important areas for ecological connectivity in conservation planning.

Using site data of individual records for 13 vertebrate species from the Victorian Fauna and Flora Atlas,[59] together with data for a set of biophysical attributes, individual species distribution models were developed by the Arthur Rylah Institute for Environmental Research (see table 3.4). The distribution models were used as a basis for developing Circuitscape analyses for each species across regional landscapes. For the Circuitscape analyses several nodes, representing the origin or core populations, were selected within the limits of the species distribution model, and the probability of dispersal routes within the landscape (Circuitscape) were calculated using the full species distribution model as a resistance surface. Species were chosen to illustrate different extents of dispersal and movement capacities within landscapes and to cover a range of Victorian regions and habitats.

Table 3.4
Selected vertebrate species used for Circuitscape modelling

SPECIES AND CONSERVATION STATUS	HABITAT	DISTRIBUTION IN VICTORIA	DISPERSAL IN HOSTILE ENVIRONMENT
Mallee Emu-wren *Stipiturus mallee* (Ve) Mallee Ningaui *Ningaui yvonneae* (nt)	sandy mallee	northwest	reasonable
Striped Legless Lizard *Delma impar* (Ve) Fat-tailed Dunnart *Sminthopsis crassicaudata* (nt)	grasslands and grassy woodlands	north and west	poor
Heath Mouse *Pseudomys shortridgei* (Vnt) Southern Emu-wren *Stipiturus malachurus*	heathlands and heathy woodlands	southwest; south	poor
Lace Monitor *Varanus varius* (v) Brown Treecreeper *Climacteris picumnus* (nt) Yellow-footed Antechinus *Antechinus flavipes*	woodlands and dry forests	widespread	reasonable
Swamp Skink *Egernia coventryi* (v) Yellow-footed Antechinus *Antechinus flavipes*	riparian (*A. flavipes* riparian in NW only)	north; south	poor
Red-groined Toadlet *Paracrinia haswelli*	wetlands	southeast	reasonable/poor
Stubble Quail *Coturnix pectoralis*	grasslands (native and exotic)	widespread lowland	very good

E/e = *endangered*, V/v = *vulnerable*, nt = *near threatened; upper case applies to Australia, lower case to Victoria*

Circuitscapes for four species are presented in figures 3.4-3.7 below. Circuitscape analysis models the net probabilities of connectivity (i.e. level of connectivity as a probability) between habitat patches within a landscape on a pixel by pixel basis. Such models highlight critical points or connections between patches as well as those areas that are redundant such as cul-de-sacs.[58] Probabilities of connectivity are represented by the intensity of colour. The darker colour represents the higher probability of dispersal. Importantly these analyses do not provide information on whether dispersal may be over short (days or weeks) or much longer time frames (years to decades). Consequently these analyses require an understanding of the biology of the individual species.

Species that have good dispersal ability are generalist in terms of habitat requirements (e.g. common brushtail possum) and are able to move easily across landscapes regardless of landscape composition. In contrast species with moderate or poor dispersal capabilities will show fine-scale patterns of movement that relate to landscape features. The Circuitscape outputs show that a direct route is rarely the most probable passage taken by a given species between patches. Since this is an electrical circuit model, these are the sum of paths of least resistance between all nodes that are used in the analysis. In reality, dispersing animals explore their environment by responding to specific environmental cues that are non-uniformly distributed across the landscape. These cues relate to aspects of the environment that offer foraging opportunities, protection from predators, shelter and breeding sites resulting in differences in movement patterns. Different species have different habitat requirements and therefore will respond individually even within identical landscapes.

The brown treecreeper represents a species with reasonable ability, but has a requirement for woodland habitat. The Circuitscape map illustrates the non-linear routes of dispersal between patches (figure 3.4). The lace monitor is another species with reasonable dispersal ability (figure 3.5). The Circuitscape model illustrates the probability of dispersal routes across much of eastern and central Victoria. Routes of low dispersal probability relate to the upper alpine slopes and plateaux and flat grassy plains of western Victoria that are marginal habitat for this species.

Species that are either poor dispersers (e.g. striped legless lizard) or have specialist habitat requirements are unable, or unwilling, to move in the absence of suitable habitat and tend to remain in more restricted areas (the mallee ningaui, figure 3.6). Many of these species are vulnerable to predation and typically require dense understorey vegetation for survival. Movement patterns by such species are likely to follow specific vegetation types that may be poorly represented in the landscape. For example, the heath mouse is a small native rodent found in south west Victoria. It occupies dry heath and open woodland with a heathy understorey between the lower Glenelg River and the Grampians National Park. The Circuitscape model for the heath mouse illustrates the relative probabilities of routes for the species between the Grampians and the lower Glenelg River. A route directly between the Grampians and the southwest has relatively low probability (figure 3.7).

Circuitscape models are only one of many potential methods for examining connectivity across landscapes. As models, they are not “correct”. Nevertheless they are useful for examining and discussing the principles of what connectivity may mean across landscapes at various spatial scales.

Brown treecreeper
Climacteris picumnus

The brown treecreeper is widely distributed across open woodlands and forests of eastern Australia. Decline in abundance because of habitat clearance has been reported across most of its range. The species has disappeared from fragments smaller than 300 ha in size where disruption to female dispersal and habitat degradation are thought to be factors in its decline. Although the species has reasonable dispersal ability, its requirement for woodland habitat restricts dispersal routes to areas with woody vegetation.

Predicted probability of dispersal
Low ▢ ▢ ▢ ▢ ▢ ▢ ▢ ▢ ▢ High

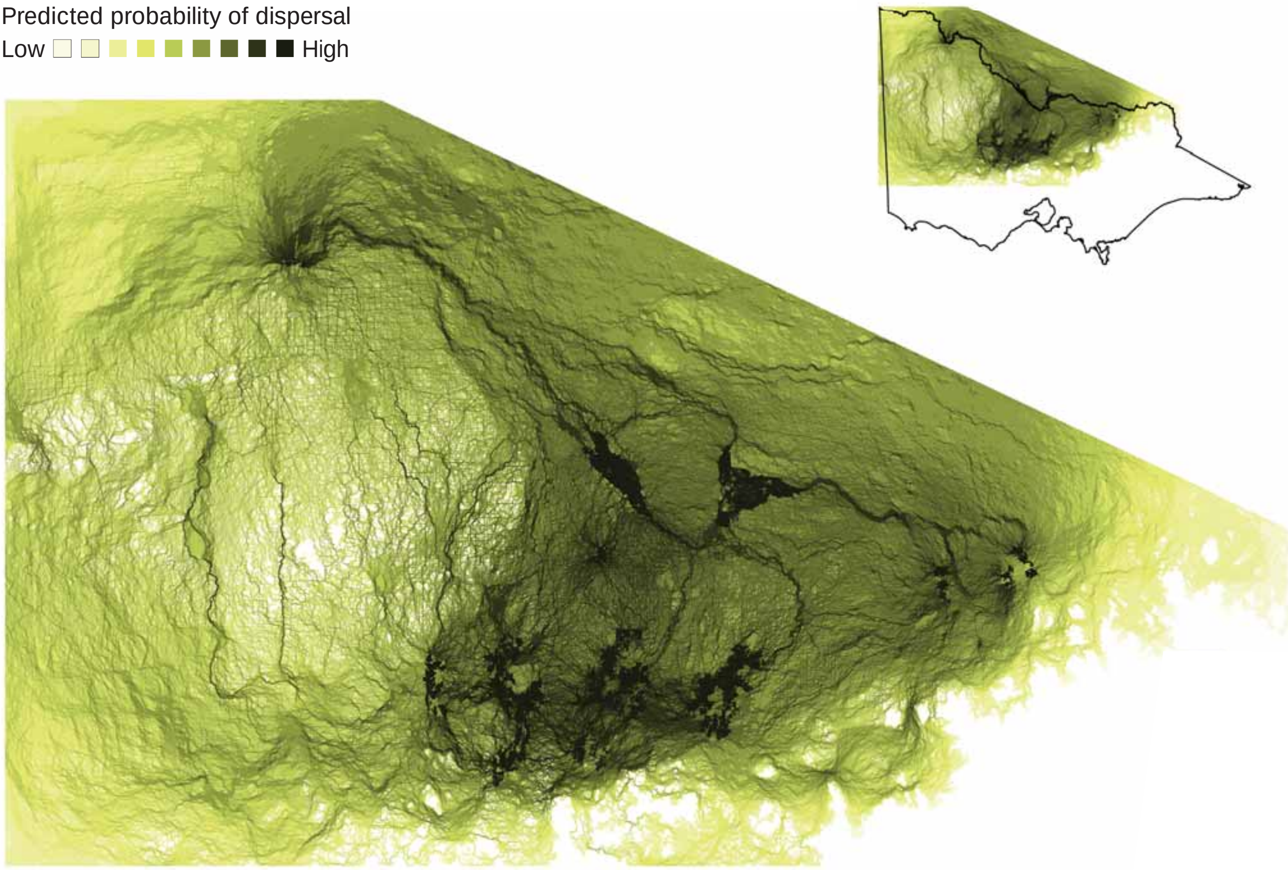


Figure 3.4
Circuitscape for brown treecreeper

Circuitscape depicts net probabilities of connectivity between designated nodes (habitat patches) within the landscape.

Lace monitor
Varanus varius

Lace monitor is Victoria's largest lizard. It inhabits dry sclerophyll woodlands of eastern Australia from Cape York to South Australia. Routes of low dispersal probability relate to the upper alpine slopes and plateaux and flat grassy plains of western Victoria.

Predicted probability of dispersal
Low ▢ ▢ ▢ ▢ ▢ ▢ ▢ ▢ ▢ High

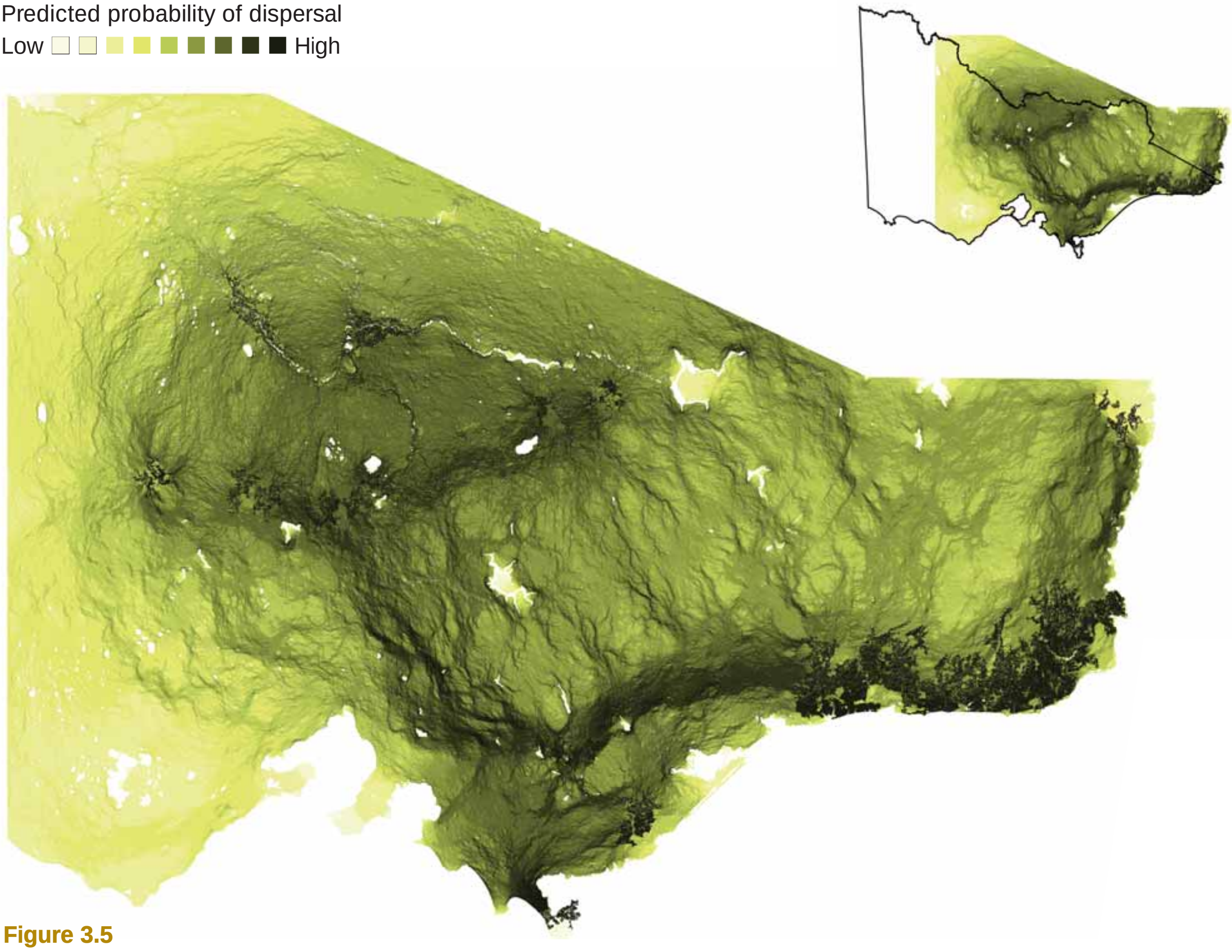


Figure 3.5
Circuitscape for lace monitor

Circuitscape depicts net probabilities of connectivity between designated nodes (habitat patches) within the landscape.

Mallee ningaui

Ningaui yvonneae

The mallee ningaui is a tiny insectivorous marsupial that inhabits the *Triodia*-mallee and mallee heathlands of the semi-arid zone of northwest Victoria including the Murray-Sunset and Wyperfeld National Parks. These nocturnal marsupials are associated with dense spinifex (*Triodia scariosa*) which they depend on for shelter and foraging. The ningaui shows moderate dispersal ability across the landscape.

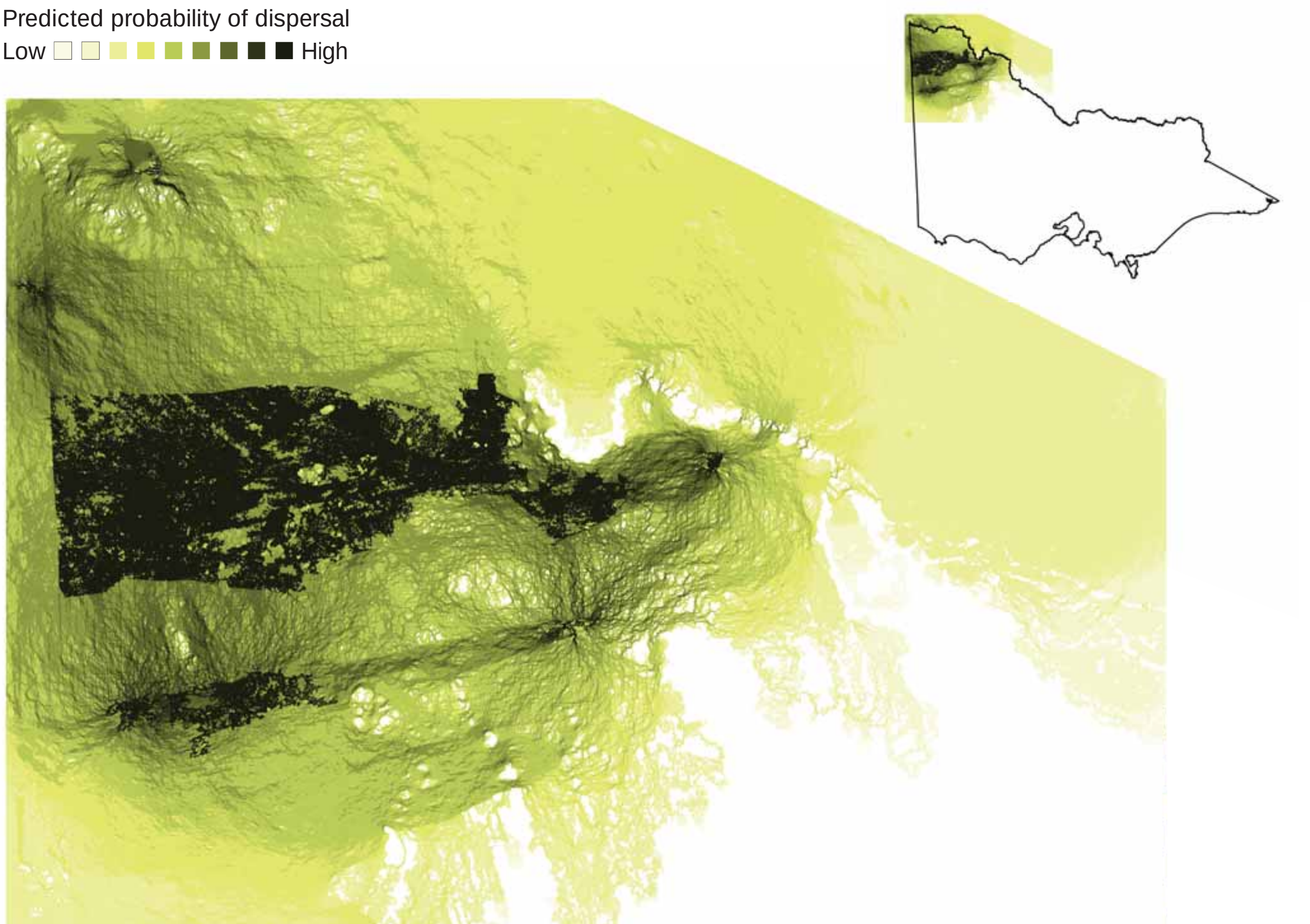


Figure 3.6
Circuitscape for mallee ningaui

Circuitscape depicts net probabilities of connectivity between designated nodes (habitat patches) within the landscape.

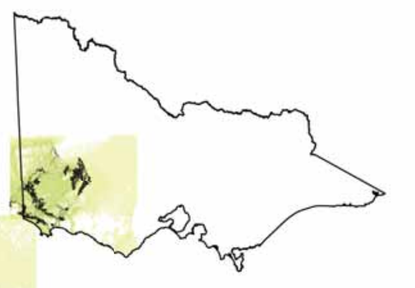
Heath mouse

Pseudomys shortridgei

The heath mouse is a native rodent endemic to the heathlands of western Victoria, southwest South Australia and southwest Western Australia. Locally the species distribution is influenced by the fire age of heaths preferring recently burnt areas. Populations disappear as local patches of heath mature and unless more suitable habitat is available nearby, more widespread extinction occurs. The heath mouse shows low probability of dispersal across the landscape.

Predicted probability of dispersal

Low ■ ■ ■ ■ ■ ■ ■ ■ ■ High



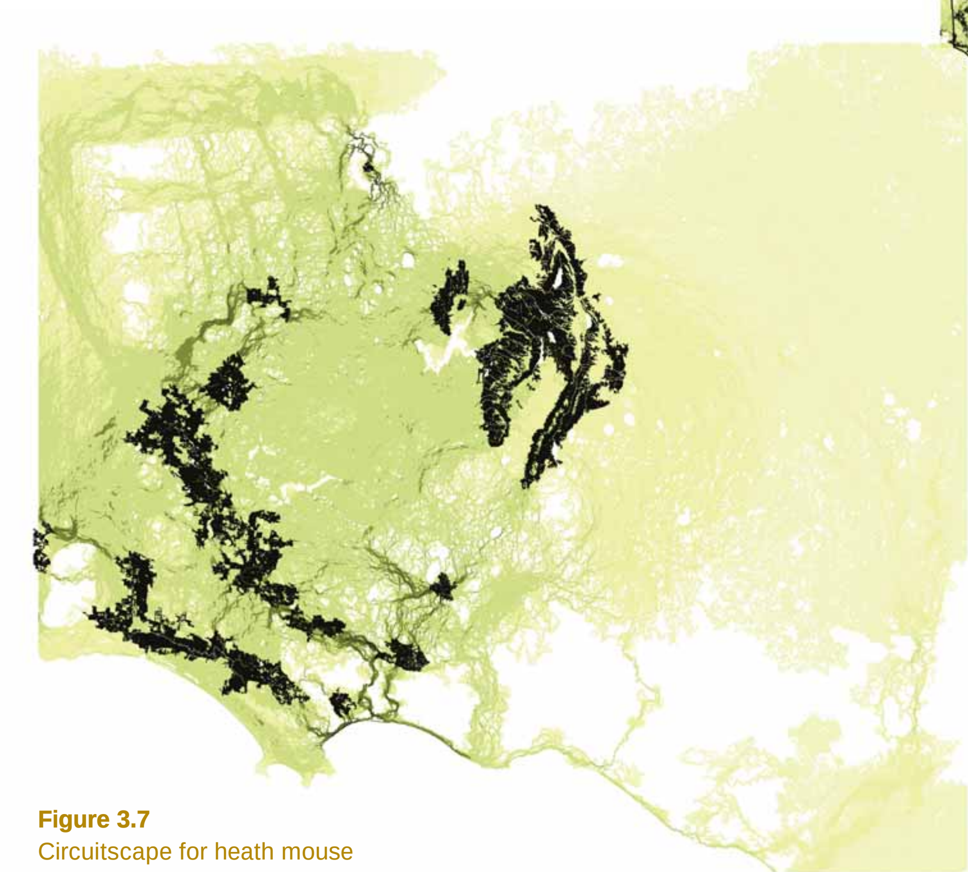


Figure 3.7

Circuitscape for heath mouse

Circuitscape depicts net probabilities of connectivity between designated nodes (habitat patches) within the landscape.

4

CHARACTERISATION OF VICTORIA'S REMNANT NATIVE VEGETATION

4.1 Statewide overview

Victoria has the lowest proportion of its original extent of native vegetation remaining of any Australian state or territory. Across much of Victoria the extent, condition and configuration of remnant native vegetation is the primary determinant of ecological health. The thrust of this discussion paper is on characterising the different landscapes of Victoria in terms of these parameters, and proposing the different actions that might be taken to improve their ecological connectivity. This characterisation of landscapes is based on Victoria's bioregions, which are relatively discrete, biophysically homogenous units. Statistics covering broader, heterogeneous areas are less useful and can be misleading. Nonetheless, it is useful to briefly examine some statewide statistics to provide context for the subsequent bioregional characterisation of landscapes. These statistics, shown in Table 4.1, reveal the following key points.

- The current extent of native vegetation in Victoria amounts to 46.2% of the original extent of native vegetation. As explained in section 3.1.1 this figure is higher than previous assessments as a result of new mapping and delineation of native vegetation extent and not because of any significant increase in the actual extent of native vegetation or improvement in the state of the biota. Typically, the newly recognised existing native vegetation is in much poorer condition than that previously recognised, highlighting some disparity in views about what is and is not 'native vegetation' when site condition is poor.
- Fragmented landscapes – the focus of this investigation – make up nearly 78.6% of Victoria but account for only 53.7% of the current extent of native vegetation.
- Across fragmented landscapes, remnant native vegetation is divided almost precisely in half (49.8% and 50.2%) between public and private land.
- Half (50.1%) of the original extent of native vegetation in largely-intact landscapes is in conservation reserves compared to 5.9% in conservation reserves in fragmented landscapes.
- Site condition and landscape context across bioregions are best summarised as median scores. These median scores are most useful as comparisons between bioregions, rather than being used as absolute measures. The statewide medians for fragmented landscapes (36.8 for site condition and 14.9 for landscape context) are of most use as reference points against which to compare individual bioregions – as in sections 4.2 and 5, below. Otherwise the statewide medians in table 4.1 confirm the expectation that largely-intact landscapes generally have better site condition and, by definition, landscape context, than fragmented landscapes.

The remainder of this section compares the fragmented landscapes in Victoria's bioregions in terms of the key parameters for native vegetation. The focus on fragmented landscapes is in accordance with the terms of reference for the investigation (see section 1.3).

Table 4.1
Statewide summary of native vegetation extent, tenure, condition and landscape context within and outside largely-intact landscapes and overall

Fragmented = outside largely-intact landscapes

	LANDSCAPE TYPE		
	Fragmented	**Largely-intact**	**All**
Total area – with and without native vegetation (ha)	17,832,299 (78.6% of Victoria)	4,866,321 (21.4% of Victoria)	22,698,620 (total area of Victoria)
Current extent of native vegetation (ha)	5,626,379 (31.6% of original extent; 53.7% of total current native vegetation)	4,853,970 (99.8% of original extent; 46.3% of total current native vegetation)	10,480,349 (46.2% of original extent)
Area of native vegetation in conservation reserves (ha)	1,057,904 (5.9% of original extent)	2,438,099 (50.1% of original extent)	3,496,003 (15.4% of original extent)
Area of native vegetation on public land (ha)	2,799,460 (49.8% of current extent)	4,779,231 (98.5% of current extent)	7,578,690 (72.3% of current extent)
Area of native vegetation on private land (ha)	2,826,919 (50.2% of current extent)	74,739 (1.5% of current extent)	2,901,659 (27.7% of current extent)
Median site condition score (out of 80)	36.8	50.7	46.6
Median landscape context score (out of 20)	14.9	18.9	17.0

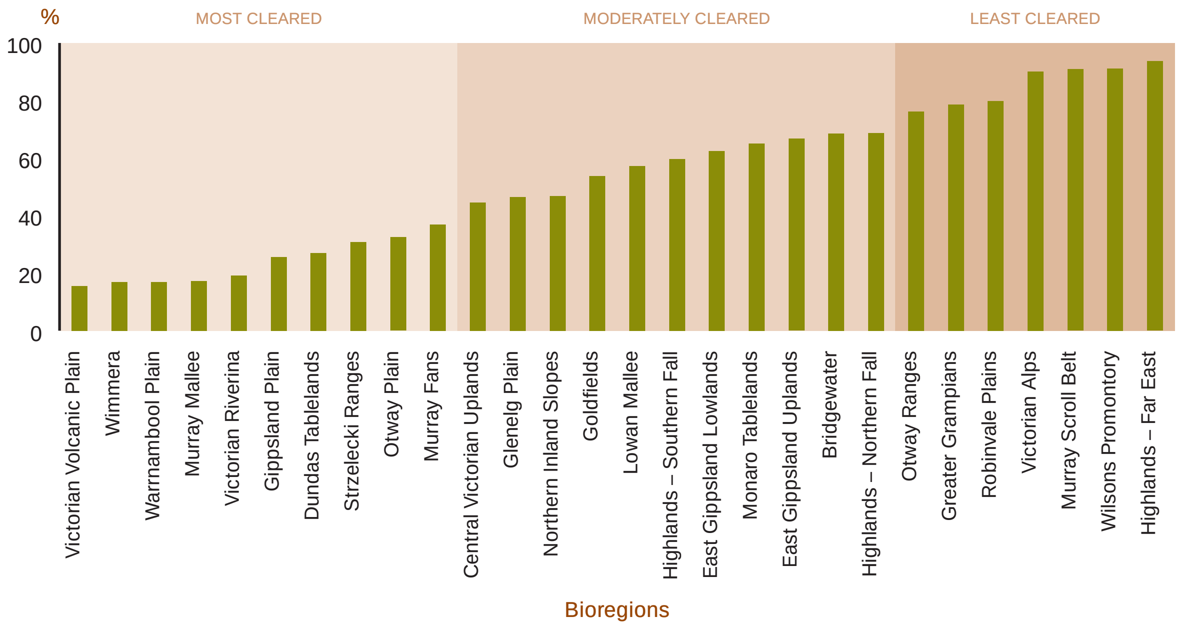
4.2 Comparison of bioregions

4.2.1 EXTENT OF REMNANT NATIVE VEGETATION

The main determinant of both ecosystem health and ecological connectivity of a landscape is the extent of remnant native vegetation. Graph 1 shows that the proportion of native vegetation remaining in the fragmented parts of Victoria's bioregions varies greatly – from less than 16% of the Victorian Volcanic Plain, to more than 93% in the Highlands – Far East. In fragmented landscapes overall, 31.6% of the state's original extent of native vegetation remains. This graph provides the basis for sorting the bioregions into the following three main groups: most cleared, moderately cleared, and least cleared bioregions.

Graph 1
Proportion of native vegetation in fragmented landscapes in each bioregion

Notes:
1. See appendix 3 for a comparative tabulation of bioregion statistics.
2. Particularly in more extensively cleared bioregions, the amount of remnant native vegetation reported here is higher than previous estimates - see section 3.1.1 for a full explanation of this change.



Most cleared bioregions

With the exception of the Strzelecki Ranges (which has an unusual land-use history, as described on page 77), the ten most cleared bioregions all have relatively flat terrain and fertile soils, and less than 40% of their original extent of native vegetation remaining. As a result, habitat loss and isolation of remnants are almost certainly the major cause of biodiversity loss in these landscapes. These bioregions are of highest relevance for the Remnant Native Vegetation Investigation:

- Victorian Volcanic Plain
- Wimmera
- Warrnambool Plain
- Murray Mallee
- Victorian Riverina
- Gippsland Plain
- Dundas Tablelands
- Strzelecki Ranges
- Otway Plain
- Murray Fans

Graph 2 shows that all these bioregions have proportionately few or no adjoining largely-intact landscapes. In addition, several of these bioregions are among the largest in Victoria – collectively the Murray Mallee, Victorian Volcanic Plain, Wimmera and Victorian Riverina account for half of the statewide area of fragmented landscapes.

Moderately cleared bioregions

Bioregions with 40-70% remnant native vegetation in their fragmented landscapes are characteristically foothills or less fertile flatter country. Although not as fragmented as the preceding bioregions, these moderately cleared bioregions are still a major focus for the Remnant Native Vegetation Investigation:

- Central Victorian Uplands*
- Glenelg Plain
- Northern Inland Slopes*
- Goldfields*
- Lowan Mallee
- Highlands – Southern Fall
- East Gippsland Lowlands
- Monaro Tablelands
- East Gippsland Uplands
- Bridgewater
- Highlands – Northern Fall

As shown in Graph 2, the bioregions in this group are generally in the middle range of sizes spanned by Victorian bioregions. Four bioregions – Lowan Mallee, East Gippsland Lowlands, East Gippsland Uplands and Highlands – Northern Fall – have extensive adjoining largely-intact landscapes which ameliorate some of the effects of fragmentation in their fragmented landscapes. See comments in section 4.2.2 below about the extent of remaining native vegetation in the three asterisked (*) bioregions.

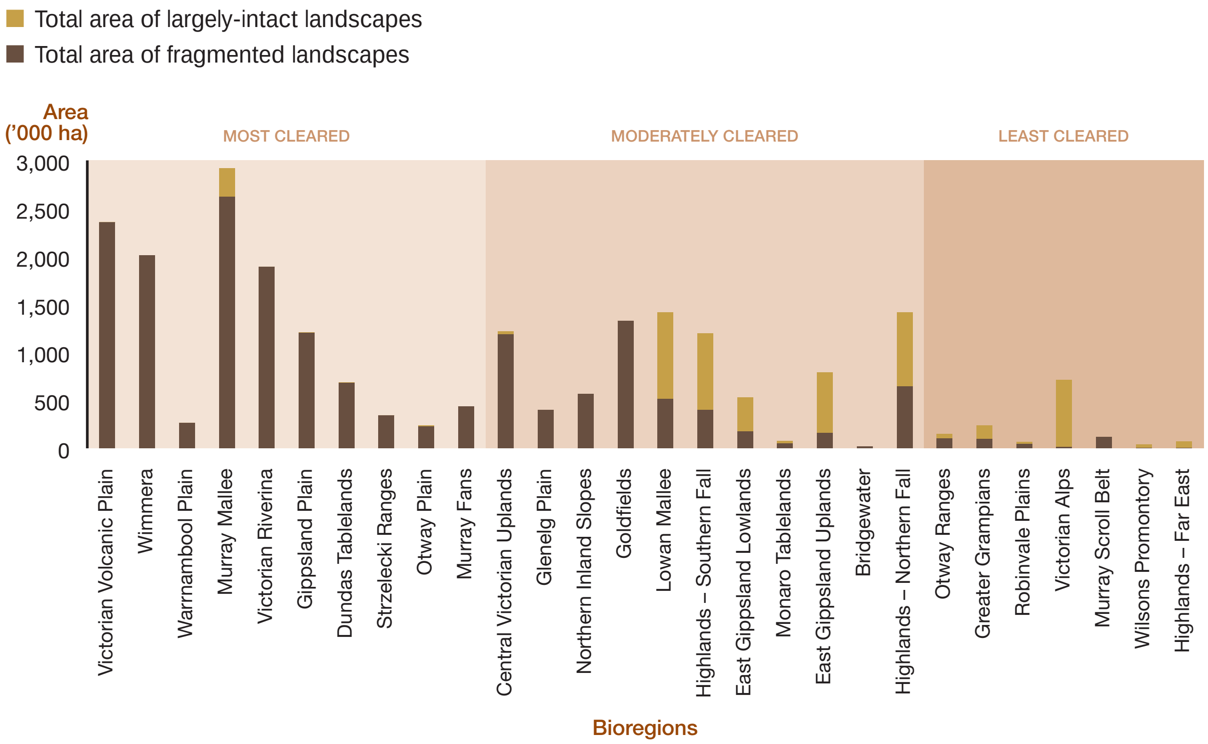
Least cleared bioregions

Even in their fragmented landscapes, the remaining seven bioregions have large extents of their original extent of native vegetation remaining – between 76% and 94%. While there may be particular characteristics (such as vegetation condition) or smaller more fragmented localities which are relevant to the Remnant Native Vegetation Investigation, generally these bioregions are not the focus of the investigation:

- Otway Ranges
- Greater Grampians
- Robinvale Plains
- Victorian Alps
- Murray Scroll Belt
- Wilsons Promontory
- Highlands – Far East

The bioregions in this group are generally small, even allowing for the proportionately extensive largely-intact landscapes in most of them (Graph 2).

Graph 2
More cleared bioregions tend to be larger



4.2.2 NEW EXTENT MAPPING

As mentioned above, the mapped extent of existing native vegetation used for this analysis is greater than previous estimates. This difference is explained in detail in DSE (2008)[2] but is essentially because of improvements in the detection of native vegetation with relatively little tree cover – such as grasslands and grassy woodlands of poorer site condition. VEAC's analysis enables site condition to be compared to native vegetation extent (see Graph 1 on the interactive web page at www.veac.vic.gov.au) and this reveals considerable variation in the proportion of poor condition native vegetation across bioregions. Notably the bioregions with a high proportion of vegetation in poor condition – e.g. Goldfields, Northern Inland Slopes, Central Victorian Uplands, Victorian Volcanic Plain and Victorian Riverina – include those mentioned by stakeholders as having surprisingly higher new extent figures. For example, the proportion of the original extent of native vegetation now remaining in the Goldfields bioregion decreases from 54% overall to 32% when poorer condition vegetation is excluded. The latter figure is comparable with earlier estimates of around 25% native vegetation remaining in this area (e.g. ECC 1997).[60]

It is important to understand that the new extent figures do not indicate any increase in the actual extent of native vegetation and that, whatever the exact extent of native vegetation remaining, very significant declines in biodiversity are occurring in these landscapes – such as the 'collapse' of bird populations in and adjoining the Goldfields.[61]

4.2.3 LAND TENURE

The tenure of the land on which remnant native vegetation occurs is an important consideration in planning for its future. Graph 3 shows the proportion of native vegetation remaining in the fragmented landscapes of each bioregion in public land conservation reserves, on other public land and on private land. In the most and moderately cleared bioregions, the proportion of native vegetation on public land varies from 20% in the Victorian Riverina – where much grassy native vegetation remains on private land in places such as the Patho Plains – to 76% in the Lowan Mallee and 80% in the small Bridgewater bioregion. Generally, the proportion of native vegetation on public land increases as the proportion of native vegetation remaining increases although there are many exceptions to this rule. Overall, though, more than half of the remnant native vegetation in the most cleared bioregions is on private land.

4.2.4 CONSERVATION RESERVES

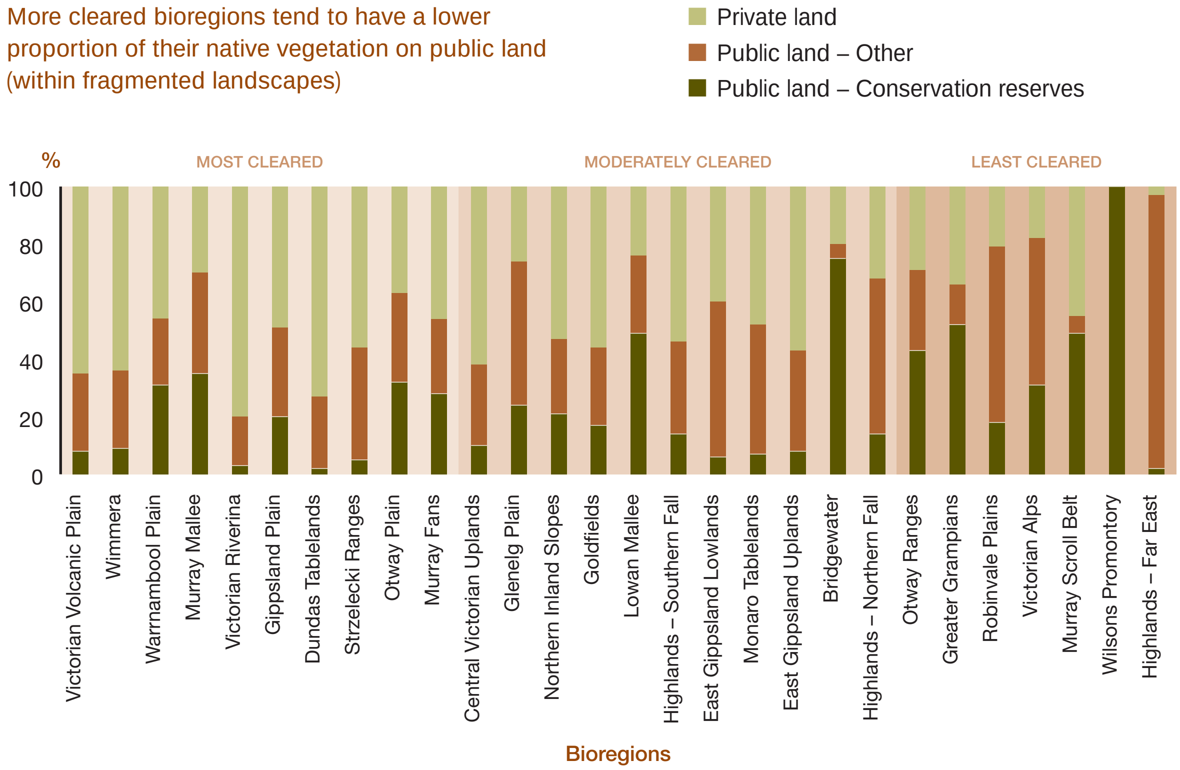
Looking at the most and moderately cleared bioregions again, Graph 3 also shows that the proportion of remnant native vegetation in formal conservation reserves varies from 2% on the Dundas Tablelands to 49% in the Lowan Mallee and 75% in the small Bridgewater bioregion. The proportion of native vegetation in conservation reserves in moderately cleared bioregions overall (18%) is only a little higher than that in the most cleared bioregions (16%), whereas that in least cleared bioregions is substantially higher (44%).

These percentages describe native vegetation in conservation reserves as a proportion of the current extent of native vegetation. Often, the extent of conservation reserves is also compared to the *original* extent of native vegetation – for example, when describing targets in Regional Forest Agreements and in the development of the National Reserve System.[62] Using the latter comparison, Graph 2 on the interactive web page at www.veac.vic.gov.au reveals low reserve system representation in the fragmented landscapes of moderately cleared bioregions (10% overall) and especially in the most cleared bioregions (3% overall) compared to the least cleared bioregions (37%). As would be expected, largely-intact landscapes are always better represented in formal conservation reserves than fragmented landscapes in the same bioregion – representation in fragmented landscapes overall is 6% compared to 15.4% for the state as a whole.

These bioregion-wide summary statistics are indicative only. The National Reserve System criteria pertain to 'ecosystems', of which there will be more than 100 in most bioregions. Often loss of vegetation and reserve system extent vary greatly between ecosystems in a bioregion, with ecosystems on flat fertile country typically being more cleared and less well represented in conservation reserves. As a result, except for bioregions with very low overall representation figures, the summary statistics may mask some very poorly represented ecosystems, and identifying specific priorities for potential new reserves requires more detailed scrutiny.

Bioregions with the lowest levels of reserve system representation (less than 5% of original extent) are Victorian Riverina and Dundas Tablelands (both 0.6%), Victorian Volcanic Plain (1.3%) and Wimmera and Strzelecki Ranges (both 1.5%). With such low levels of overall representation, nearly all the component ecosystems in these bioregions will be priorities to address under *Australia's Strategy for the National Reserve System.*[62]

Graph 3
More cleared bioregions tend to have a lower proportion of their native vegetation on public land (within fragmented landscapes)



4.2.5 VEGETATION ON ROAD RESERVES

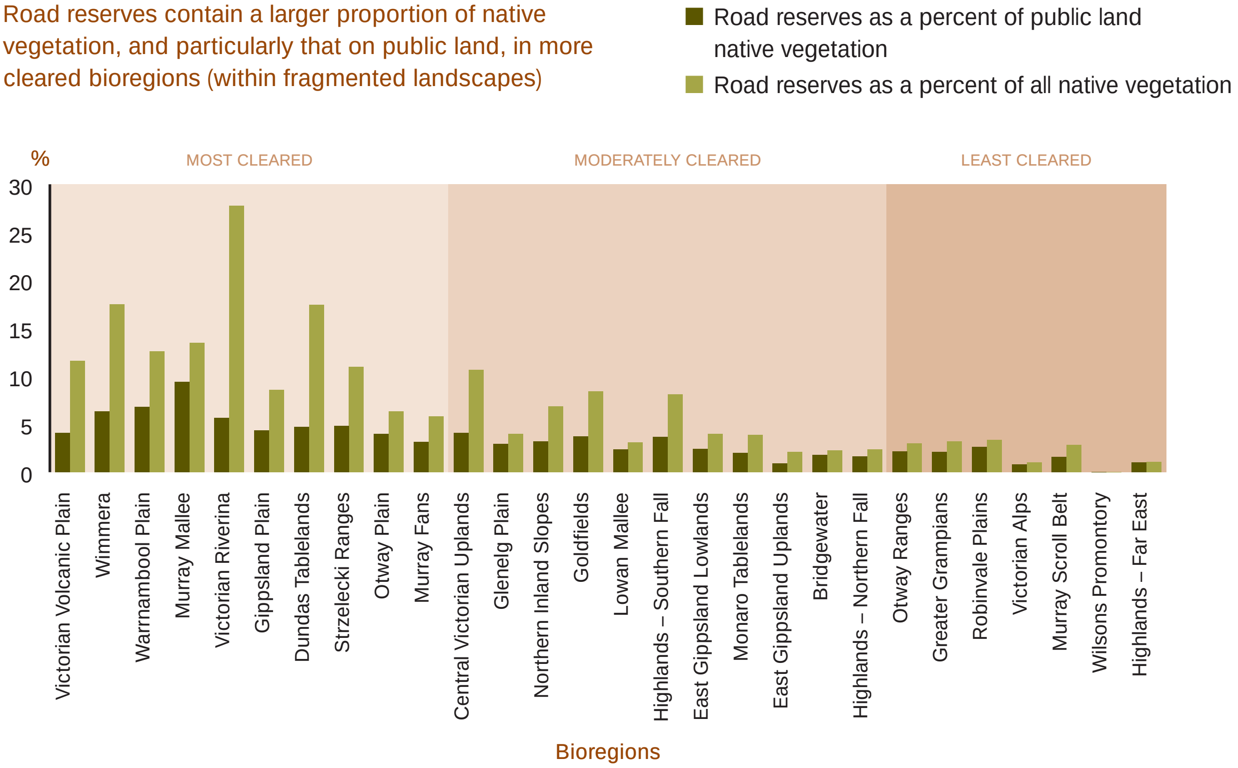
At several regional workshops held by VEAC in November and December 2009, the importance of vegetation on roadsides was raised and participants were keen to have statistics on its extent. The improved modelling of native vegetation extent together with the public land use spatial layer compiled by VEAC and DSE for this investigation enables these statistics to be presented here for the first time, notwithstanding the caveats described in section 3.2. According to the public land spatial layer, the total area of road reserves in Victoria is in the order of 570,000 hectares (555,000 hectares in fragmented landscapes), of which about 122,000 hectares are unused roads (all but about 300 hectares in fragmented landscapes, with some 85,000 hectares licensed). Unused roads are where no public road has been made within the road reserve and over which a nearby landholder often has a licence. There are around 24,000 such licences statewide, all but about 100 of which are in fragmented landscapes. Some 245,000 hectares of road reserves (used and unused) support native vegetation – 235,000 hectares of it in fragmented landscapes.

Graph 4 shows the proportion contributed by roadsides to total and public land remnant native vegetation for each bioregion. Notwithstanding a few exceptions, both proportions are strongly correlated with the level of vegetation loss; that is, the importance of vegetation along roads in bioregions increases with decreasing extent of remnant native vegetation.

In four bioregions road reserves account for more than 5% of total remnant native vegetation in fragmented landscapes – Murray Mallee (9.4%), Warrnambool Plain (6.8%), Wimmera (6.3%) and Victorian Riverina (5.7%). The high Murray Mallee figure is particularly interesting given the relatively large tracts of native vegetation in this bioregion fringing the Sunset Country, including much outside largely-intact landscapes (see map A, back pocket). That is, roadside vegetation is even more important in most of this bioregion than the high figure suggests. Three bioregions have more than 15% of their fragmented public land native vegetation on roadsides – Victorian Riverina (27.8%), Wimmera (17.5%) and Dundas Tablelands (17.4%). All these bioregions are in the most cleared group. As with several other measures, the figures for roadside native vegetation in the Central Victorian Uplands, Northern Inland Slopes and Goldfields bioregions are as comparable to those in the most cleared group as much as to their own moderately cleared group.

Graph 4

Road reserves contain a larger proportion of native vegetation, and particularly that on public land, in more cleared bioregions (within fragmented landscapes)



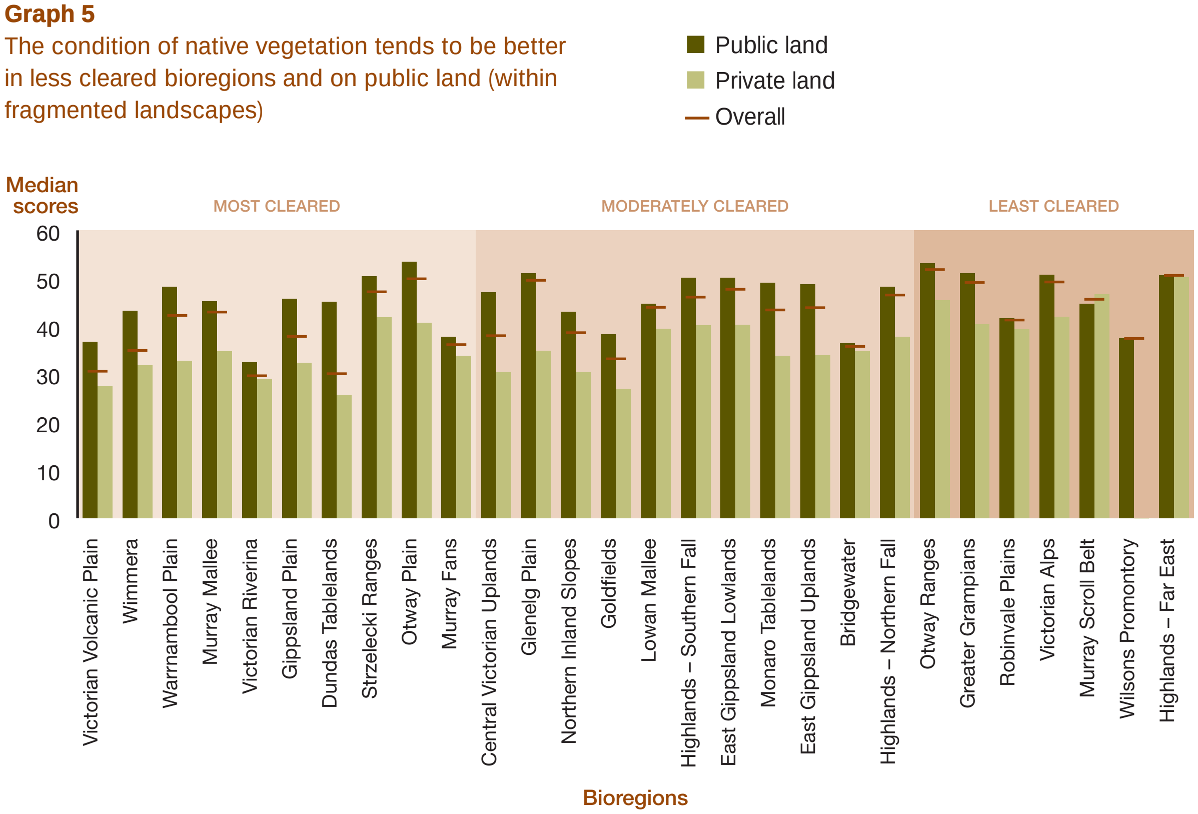
4.2.6 SITE CONDITION

The quality of remnant native vegetation varies widely in different parts of Victoria and is a key factor in its management and its value for conservation of plants and animals. Graph 5 shows the median total site condition score (i.e. all component scores combined) for public land, private land and overall for each bioregion. The derivation of site condition scores is explained in Section 3.1.2. Compared to other parameters, patterns in the variation of site condition between the bioregion groups are less obvious, with many bioregions having idiosyncrasies that distinguish them from others in their group. For example, the bioregions with the lowest overall site condition scores are in the most cleared group (such as the Victorian Riverina, Dundas Tablelands and Victorian Volcanic Plain), but several other bioregions in that group have high overall scores (notably the Otway Plain, which has the third highest overall median of all bioregions, and the Strzelecki Ranges). Presumably the generally dense understorey vegetation in remnant patches of the latter two examples has provided some resistance to degrading activities, such as stock grazing and firewood collecting, which are likely to be much more prevalent in patches with open grassy understorey vegetation such as that in the former three bioregions. Similarly, in the Goldfields bioregion, where soil disturbance from the gold rushes and subsequent mining has been pervasive, site condition is noticeably poorer than others in the moderately cleared group. This is also the case in the Central Victorian Uplands and Northern Inland Slopes – the two other bioregions with significant mining history. Generally, though, site condition improves with increasing percent of original vegetation extent remaining.

A common pattern across the bioregions, but decreasing as the percent of original native vegetation extent remaining increases, is for public land to support vegetation of higher overall site condition than private land. The disparity between public land and private land site condition is most pronounced in the Dundas Tablelands and Central Victorian Uplands. Idiosyncrasies of individual bioregions are explored in the narratives in Section 5.

The only bioregion where private land generally supports better quality vegetation than public land is the Murray Scroll Belt. This bioregion originates from thousands of years of widespread overbank flooding of the Murray River downstream of Mildura. The most flood-prone parts of the bioregion have generally remained in public ownership. In the 10 years prior to 2005 (when site condition was assessed), these public lands were (and continue to be) more severely impacted by the absence of overbank flooding than the naturally less flood-prone areas that are mostly now private land. Other bioregions with extensive

Graph 5
The condition of native vegetation tends to be better in less cleared bioregions and on public land (within fragmented landscapes)



riverine floodplains – Murray Fans and Robinvale Plains – also have relatively little difference in the condition of private and public native vegetation.

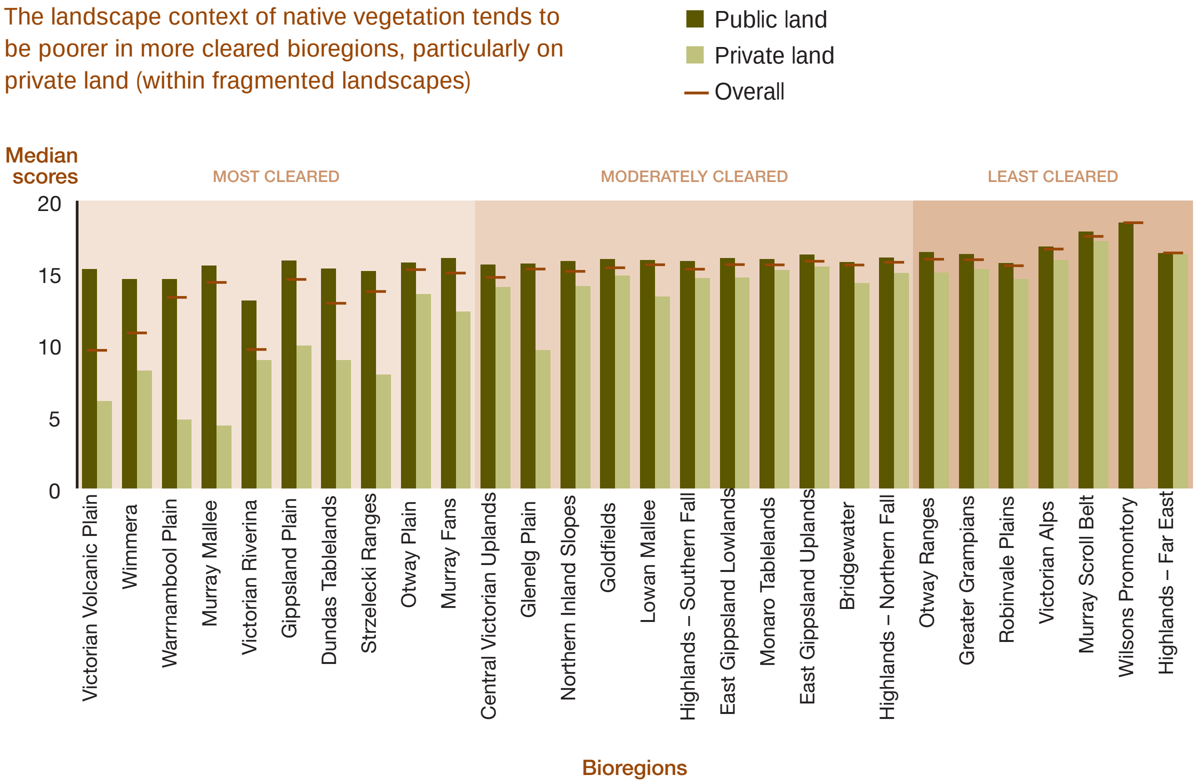
4.2.7 LANDSCAPE CONTEXT

Notwithstanding some exceptions, there is a clear trend for overall landscape context scores to increase with increasing percent of original vegetation extent remaining in the bioregions (Graph 6; see Section 3.1.4 for an explanation of the basis of these data). This is not surprising, of course – with more native vegetation in the landscape, it is inevitable that the scores for landscape context components (such as patch size, distance to core area, extent of nearby native vegetation) would generally increase. That said, there is a striking disparity in the landscape context scores of public land and private land remnants in the most cleared bioregions, and particularly in the four most cleared bioregions. This is mostly because a high proportion of public land native vegetation in these bioregions is in a small number of relatively large remnants: in the extreme northwest of the Murray Mallee, the saline lakes and extreme southwest of the Victorian Volcanic Plain; fringing the Otways in the Warrnambool Plain; and south of the Little Desert in the Wimmera. Other parts of these bioregions (covering very large areas of the Victorian Volcanic Plain, Wimmera and Murray Mallee) and several others will have very poor landscape connectivity, and are likely to require quite different emphasis in both analysis and action to that of their better connected landscapes.

As was pointed out by stakeholders at regional workshops, this divergence is even more pronounced when the better connected areas are wetlands – such as those in the Lake Corangamite area in the Victorian Volcanic Plain. These habitats differ not only in their landscape context scores but are also typically very different ecologically to adjacent terrestrial habitats – to such an extent, in fact, that they may be barriers rather than connections for many elements of the biota. For example, many non-flying animals and small birds may be more likely to move through exotic pastures or crops – mapped as having very poor landscape connectivity – than across extensive water bodies. In such instances, there is reason for specific consideration and perhaps more refined analysis. The circuitscape approach shown in Section 3.4 is an example of the sort of species-specific further analysis that can be carried out.

Graph 6

The landscape context of native vegetation tends to be poorer in more cleared bioregions, particularly on private land (within fragmented landscapes)



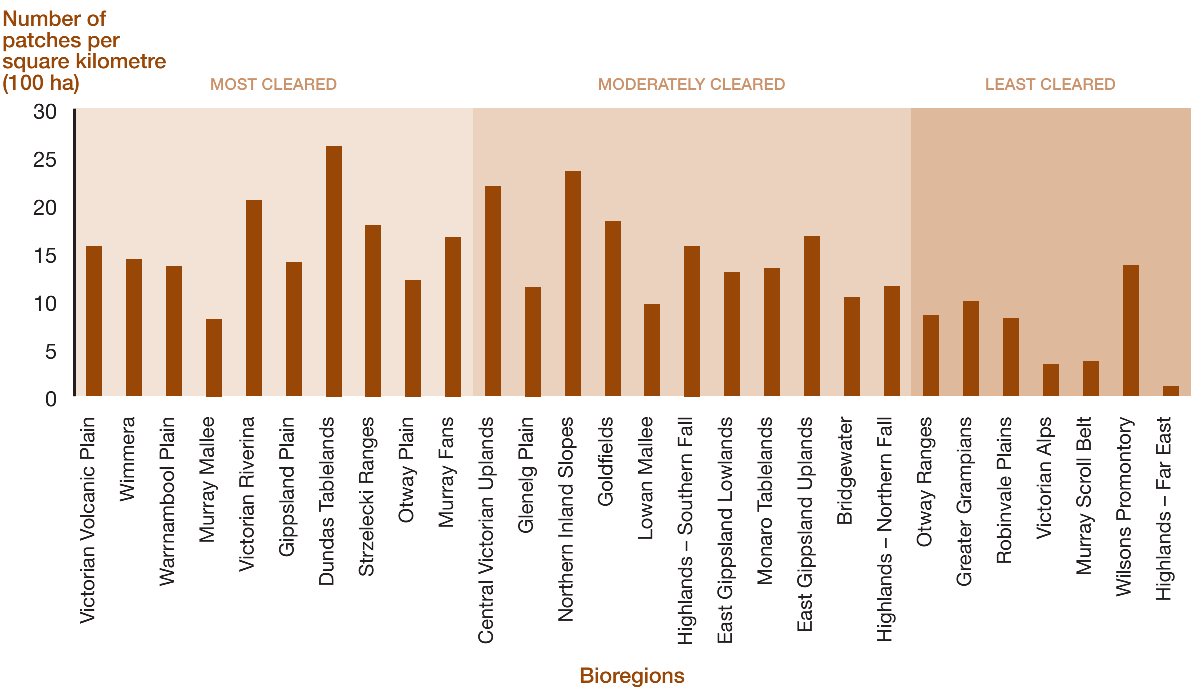
4.2.8 NUMBERS OF PATCHES

The number of patches in a landscape is highly dependent on the rules used to delineate patches. Patch analysis depends on first establishing rules about, for example, the minimum distance without native vegetation required to recognise two separate patches, or how long and narrow the connection between two parts of a single patch can be before the two parts are recognised as two separate patches. A small change to these rules can lead to very large changes in the area or number of patches in different size classes within a landscape. The results of such analyses are therefore only indicative as absolute measures, and are most useful relative to the results of identical analyses for other bioregions.

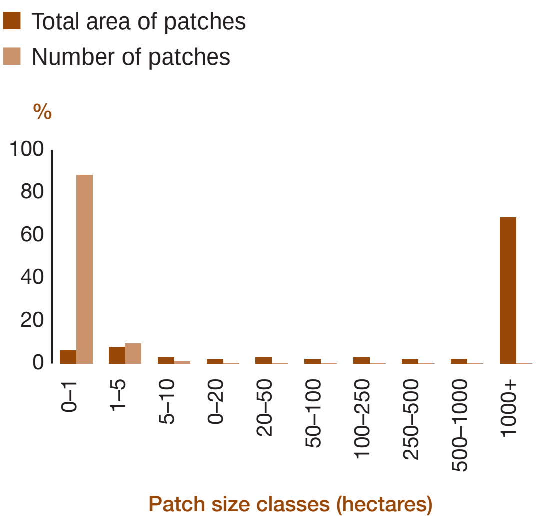
Using the rules applied by DSE to delineate patches for its analysis of landscape context, there are some 2.72 million patches of native vegetation in Victoria. The absolute number of patches in each bioregion varies greatly according to bioregion size so Graph 7 shows the density of patches (the average number of patches per square kilometre) in the fragmented landscapes of each bioregion. This graph reveals a pattern of relatively few patches in the highly cleared landscapes, more patches in remaining most cleared and moderately cleared landscapes and very few in the least cleared landscapes. In the last group, so much native vegetation remains in the landscape that it is mostly connected in a small number of patches – in some cases just a single large area. In the second group, moderate levels of clearing have separated the remaining native vegetation into a large number of patches. In the highly cleared landscapes, the scarcity of remnant native vegetation is so extreme that even very small patches have been lost on a large scale.

Graph 8 shows the statewide proportions of the total number and area of patches in 10 patch size classes. These distributions are highly skewed with 88% of patches statewide being less than a hectare in size but 68% of the total area of native vegetation in patches greater than 1,000 hectares in size. The extreme skewness of these distributions makes it difficult to portray variation between bioregions in a simple fashion but relevant data are provided on the interactive web page of the VEAC website – www.veac.vic.gov.au.

Graph 7
In fragmented landscapes, the density of patches tends to decrease with increasing extent of native vegetation remaining



Graph 8
Most patches are very small but, by total area, remnant native vegetation is mostly in very large patches (fragmented landscapes, all bioregions combined)



4.2.9 MORE COMPLEX AND DETAILED ANALYSES

The information presented to this point has been the product of considerable summarising of the large and complex datasets on which it is based. With 29 land tenure categories, five landscape context components, seven site condition components and a variety of other variables, there are very many possible combinations of factors to analyse. The examples in on the interactive web page at www.veac.vic.gov.au are intended to provide some insight into the sorts of analyses that are possible, as well as being of interest in their own right.

4.2.10 SUMMARY CHARACTERISATION OF VICTORIA'S BIOREGIONS

The three groups into which bioregions have been placed here emerge as sufficiently homogenous to serve as a basis to categorise the fragmented landscapes of Victoria in terms of the characteristics that are important for ecological connectivity. As summarised in table 4.2, the bioregions of most interest to this investigation readily fit into the two groups of most cleared and moderately cleared bioregions, with a relatively small number of exceptions in each group to allow for the relevant idiosyncrasies of some bioregions. This seems to be a workable basis from which to start identifying opportunities to improve ecological connectivity.

Table 4.2
Bioregion groups have similar key characteristics, with some variations

GROUPS AND BIOREGIONS	CHARACTERISTICS OF FRAGMENTED LANDSCAPES	NOTABLE VARIATIONS
Most cleared ▶ Victorian Volcanic Plain ▶ Wimmera ▶ Warrnambool Plain ▶ Murray Mallee ▶ Victorian Riverina ▶ Gippsland Plain ▶ Dundas Tablelands ▶ Strzelecki Ranges ▶ Otway Plain ▶ Murray Fans	▶ mostly low elevation, flat, fertile country ▶ less than 40% of original extent of native vegetation remaining ▶ often large ▶ rarely adjoin largely-intact landscapes ▶ high proportion of remnant native vegetation on private land ▶ poor conservation reserve representation ▶ high proportion of native vegetation on roadsides ▶ generally poor site condition ▶ generally poor landscape context – especially on private land – and many small patches and relatively little native vegetation in large patches ▶ landscape context particularly bimodal, with much native vegetation in a small number of large patches (usually on public land) and otherwise large areas with little native vegetation (mostly on private land)	▶ site condition relatively good in Murray Mallee, Warrnambool Plain and, in particular, Otway Plain and Strzelecki Ranges ▶ landscape context especially poor in Victorian Volcanic Plain, Wimmera and Victorian Riverina ▶ 'bimodal' bioregions – with extensive highly cleared landscapes contrasting with a small number of relatively large patches – includes Murray Mallee, Warrnambool Plain, Wimmera, Victorian Volcanic Plain (with wetlands forming a significant proportion of the larger patches in the last bioregion)
Moderately cleared ▶ Central Victorian Uplands ▶ Glenelg Plain ▶ Northern Inland Slopes ▶ Goldfields ▶ Lowan Mallee ▶ Highlands – Southern Fall ▶ East Gippsland Lowlands ▶ Monaro Tablelands ▶ East Gippsland Uplands ▶ Bridgewater ▶ Highlands – Northern Fall	▶ typically foothills or less fertile flat country ▶ 40-70% of original extent of native vegetation remaining ▶ extent of adjoining largely-intact landscapes varies ▶ generally intermediate between the other two bioregion groups in terms of – size – ratio of public land to private land remnant native vegetation – conservation reserve system representation – proportion of native vegetation found in road reserves ▶ site condition is also generally intermediate but highly variable ▶ landscape context is also generally intermediate and similar between bioregions	▶ Bridgewater is very small: a minor focus only for investigation ▶ Lowan Mallee, Highlands – Southern Fall, East Gippsland Lowlands, East Gippsland Uplands and Highlands – Northern Fall include substantial largely-intact landscapes ▶ Lowan Mallee has generally high conservation reserve system representation ▶ Goldfields and Highlands – Southern Fall have high proportion of public land native vegetation on road reserves ▶ bioregions with significant mining history – Goldfields, Northern Inland Slopes and Central Victorian Uplands – have poor site condition ▶ landscape context on private land significantly poorer than that on public land in Glenelg Plain

GROUPS AND BIOREGIONS	CHARACTERISTICS OF FRAGMENTED LANDSCAPES	NOTABLE VARIATIONS
Least cleared ▶ Otway Ranges ▶ Greater Grampians ▶ Robinvale Plains ▶ Victorian Alps ▶ Murray Scroll Belt ▶ Wilsons Promontory ▶ Highlands – Far East	▶ mountainous or (formerly) flood-prone ▶ more than 70% of original extent of native vegetation remaining ▶ often small ▶ most have significant adjoining largely-intact landscapes ▶ high proportion of remnant native vegetation on public land, with very high conservation reserve representation ▶ roadsides hold a small proportion of total native vegetation ▶ generally good site condition and very good landscape context	▶ Murray Scroll Belt and Robinvale Plains have relatively poor site condition due to reduced inundation of their River Murray floodplains (mostly public land)
All bioregions	▶ public land generally has better site condition than private land with, in particular, a very large proportion of areas of highest site condition on public land	▶ Murray Scroll Belt, Robinvale Plains, Murray Fans and Victorian Riverina show relatively little difference from private land – the first three due to reduced inundation of their River Murray floodplains (mostly public land)

5

FINDINGS BY BIOREGION

Biogeographical regions or bioregions are large, geographically distinct areas of land characterised by landscape-scale natural features and environmental processes that influence the function of entire ecosystems. Bioregions are delineated by physical characteristics such as geology, natural landforms, and climate, which are correlated to ecological features, plant and animal assemblages and landscape-scale ecosystem processes. Twenty-eight Victorian bioregions nest within the national categorisation for terrestrial environments under the Interim Biogeographic Regionalisation for Australia (IBRA) and in the Victorian Biodiversity Strategy. Bioregions provide a useful means to report on underlying complex patterns of biodiversity for regional-scale conservation planning (figure 5.1).

This section provides native vegetation statistics, highlights key findings for each Victorian bioregion and briefly describes the major post-European land use activities that have shaped the fragmentation patterns of vegetation in individual bioregions.

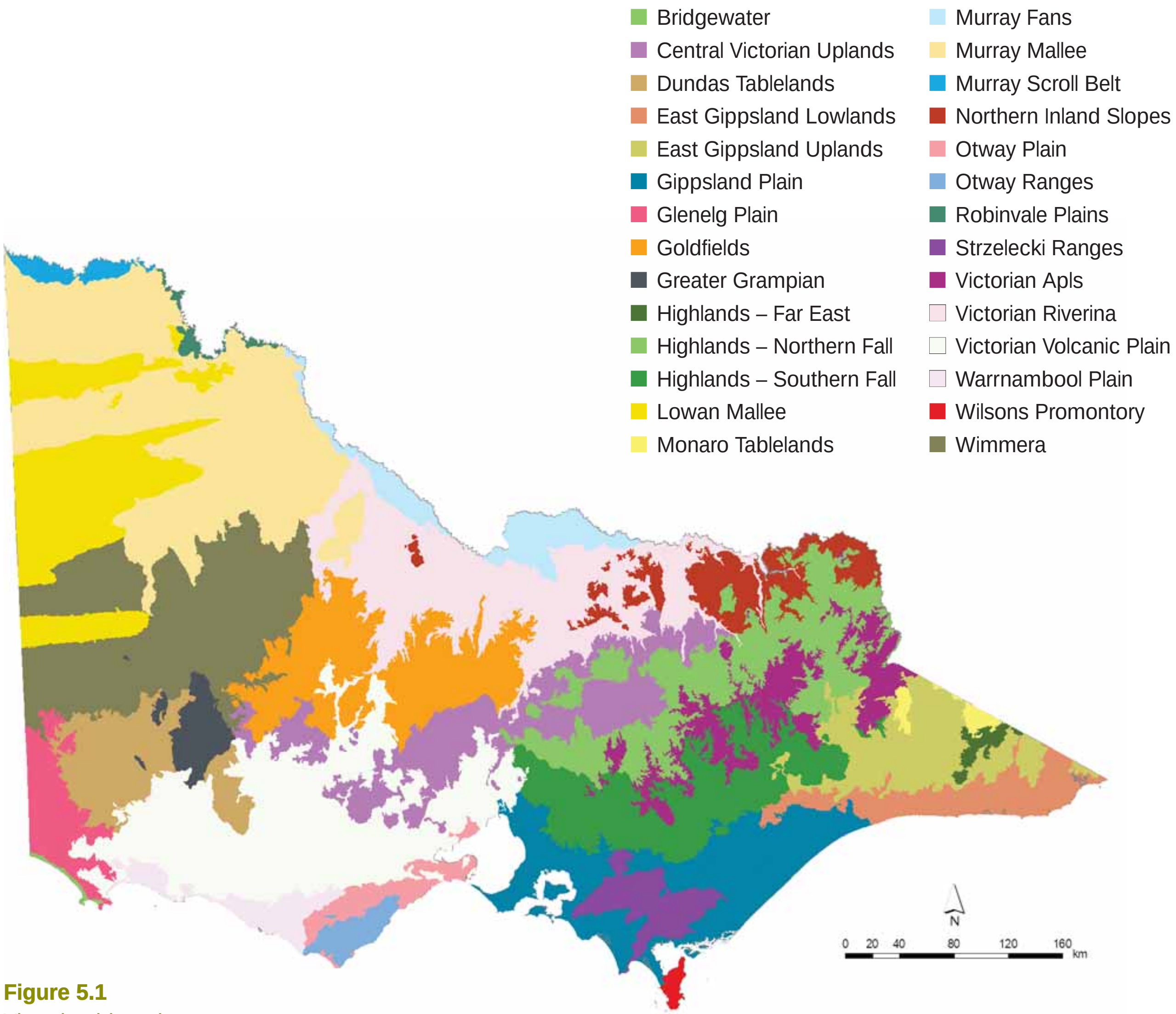


Figure 5.1
Victorian bioregions
Source: DSE 2010[4]

5.1 Native vegetation statistics

The following statistics are presented for each bioregion:

- **Total bioregion** – the area of each bioregion in hectares and/or square kilometres.
- **Largely-intact landscape** – the area of largely-intact landscape (if any) in the bioregion (see section 1.1). Largely-intact landscapes fall outside the terms of reference for this investigation and are excluded from further statistical assessment.
- **Fragmented landscape** – the area of the bioregion that is outside the largely-intact landscape (includes native vegetation, land cleared of native vegetation, buildings, roads, infrastructure).
- **Native vegetation extent** – the area of native vegetation remaining in the fragmented landscape.
- **Not native vegetation** – the area of land in the fragmented landscape that does not support native vegetation (includes farmland without native vegetation, infrastructure, roads, buildings, native and non-native plantations).

The key findings section in each bioregion summary describes the fragmented landscape in terms of clearing patterns, the type of native vegetation remnants and the site condition of the native vegetation. Terminology follows that used in section 2.1 and in figure 2.3. Unless specified otherwise, these descriptions cover both public and private land. The data on which these accounts are based are provided in appendix 3.

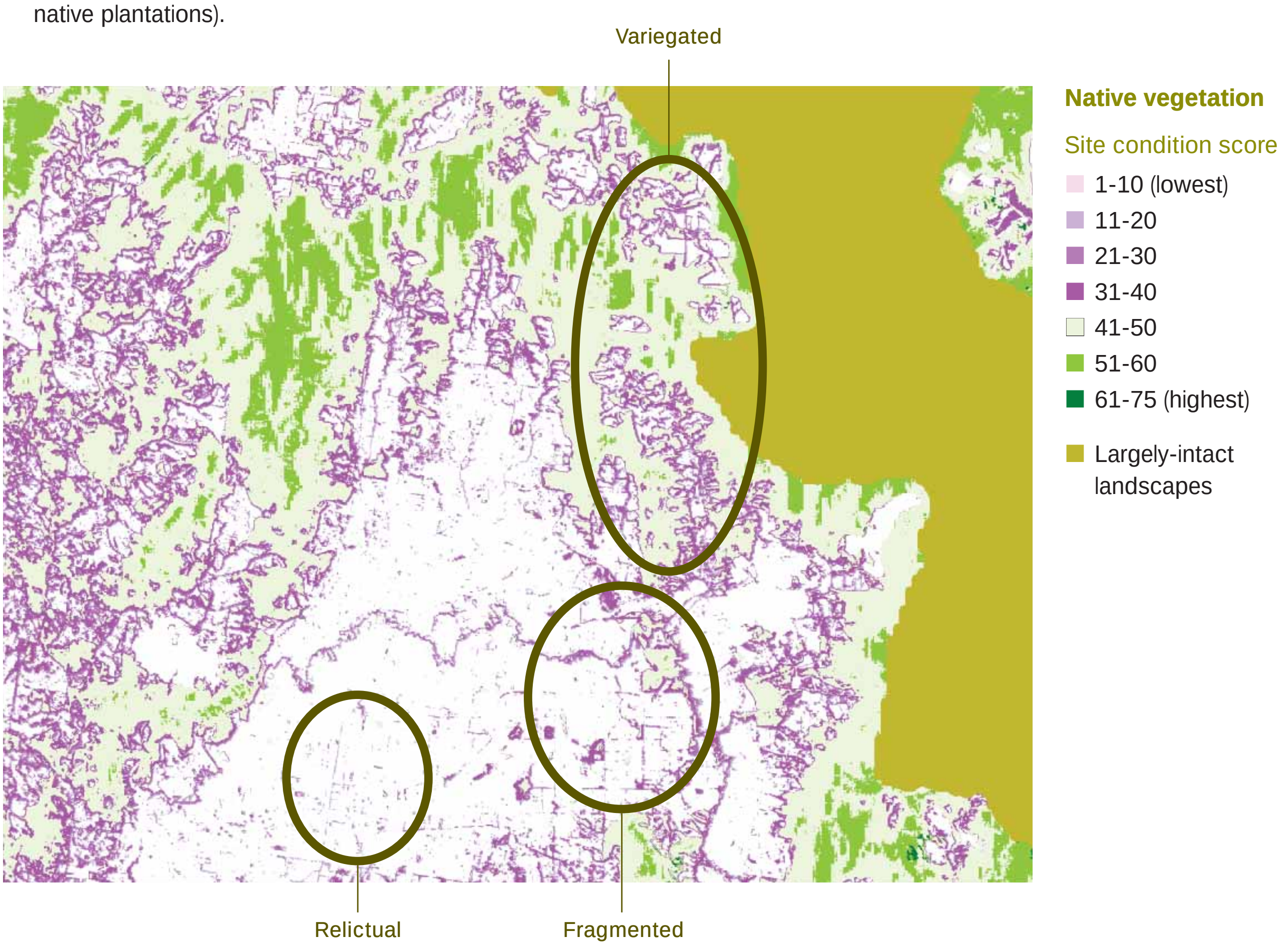


Figure 5.2
An example of types of fragmentation patterns of native vegetation and the terminology used to describe them
Source: DSE 2010[59]

5.2 Site condition and landscape context scores

The unique assemblage of biophysical attributes of each Victorian bioregion has resulted in different historical patterns of land use, and hence the extent and pattern of vegetation clearance. The extent of native vegetation indicates how much of the bioregion has been cleared, and the site condition and landscape context scores provide information on the quality and spatial configuration of remaining vegetation within the fragmented landscape in individual bioregions.

Bioregions may have the same *extent* of cleared vegetation but differences in the *pattern* of clearance, which is influenced by landscape features and land use, which will in turn influence landscape context and site condition scores of remnant vegetation. A bioregion or landscape consisting of a high proportion of small unconnected remnants will have a correspondingly high proportion of native vegetation subject to edge effects and is likely to have low site condition and landscape context scores. Bioregions that are heavily cleared, but contain a few large, high quality remnants, are likely to score better for site condition and landscape context.

Several Victorian bioregions are traversed by many river systems. Native vegetation of linear configuration in the form of river and stream systems (or extensive areas of vegetated road reserves) will contribute to higher landscape context scores, but the high edge to patch size ratio of linear features will contribute to relatively poor site condition scores.

5.3 Conservation reserves

The most cleared bioregions have little, if any, area of largely-intact landscapes and the lowest proportions of native vegetation represented in the conservation reserve system. Several of the moderately cleared bioregions have a significant proportion of their area within largely-intact landscapes. However, outside the largely-intact landscape, these bioregions (with the exception of the Lowan Mallee) generally have a low proportion of native vegetation in conservation reserves. The remaining bioregions either have a large proportion of the bioregion consisting of largely-intact landscapes or a significant proportion of remnant native vegetation outside largely-intact landscapes in conservation reserves.

5.4 Land use

5.4.1 ABORIGINAL LAND USE

Indigenous people have been custodians of Australia for at least 50,000 years. Most areas within Victoria have supported and nurtured Aboriginal people. Resources obtained from the land include plants, animals, water, minerals and stone. These resources were used to sustain a lifestyle that serviced basic needs and supported a rich cultural life with jewellery, ornaments, transport, mythology, art and craft.[63] These connections remain important to Aboriginal people today.

Understanding the physical environment and managing natural resources formed an integral part of the patterns of everyday living for Aboriginal people. Accumulated knowledge gathered over hundred of generations about specific foods, weather conditions and seasonal patterns played an important role in influencing how Aboriginal people lived and moved in the landscape. Significant forward planning and forethought was given to what plant and other foodstocks and natural resources would be available in each location at different times of the year. The use of fire to increase local food abundance is an often cited example of how Aboriginal people actively managed the landscape.

Aboriginal people continue to live throughout Victoria, often with strong ties to their original clan and tribal areas. They continue to have a strong desire to be involved in an active and formal way in all areas of natural resource management.

The Land and Biodiversity White Paper has noted that, in the 200 years since European settlement of Australia, the landscape in the area now known as Victoria has been transformed, often to the detriment of ecosystems and biodiversity.

5.4.2 EUROPEAN LAND USE

Permanent settlement by Europeans in Victoria commenced in the Port Phillip and Portland districts during the 1830s. The first permanent settlers were the Henty brothers, who established a grazing industry in the Portland Bay area in 1834. A wave of squatters to the Port Phillip District and inland Victoria followed explorers such as Charles Sturt, Hamilton Hume, William Hovell and Major Thomas Mitchell who acclaimed and promoted the abundant natural pastures in the country they crossed. The advance of pastoralism was rapid, especially in the years 1838-40 after the official opening of the Port Philip District in 1836, and continued until the 1880s. From the 1860s, a series of selection and settlement acts were introduced. These acts aimed to settle a class of yeomen farmers on small holdings, although frequently without success. From the 1860s until the 1960s agricultural intensity increased rapidly across Victoria aided by new technologies including the stump-jump plough that enabled cultivation of soils that still contained stumps. In the first three decades of the 20th century, the stump-jump plough and the mallee roller helped clear large tracts of mallee for broadacre dryland farming. Other developments such as introduction of subterranean clover, super-phosphate fertiliser, herbicides and insecticides, along with irrigation and soldier settlement schemes and incentives, further aided the expansion and intensification of agriculture.

Mining is another major activity that has resulted in major landscape modification in Victoria. Alluvial gold was first discovered in areas around Ballarat, Clunes and Warrandyte in 1851. The Mount Alexander goldfields (taking in the goldfields of Castlemaine and Bendigo) were among the world's largest and the impact of gold mining on these natural landscapes was devastating. Vegetation was cleared and the upper layer of soil turned over. Creeks and rivers were polluted, silted and riverbanks eroded and removed. Provincial cities around the goldfields grew with a wave of immigrants, bringing railways, roads, buildings and businesses. During this era, Melbourne was one of the world's wealthiest and fastest growing cities.

Landscape modification continues as urban areas expand, agricultural land is sub-divided for lifestyle properties, and agricultural land uses change in response to economic factors and climate change. In recent decades, the expansion of Melbourne and provincial town boundaries has impacted on semi-rural landscapes. Recent trends in agricultural land use in Victoria include the formation of fewer, larger farms, intensification of agricultural activities, the expansion of tree plantations and centre-pivot and travelling irrigators, diversification of agricultural produce by single farms, and broad shifts in the types of agriculture such as from sheep grazing to cereal cropping.[64]

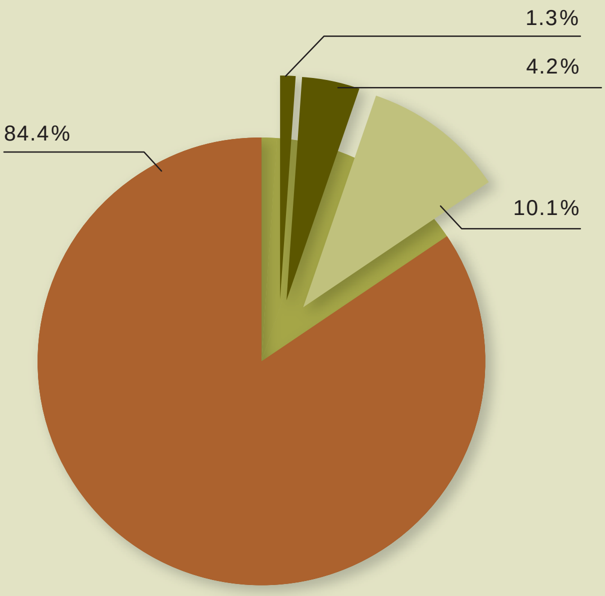
5.5 Bioregional summaries

The bioregional summaries are presented in the following order: from the most cleared bioregions, of most relevance to the investigation, to the least cleared bioregions.

VICTORIAN VOLCANIC PLAIN

TOTAL BIOREGION 2,355,732 ha

- Largely-intact landscape Nil
- Fragmented landscape 2,355,732 ha – 100%



FRAGMENTED LANDSCAPE

- Native vegetation extent 366,456 ha – 15.6%
  - On public land [total] 128,947 ha – 5.5%
    - In conservation reserves 30,201 ha – 1.3%
    - In other public land categories 98,746 ha – 4.2%
  - On private land 237,509 ha – 10.1%
- Not native vegetation 1,989,276 ha – 84.4 %

KEY FINDINGS

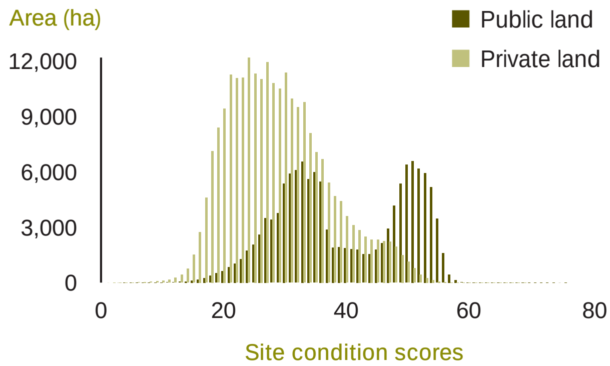
The Victorian Volcanic Plain is one of the state's largest bioregions. There are no largely-intact landscapes. It is the most cleared bioregion with only 15.6% native vegetation remaining, and fragmented and relictual landscapes dominating. About one third of the remaining native vegetation is on public land, and about one-seventh of that is on road reserves. Representation within the conservation reserve system is low (1.3% of the bioregion). Significant areas, largely outside reserves, that contain native vegetation which is relatively connected and/or of good site condition are:

- Wyndham Vale (west of Werribee)
- an area bounded by Lyons, Hotspur and Milltown (north of Heywood)
- Lake Corangamite and hinterland (inclusive of lake bodies).

These areas stand out from the otherwise highly cleared relictual landscapes that characterise the vast majority of the bioregion.

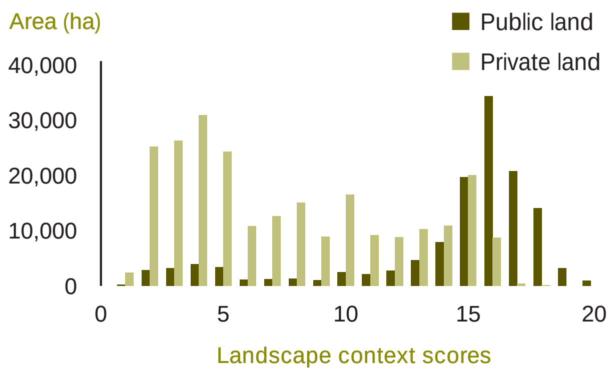
Both site condition and landscape context are significantly poorer on private land compared to public land and overall lower than the state median. A significantly greater proportion by area of small to medium size patches (0-1,000 ha) are found on private land compared to public land. A significantly greater proportion by area of the largest patches (>1,000 ha) occur on public land.

Distribution of site condition scores



Public land median score – 36.7
Private land median score – 27.5
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.2
Private land median score – 6.1
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Victorian Volcanic Plain bioregion is characterised by extensive areas of flat to undulating basalt plains formed from volcanic lava flows and ash. Stony rises, numerous old eruption points, extinct craters and shallow lakes are scattered throughout the bioregion. The soils are variable supporting a variety of vegetation communities. The low plains support Stony Knoll Shrubland, Plains Grassy Woodland, Plains Grassy Wetland ecosystems. The stony rises support Stony Rises Herb-rich Woodland, Basalt Shrubby Woodland and Herb-rich Foothill Forest EVCs.

Average annual rainfall across the bioregion: 500-800 mm
Daily mean temperature across the bioregion: 12-15˚C

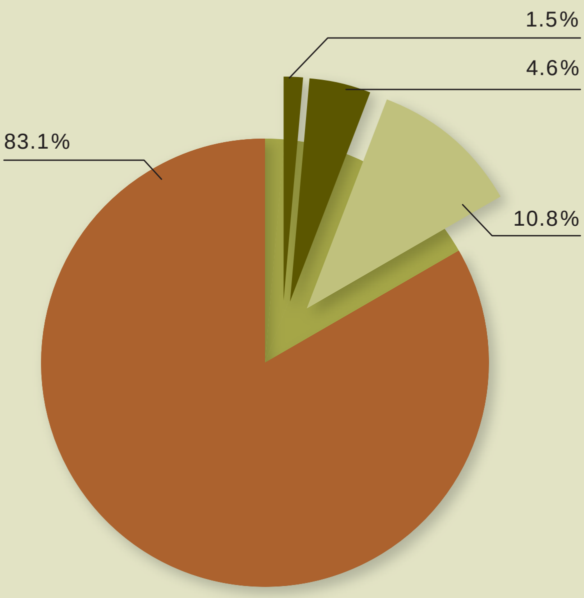
LAND USE HISTORY

The relatively flat terrain, fertile soils, reliable rainfall and the lack of trees made the region attractive to farmers for grazing livestock – particularly sheep grazing for wool, which continues to the present day. Urbanisation in the eastern fringe of the bioregion (southwest of Melbourne) has increased significantly in recent decades encroaching on the once extensive grassy plains. As one of the earliest settled areas of Victoria, and recognised as quality agricultural land, few areas of public land remain. Consequently vegetation in remnants, parks and reserves are generally small and scattered.

WIMMERA

TOTAL BIOREGION 2,011,321 ha

- Largely-intact landscape 251 ha – less than 1%
- Fragmented landscape 2,011,069 ha – ~100%



FRAGMENTED LANDSCAPE

- Native vegetation extent 340,045 ha – 16.9%
  - On public land [total] 123,026 ha – 6.1%
    - In conservation reserves 30,525 ha – 1.5%
    - In other public land categories 92,501 ha – 4.6%
  - On private land 217,019 ha – 10.8%
- Not native vegetation 1,671,024 ha – 83.1%

KEY FINDINGS

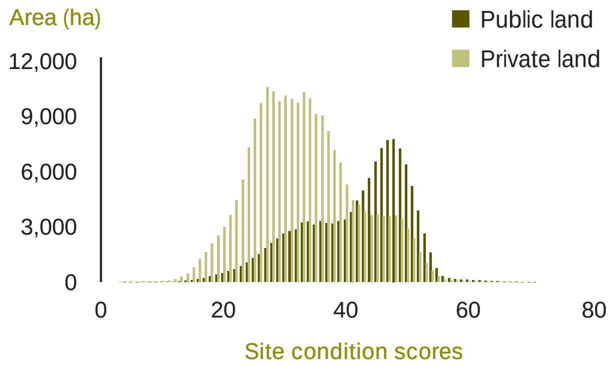
The Wimmera is one of the state's largest bioregions and the second most heavily cleared. A small proportion (16.9%) of the original extent of native vegetation remains in the fragmented landscape. Most remaining native vegetation occurs on private land and is generally in poorer condition than that on public land. About one third of the remaining native vegetation is on public land and about 20% of that is on roadsides. The site condition of roadside vegetation is generally comparable to that of private land. A very small proportion of the bioregion is represented in the conservation reserve system (1.5%). A significantly greater proportion of the total area of small to medium size patches (0-500 ha) is found on private land compared to public land. The proportion by area of the largest patches (500-1,000+ ha) for both public and private land is similar.

The extent and pattern of clearing varies according to soil fertility, resulting two distinctively different zone. The eastern, central and northwest Wimmera are the most heavily cleared areas, with native vegetation occurring almost exclusively as roadside or fragmented remnants. In these relictual landscapes, large paddocks have been comprehensively cleared for broadacre cropping. In these areas the more substantial – but still relatively small – remnants on public and private land are associated with riparian zones (e.g. Yarriambiak Creek and Richardson River), and Lake Buloke and its nearby lunettes. Generally the condition of vegetation is poor.

In the southwest of the bioregion, moderate to large-sized remnants associated with ancient beach ridges remain, leading to a landscape that would by classified as 'fragmented' under the McIntyre and Hobbs (1999) framework. The interspersed clay pans, which are more suitable for agriculture, have been cleared in a variegated or fragmented pattern, depending on the extent of the clay pans and sandy dunes. Many small fragments, which generally do not occur in the central and eastern part of the bioregion, are dispersed between the ridges. Site condition of native vegetation within the southwest of the bioregion is moderate to good. Some of these patches are extensive in size with relatively good connectivity. In the northwest of the bioregion (north of the Little Desert), the ancient beach ridges are more heavily cleared with poorer connectivity.

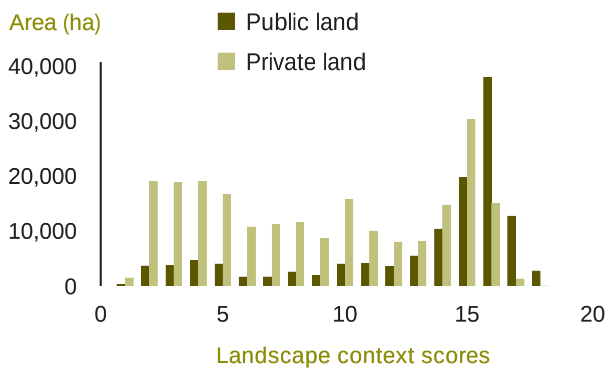
The finger of the bioregion flanking the eastern side of the Greater Grampians bioregion (i.e. between Stawell and Halls Gap) has a variegated clearance pattern. This landscape contains some reasonably connected remnants though the site condition of these remnants is mixed. The highly connected remnants south of Stawell are of poor site condition, whilst connected remnants near to Halls Gap are of much better quality.

Distribution of site condition scores



Public land median score – 43.2
Private land median score – 31.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 14.5
Private land median score – 8.2
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Wimmera is typified by flat to gently undulating plains with black and grey cracking clay soils in the eastern part of the bioregion. These soils are dominated by Plains Woodland, Plains Grassy Woodland, Plains Grassland, Red Gum Wetland and Grassy Woodland EVCs. The southwest is characterised by ancient stranded beach ridges interspersed with clay plains with cracking clay soils and red texture contrast soils, and swamps, lakes, lagoons and lunettes. The native vegetation on these less fertile plains is dominated by Heathy Woodland and Shallow Sands Woodland.

Average annual rainfall across the bioregion: 400-700 mm
Daily mean temperature across the bioregion: 18-21˚C

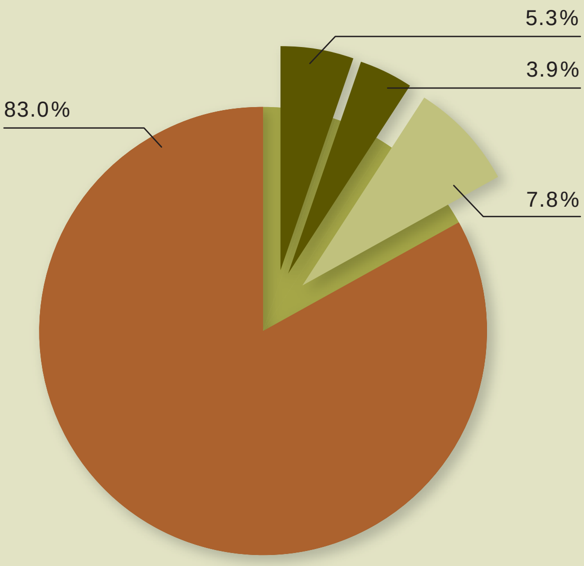
LAND USE HISTORY

Squatters grazing sheep were the first to settle the Wimmera bioregions following reports of favourable land from Major Mitchell. During the squatting era, exotic pest species were introduced and caused major soil and vegetation degradation in the region. A shift to freehold land and small farms commenced in the late 1860s. From the early days of settlement, woodlands capable of yielding timber were cleared early to make way for agriculture. By the 1940s rotational farming of dry crops was established and continues to the present day. Other production industries include sheep and cattle grazing, pig enterprises, plantation forestry, mineral exploitation and apiculture. Drier conditions appear to be at least partly responsible for two trends in the southwest of the bioregion (south of the Little Desert) in recent years: the expansion of centre pivot irrigation in some places and dryland cereal cropping in others. Both of these trends would lead to losses of native vegetation in this area, particularly isolated large old paddock trees.

WARRNAMBOOL PLAIN

TOTAL BIOREGION 264,110 ha

- Largely-intact landscape Nil
- Fragmented landscape 264,110 ha – 100%



FRAGMENTED LANDSCAPE

- Native vegetation extent 44,783 ha – 17.0%
  - On public land [total] 24,090 ha – 9.2%
    - In conservation reserves 13,892 ha – 5.3%
    - In other public land categories 10,198 ha – 3.9%
  - On private land 20,694 ha – 7.8%
- Not native vegetation 219,327 ha – 83.0%

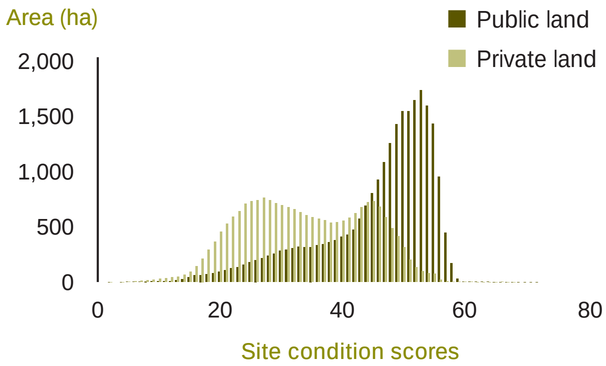
KEY FINDINGS

The Warrnambool Plain is one of the state's most heavily cleared bioregions, modified largely by the introduction of pasture species for stock grazing. Less than one fifth of the original native vegetation extent has been retained, of which more than half is public land and more than half of this is in the conservation reserve system. A greater proportion by area of small to moderate size patches (0-250 ha) is found on private land compared to public land. The proportion by area of medium sized patches (250-500 ha) on private and public land is similar. The proportion by area of patches in the 500-1,000+ ha range is considerably greater on public land.

The patterns of the remaining native vegetation are those typically associated with extensive agricultural activities. Native vegetation is predominantly relictual and fragmented or in road reserves. There are few large patches of native vegetation in the bioregion. The most extensive remnants of native vegetation are conservation reserves and forest blocks on public land adjoining the Otway Plain bioregion and reserves along the coast. South of Mount Eccles National Park in the far west of the bioregion (east of Tyrendarra), several large-sized remnants remain. These few but relatively large, patches contribute to the overall site condition and landscape context scores for public land which are significantly greater than those for private land.

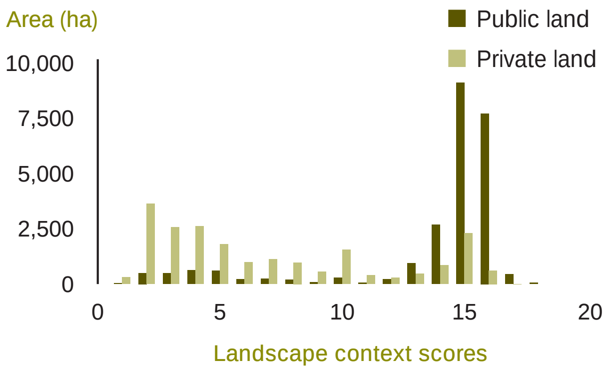
The bioregion contains significant areas of riparian and wetland vegetation. Most prominent, and of high conservation value, are the nationally significant wetlands of Yambuck and Lower Merri wetlands, and portions of the Lower Curdies River.

Distribution of site condition scores



Public land median score – 48.2
Private land median score – 32.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 14.6
Private land median score – 4.8
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Warrnambool Plain consists of deficient soils over low calcareous dune formations and a distinctive cliffed coastline. Much of the limestone has been overlain by more recent sediments. Between the limestone dunes areas of swamplands are characterised by fertile peats. The area east of Warrnambool is characterised by deeper soils of volcanic origins overlying limestone, which are dissected by streams. The bioregion supports Damp Sands Herb-rich Woodland, heathlands, heath scrubs, Herb-rich Woodland and Swamp Scrub EVCs.

Average annual rainfall across the bioregion: 600-700 mm
Daily mean temperature across the bioregion: 12-15˚C

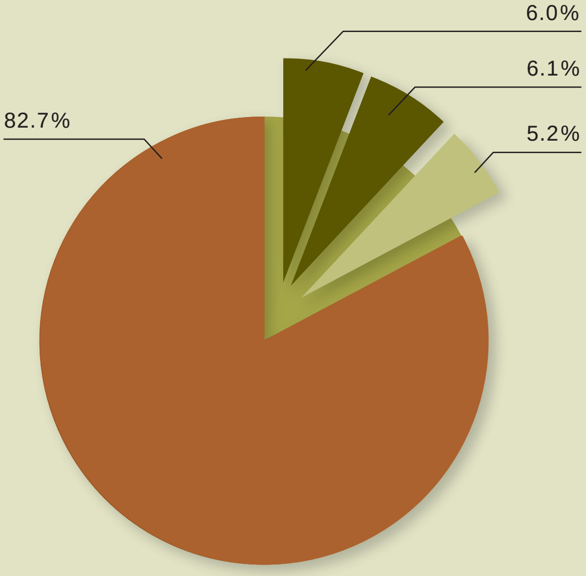
LAND USE HISTORY

The Warrnambool Plain was settled by Europeans in the late 1830s. The relatively flat terrain, fertile soils, reliable rainfall and the lack of trees made the region attractive to farmers for grazing livestock and dairy farming.

MURRAY MALLEE

TOTAL BIOREGION 2,919,064 ha

- Largely-intact landscape 297,439 ha – 10.2%
- Fragmented landscape 2,621,625 ha – 89.8%



FRAGMENTED LANDSCAPE

- Native vegetation extent 453,790 ha – 17.3%
  - On public land [total] 315,969 ha – 12.1%
    - In conservation reserves 157,617 ha – 6.0%
    - In other public land categories 158,352 ha – 6.1%
  - On private land 137,822 ha – 5.2%
- Not native vegetation 2,167,835 – 82.7%

KEY FINDINGS

Representing the state's largest bioregion, the Murray Mallee also has the largest area of fragmented landscape. Only 17.3% of native vegetation within the fragmented landscape is retained. More than two thirds of this remaining vegetation is on public land, half of which is in the conservation reserve system. The Murray Mallee has blocks of moderate quality remnant native vegetation, many of which are contiguous with the largely-intact landscapes in the adjoining Lowan Mallee bioregion – overall a variegated landscape (see figure 2.3). Outside these areas, the land has been extensively cleared for broadacre cropping, leaving a relictual landscape. The stark difference between these areas makes this one of the most dimorphic bioregions in Victoria. The heavily cleared areas include much of the eastern part of the bioregion and the more productive soils found between Wyperfeld and Murray-Sunset National Parks. Typical of heavily cleared bioregions, the Murray Mallee roadside vegetation is disproportionately a prominent feature of the landscape. About 15% of native vegetation on public land is on roadsides. A greater proportion by area of small sized patches (0-100 ha) occur on private land than public land. The proportion by area of 100-1,000 ha patches is higher on public land than private with the vast majority of the 1,000+ ha patches on public land.

Significant areas of public land that adjoin the largely-intact landscapes include:

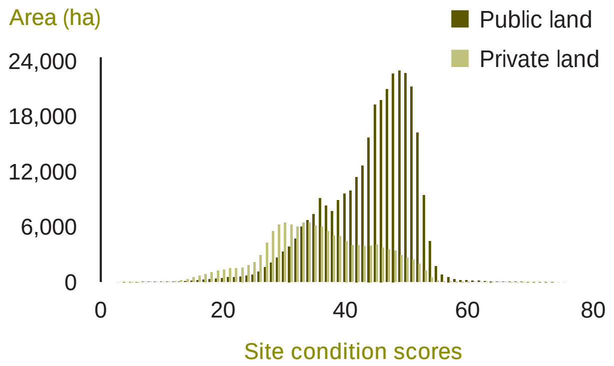
- the northwest of the Murray-Sunset National Park, bordering South Australia and the Murray Scroll Belt
- Yarrara Fauna and Flora Reserve
- areas contiguous with the Murray-Sunset and Hattah-Kulkyne National Parks and Annuello Fauna and Flora Reserve
- Koorlong Education Area (near Mildura) and a mix of public and private land surrounding this and an area north of Cowangie (near Murrayville).

These few but relatively large patches make a substantial contribution to the significantly higher site condition and landscape context scores for public land than for private land.

Lake systems and creek outlets on both public and private land with significant native vegetation retained include:

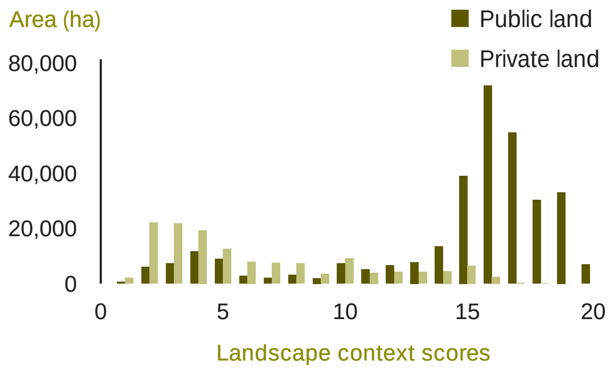
- Lakes Tyrrell, Wahpool and Timboram
- the Wimmera River and Outlet Creek system including Lakes Albacutya and Hindmarsh.

Distribution of site condition scores



Public land median score – 45.2
Private land median score – 34.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.5
Private land median score – 4.4
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Murray Mallee is part of the much larger Murray Darling Basin that extends through Victoria, South Australia and New South Wales. Once an inland sea, the Murray Mallee is characterised by an extensive sandy plain with overlying stabilised linear sand dunes with intervening clay soils in the swales and clay pans.

The vegetation of the region is dominated by open 3-7 m tall multi-stemmed eucalypt shrublands with sandy soils supporting an understorey of *Triodia* (spinifex grass) and various shrubs (e.g. Wattles, Moonah). The heavier clay soils of the dune swales and clay pans support saltbush and semi-succulents species.

Average annual rainfall across the bioregion: 300-400 mm
Daily mean temperature across the bioregion: 15-21˚C

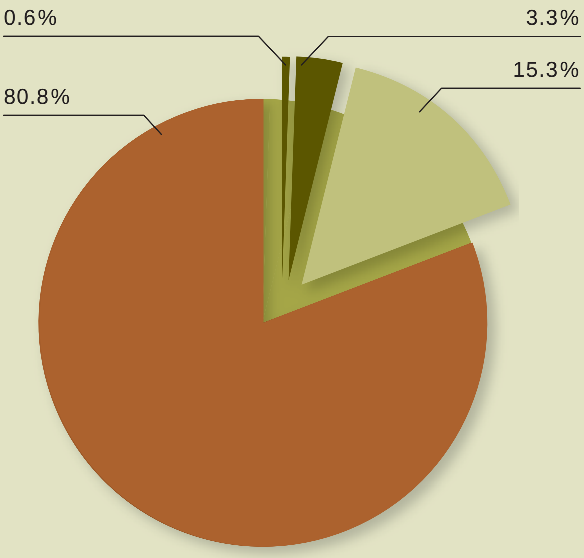
LAND USE HISTORY

White settlement in the Murray Mallee bioregion was patchy until the early 20th century. The bioregion was first settled by squatters and pastoralists for grazing sheep and cattle. The invention of the mallee roller and the stump-jump plough in the early 1900s enabled land containing mallee stumps to be cultivated. During the period 1900-1930, vast areas of land were heavily cleared for dryland wheat and cereal cropping.

VICTORIAN RIVERINA

TOTAL BIOREGION 1,890,328 ha

- Largely-intact landscape Nil
- Fragmented landscape 1,890,328 ha – 100%



FRAGMENTED LANDSCAPE

- Native vegetation extent 362,815 ha – 19.2%
  - On public land [total] 73,886 ha – 3.9%
    - In conservation reserves 10,896 ha – 0.6%
    - In other public land categories 62,990 ha – 3.3%
  - On private land 288,929 ha – 15.3%
- Not native vegetation 1,527,513 ha – 80.8%

KEY FINDINGS

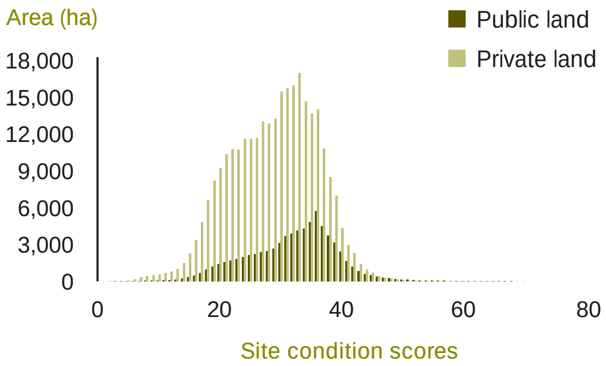
Much of this large bioregion is heavily fragmented with relatively little native vegetation remaining and no largely-intact landscapes. The blocks of native vegetation remaining are regionally significant given the paucity of large patches within the bioregion. About one fifth of original native vegetation extent is retained, of which about one fifth is on public land with a very small proportion of the bioregion represented (0.6%) within the conservation reserve system. Remnant vegetation associated with riparian and roadside reserves is disproportionately a dominant feature of the landscape. Of the remaining native vegetation on public land almost 40% is on road reserves. The high proportion of vegetation clearing and fragmentation has resulted in site condition and landscape context scores below the state average for both public and private land. This bioregion is unusual in that site condition and landscape context scores for both tenures are similar. Also the proportion by area of all patch size categories is significantly greater on private than public land, including the largest patches (1,000+ ha).

Areas of good quality and connected landscapes on both private and public land occur at Boorhaman East, Reef Hills State Park, Longwood Plains, west of Axedale and the Terrick Terrick/Patho Plains. Significant areas of riparian vegetation and wetlands on public and private land include:

- Kow Swamp and the nearby region southwest of Gunbower
- Kerang Lakes
- Reedy Lake and Bailieston East
- riparian zones along the Ovens and Goulburn Rivers.

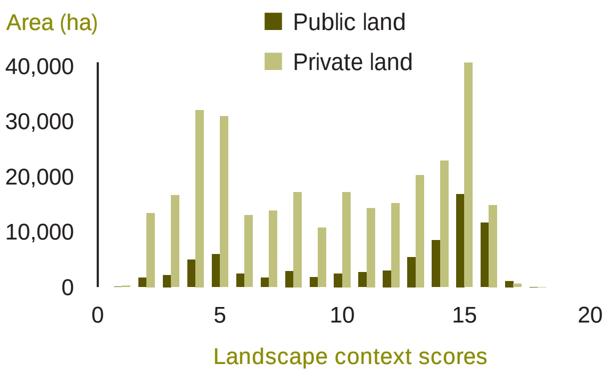
Notwithstanding these variegated landscapes, and some relictual landscapes in places such as more intensively irrigated areas, this is a relatively homogenous bioregion, mostly ‘fragmented’ (see figure 2.3).

Distribution of site condition scores



Public land median score – 32.5
Private land median score – 29.0
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 13.1
Private land median score – 8.9
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Victorian Riverina is characterised by flat to gently undulating landscapes with evidence of former stream channels and wide floodplain areas associated with major river systems and streams. Deposits from ancient flood plains have given rise to the fertile red brown earths and soils which dominate the Riverine Plain. The vegetation is dominated by five major vegetation types; Grasslands, Lower Slope Grassy Woodlands, Plains Grassy Woodlands and Forests, Riverine Grassy Woodlands and Forests, and Wetlands.

Average annual rainfall across the bioregion: 350-600 mm
Daily mean temperature across the bioregion: 15-18°C

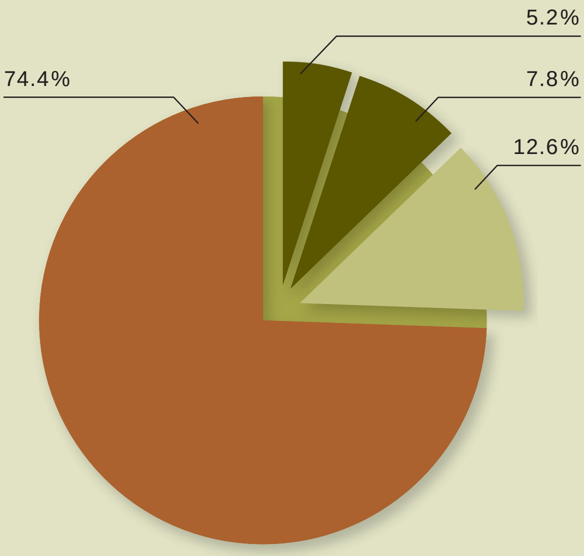
LAND USE HISTORY

The open grassland plains and grassy woodlands were settled and developed early by Europeans. The fertile soils and secure water supply made much of the area suitable for extensive agriculture, which remains the dominant land-use. Later, large-scale irrigation schemes for the production of fodder crops, cereals and fruits were established along the Campaspe, Goulburn, Loddon and Murray valleys.

GIPPSLAND PLAIN

TOTAL BIOREGION 1,208,072 ha

- Largely-intact landscape 5,280 ha – less than 1%
- Fragmented landscape 1,202,792 ha – ~100%



FRAGMENTED LANDSCAPE

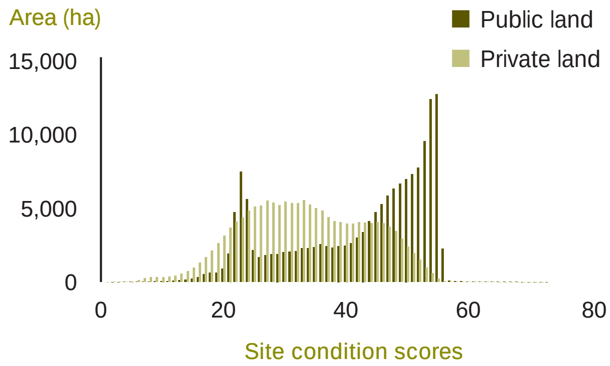
- Native vegetation extent 308,320 ha – 25.6%
  - On public land [total] 156,911 ha – 13.0%
    - In conservation reserves 62,785 ha – 5.2%
    - In other public land categories 94,126 ha – 7.8%
  - On private land 151,409 ha – 12.6%
- Not native vegetation 894,472 ha – 74.4%

KEY FINDINGS

The Gippsland Plain retains native vegetation of disparate pattern, reflecting a variety of land-use histories in the bioregion. Less than one percent of the bioregion is largely-intact. Much of the bioregion has been heavily modified with only a quarter of the original extent of native vegetation remaining of which about half is on public land, a substantial proportion within conservation reserves. Overall site condition and landscape context scores for public land are greater than private land and the overall state median. In each patch size class, the proportion by area on private land is slightly greater than that on public land for all except the largest patch size, in which public land dominates.

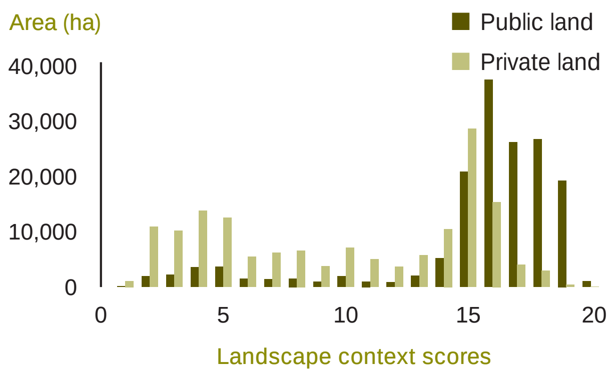
The western end of the bioregion encompasses the populated southeastern suburbs of Melbourne. Here native vegetation patches are few, small and of poor quality. The Mornington Peninsula and the eastern rural area of the bioregion have a high proportion of small scattered patches of poor site condition because of agricultural land-use activities. Similarly, in the central area of the Gippsland Plain – particularly adjacent to the Highlands – Southern Fall bioregion – the land has been heavily cleared for agriculture and few patches of substantial size exist. In these areas the proportion of native vegetation on road reserves is higher than elsewhere in the bioregion. Several islands in the Nooramunga Marine and Coastal Park have vegetation of moderate to good site condition. Large patches occur in the less fertile regions near the coast – around the Gippsland Lakes and Ninety Mile Beach, on French Island and between Holey Plains State Park and Yarram. These patches are of high quality and connectivity – a variegated landscape (see figure 2.3), contrasting sharply with the relictual landscapes of the remainder of the bioregion.

Distribution of site condition scores



Public land median score – 45.7
Private land median score – 32.4
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.8
Private land median score – 9.9
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Gippsland Plain bioregion is characterised by lowland alluvial and coastal plains formed from erodible Tertiary sediments and Quaternary alluvial deposits. The terrain is flat to gently undulating and vegetated by Swamp Scrub and open forests with a grassy and herbaceous ground-layer. The bioregion is generally below 200 m in altitude, with coastal areas of sandy beaches, shallow inlets and extensive mudflats and mangroves. The Gippsland Plain contains a large number of freshwater wetlands and saline estuaries and lagoons. Major rivers include the Bass, La Trobe, Thomson, Macalister, Avon and Mitchell.

Average annual rainfall across the bioregion: 600-1100 mm
Daily mean temperature across the bioregion: 9-15˚C

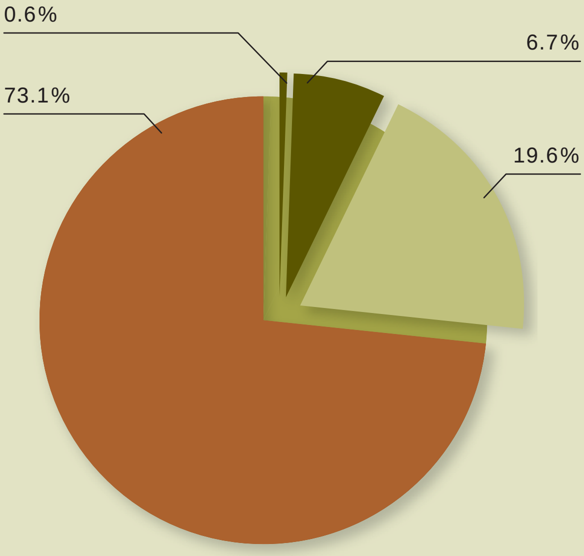
LAND USE HISTORY

European settlement occurred relatively late, with most settlement occurring after 1860 and settled by families on small farms. Vegetation on less fertile soils was cleared after the development of fertilisers and trace element technology in the 1950s. Substantial areas in the west of the bioregion near Melbourne are urbanised and areas to the immediate east have been heavily cleared for dairy and cattle grazing. Land-use outside the Melbourne region is varied but centred on natural resources – agriculture, energy, forestry and water are the most significant economic activities. In some areas, there has been considerable purchase of land for lifestyle properties and coastal areas are popular tourist locations.

DUNDAS TABLELANDS

TOTAL BIOREGION 688,164 ha

- Largely-intact landscape 5,553 ha – 0.8%
- Fragmented landscape 682,612 ha – 99.2%



FRAGMENTED LANDSCAPE

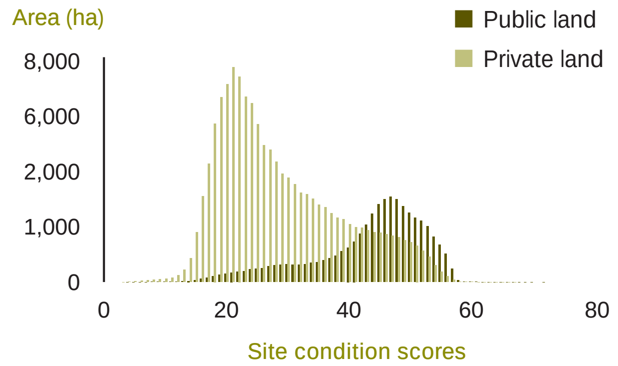
- Native vegetation extent 183,895 ha – 26.9%
  - On public land [total] 49,710 ha – 7.3%
    - In conservation reserves 4,078 ha – 0.6%
    - In other public land categories 45,632 ha – 6.7%
  - On private land 134,185 ha – 19.6%
- Not native vegetation 498,717 ha – 73.1%

KEY FINDINGS

A substantial proportion of the Dundas Tablelands has been heavily modified. Less than 1% of the entire bioregion is within largely-intact landscapes (extending out from the adjoining Greater Grampians bioregion near Glenthompson and just south of Rocklands Reservoir), and barely a quarter of the original native vegetation extent is retained in the fragmented landscape. Almost three quarters of the remaining native vegetation occurs on private land and has poorer site condition and landscape context scores than vegetation on public land. A tiny proportion of remaining native vegetation occurs within the conservation reserve system (0.6% of the fragmented landscape). The proportion by area of all patch size categories is greater on private than public land, including the largest patches (1,000+ ha).

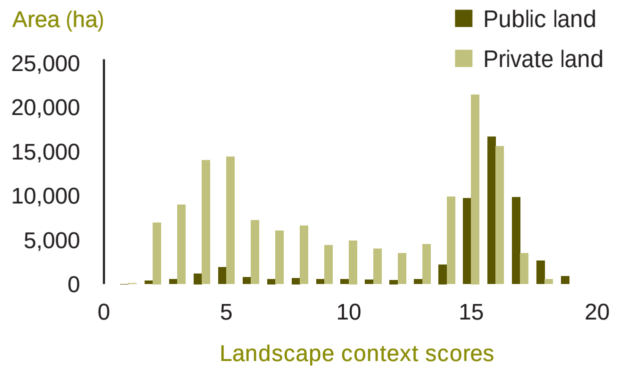
The Dundas Tablelands occurs in two blocks, separated the Greater Grampians bioregion. The block west of the Grampians is the larger of the two. The western half of this larger block is noticeably more heavily cleared (for agriculture) than the east, notwithstanding larger patches on the periphery of Dergholm State Park (which is in the adjoining Glenelg Plain bioregion), centred on state forests north thereof, and along the Glenelg River near Harrow. As well as being better connected, native vegetation in the eastern part of this block and adjacent to the Grampians (including Black Range State Park) is generally in much better condition than that to the west. The same broad pattern is repeated in the smaller block of the bioregion around Glenthompson – native vegetation in the small area fringing the Grampians is more extensive, better connected and in better condition than elsewhere in this block, where there is little in the way of sizeable patches of native vegetation beyond a few relatively small wildlife reserves of modest condition (Mt William, Lake Muirhead and Cobra Killuc).

Distribution of site condition scores



Public land median score – 45.1
Private land median score – 25.7
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.3
Private land median score – 8.9
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Dundas Tablelands is a dissected plateau forming the western-most portion of the Victorian Midlands IBRA region. The tablelands comprise thin marine Tertiary sediments overlaying a Palaeozoic palaeoplain. Black earths dominate the valleys, yellow texture contrast soils and cracking clays dominate the rest of the table tops. Soils tend to become saturated between May and September.

The native vegetation is a complex mosaic dominated by Grassy and Herb-rich Woodlands. The major vegetation types are Plains Grassy Woodland, Damp Sands Herb-rich Woodland, Grassy Woodland and Creekline Grassy Woodland EVCs and related complexes and mosaics.

Average annual rainfall across the bioregion: 600-700 mm
Daily mean temperature across the bioregion: 12-15˚C

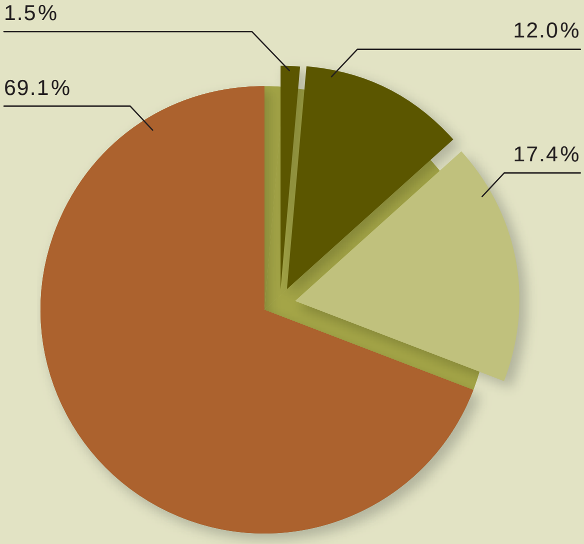
LAND USE HISTORY

The Dundas Tablelands was settled early by pastoralists and has a long history of growing fine merino wool. The grazing industries expanded rapidly and intensified during the 1920s with the introduction of subterranean clovers and super-phosphate. Soldier settlement and closer settlement policies in the 1920s and the 1950s led to increases in the number of landholdings and intensity of use.

STRZELECKI RANGES

TOTAL BIOREGION 342,179 ha

- Largely-intact landscape Nil
- Fragmented landscape 342,179 ha – 100%



FRAGMENTED LANDSCAPE

- Native vegetation extent 105,683 ha – 30.9%
  - On public land [total] 46,087 ha – 13.5%
    - In conservation reserves 5,208 ha – 1.5%
    - In other public land categories 40,879 ha – 12.0%
  - On private land 59,597 ha – 17.4%
- Not native vegetation 236,496 ha – 69.1%

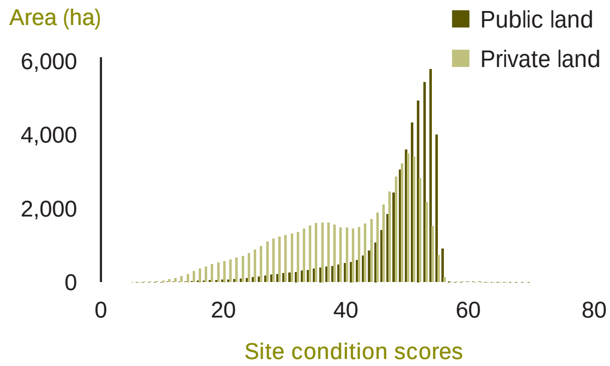
KEY FINDINGS

The Strzelecki Ranges is heavily modified and has a diverse pattern of landscape clearance. This bioregion is unusual in that much of the landscape is hilly and yet has been relatively heavily cleared. The bioregion contains no largely-intact landscapes and retains almost one third of the original extent of native vegetation. Less than half of the remaining native vegetation is on public land and a small proportion is within the reserve system (1.5% of the bioregion). In patch size classes less than 500 ha, the proportion by area is slightly greater on private than public land, while the reverse is true for larger patch size categories.

The far west of the bioregion is the most heavily cleared and comprises vegetation patches that are highly fragmented, relictual or within roadside reserves. No large patches occur here. In the centre of the bioregion, larger patches of native vegetation are associated with the Mount Worth State Park and Mirboo North Regional Park. In the east of the bioregion, more extensive areas of native vegetation remain. The most extensive areas of reasonably well connected native vegetation occur along the ridge of the Strzelecki Ranges bounded by Willung South, Tarra Valley, Dumbalk and Yinnar South. Interspersed and adjoining this native vegetation are softwood plantations of comparable total extent. A sizeable area of native vegetation occurs at the base of the range along the Albert River (north of Binginwarri) and through to Alberton West State Forest, and is connected to the Strzelecki Range by a variegated landscape. Cape Liptrap Coastal Park at Waratah Bay is the only significant area of native vegetation remaining in the coastal area of the bioregion.

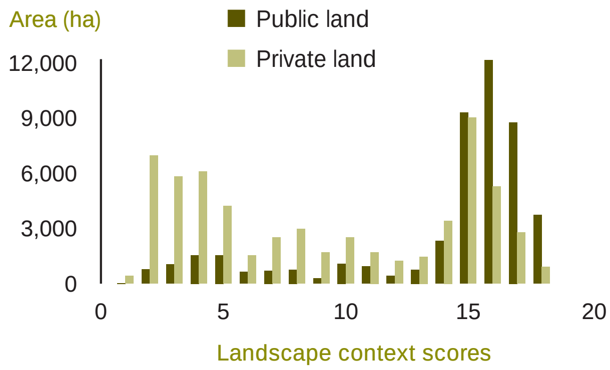
The site condition scores of native vegetation on both public and private land are comparable. Overall, the site condition scores for both public and private land are higher than the state average suggesting that the structure of the remaining native vegetation has not been greatly modified. Landscape context scores are high overall on public land indicating a moderate to good level of connectivity, not negated by the more heavily cleared western parts of the bioregion because there is very little public land there.

Distribution of site condition scores



Public land median score – 50.5
Private land median score – 41.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.1
Private land median score – 7.9
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Strzelecki Ranges bioregion consists of moderate to steep slopes, deeply dissected blocks of alternating beds of sandstone, siltstone and shales, and swampy alluvial fans in the lowlands. The geology is of Mesozoic non-marine deposits covered with younger Cainozoic deposits including newer basalts. Textured acidic and occasional red earths are found throughout the bioregion with leached sands in the lowlands.

The dominant native vegetation is Wet Forest and Damp Forest on the higher slopes; and Shrubby Foothill Forest and Lowland Forest on the lower slopes.

Average annual rainfall across the bioregion: 700-1000 mm
Daily mean temperature across the bioregion: 12-15˚C

LAND USE HISTORY

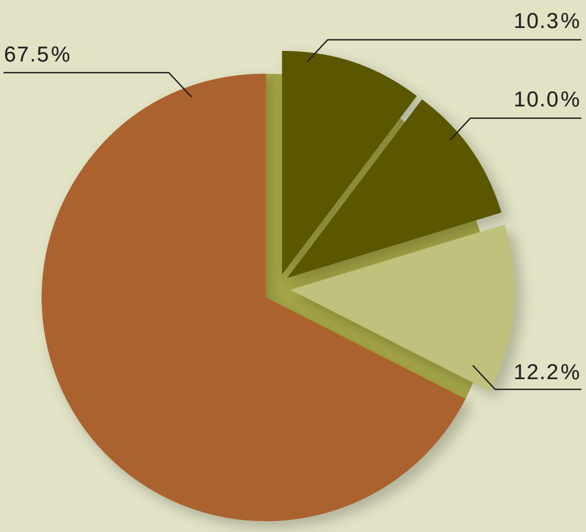
Land use history of the Strzelecki Ranges bioregion is similar to that of the Gippsland Plain. European settlement tended to occur even later because of the rugged terrain – particularly in the east where most of the native vegetation that escaped clearing remains today. Nonetheless, compared to other mountainous bioregions, the Strzelecki Ranges has been heavily cleared. Early settlers reasoned that dense forest indicated great agricultural potential and by 1900 most of the land had been cleared with axe, saw and fire. In addition much of the Strzeleckis was burnt in intense wildfires – particularly in 1898, 1939 and 1944.

Dairying quickly became the dominant land-use but in some areas regrowth of native vegetation remained difficult to control for years after clearing, or soils were too shallow or slopes to steep for long-term profitable farming. As a result some cleared land was abandoned to be replaced by natural regrowth which was subsequently targeted in large reafforestation schemes leading to pine and eucalypt plantations (some indigenous) replacing the dogwood and bracken of abandoned farms. Today the bioregion is a mosaic of dairy and beef production, native and plantation forests, and some lifestyle properties.

OTWAY PLAIN

TOTAL BIOREGION 237,190 ha

- Largely-intact landscape 9,529 ha – 4%
- Fragmented landscape 227,661 ha – 96%



FRAGMENTED LANDSCAPE

- Native vegetation extent 73,910 ha – 32.5%
  - On public land [total] 46,189 ha – 20.3%
    - In conservation reserves 23,442 ha – 10.3%
    - In other public land categories 22,747 ha – 10.0%
  - On private land 27,721 ha – 12.2%
- Not native vegetation 153,751 ha – 67.5%

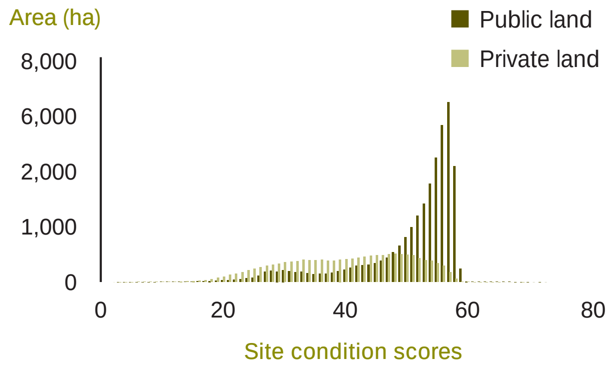
KEY FINDINGS

The Otway Plain is a highly cleared bioregion. Within the fragmented landscape, one-third of the original extent of native vegetation remains. Of this, almost two-thirds is public land, half of which is within the conservation reserve system. The median site condition and landscape context scores are significantly higher for public land than for private land. With the exception of the three patch size classes of 250 ha or greater, in all patch size classes the total area of private land is greater than that of public land.

Around Werribee and Greater Geelong, native vegetation has been heavily cleared and modified, and what remains is associated with road reserves and waterways. On the Bellarine Peninsula, remnants are largely fragmented and in poor condition. More extensive remnants occur within marsh and estuarine ecosystems.

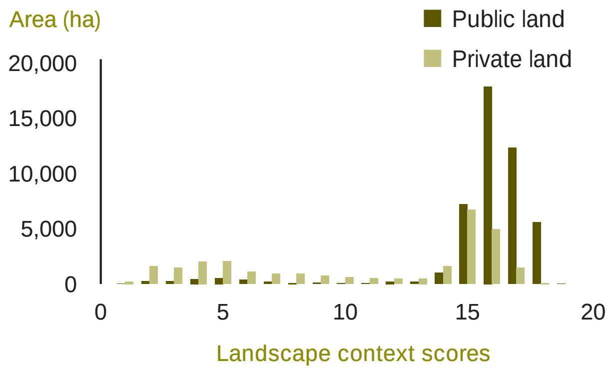
Significant patches of moderate to large size are found further west, adjacent to the Otway Ranges bioregion. Southwest of Barongarook, a number of conservation reserves (e.g. Great Otway National Park) and the surrounding native vegetation form an extensive network of connected remnants in good to very good condition.

Distribution of site condition scores



Public land median score – 53.4
Private land median score – 43.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.7
Private land median score – 13.5
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Otway Plain includes coastal plains, river valleys and foothills and swamps in the lowlands extending from the Bellarine Peninsula west to Princetown. There is also small outlier near Werribee, on the western shore of Port Phillip Bay. The Otway Plain is one of three similar bioregions that form the coastal plains of southern Victoria, the other two being the Warrnambool Plain and the Gippsland Plain.

The bioregion is dominated by gently undulating plains of Tertiary deposits. Ridges mark positions of ancient shorelines. Soils types and fertility vary across the bioregion. The soils associated with the upper terrain are texture contrast soils and support Lowland Forest and Heathy Woodland EVCs. The dunes around Anglesea are predominantly low fertile, sandy soils. The floodplains and swamps are earths, pale yellow and grey texture contrast soils supporting Grassy Woodland and Plains Grassy Woodland. Dry sclerophyll forest dominated by Mountain Grey Gum and Messmate occur around the Otway foothills. River Red Gum woodlands occur along some drainage lines.

The bioregion is drained in the east mainly by the Barwon River (which originates in the Otway Ranges) and its tributaries. In the west the bioregion is drained mainly by tributaries of the Gellibrand River, although some streams flow north to Lakes Corangamite and Colac in the Victorian Volcanic Plain.

Average annual rainfall across the bioregion: 500-1000 mm
Daily mean temperature across the bioregion: 12-15°C

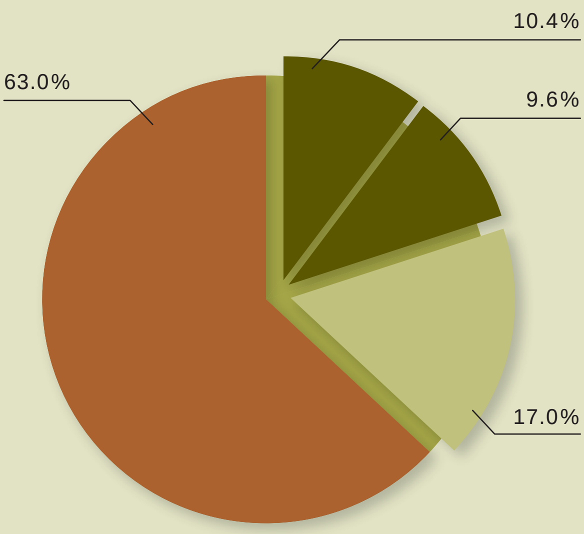
LAND USE HISTORY

Presently, much of the Otway Plain is used for grazing, cropping and dairying. In recent years viticulture has become a local land-use, particularly in the Bellarine Peninsula. Firewood and some timber is produced from the foothill forests. Blue gum and pine plantations are being established in the western part of the bioregion. Brown coal is mined near Anglesea. That part of the bioregion near Werribee is dominated by the sewage treatment plant west of the Werribee River, and intensive horticulture and residential development to the east. Part of the greater Geelong urban area occurs in the bioregion, with significant semi-urban areas and residential sub-divisions occurring along coastal areas, at the outskirts of Geelong and on the Bellarine Peninsula. Other coastal areas are popular tourist destinations.

MURRAY FANS

TOTAL BIOREGION 435,153 ha

- Largely-intact landscape Nil
- Fragmented landscape 435,153 ha – 100%



FRAGMENTED LANDSCAPE

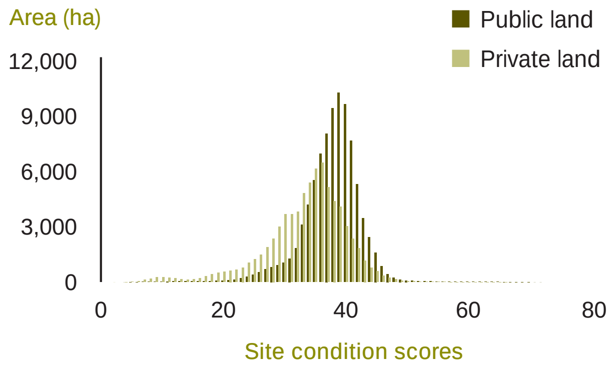
- Native vegetation extent 160,856 ha – 37.0%
  - On public land [total] 86,966 ha – 20.0%
    - In conservation reserves 45,268 ha – 10.4%
    - In other public land categories 41,698 ha – 9.6%
  - On private land 73,889 ha – 17.0%
- Not native vegetation 274,297 ha – 63.0%

KEY FINDINGS

The Murray Fans is one of three bioregions along the Murray River floodplain downstream of the Ovens junction. The Murray Fans is highly connected but contains native vegetation of poor to very poor site condition. The riparian zones and recently active floodplains are mostly public land. These areas have retained much of their original native vegetation but are of poor site condition because of reduced floodplain inundation in the decade before 2005 when assessments were made. Much of the native vegetation on private land was once on the active floodplain but has been separated from it by levees and has been degraded as a result of agricultural use. In these areas – and particularly those parts developed for irrigation between Cobram and Nathalia, Leitchville and Kerang, and Swan Hill and Woorinen – native vegetation loss has left relictual landscapes surrounded by the variegated landscapes that dominate the bioregion.

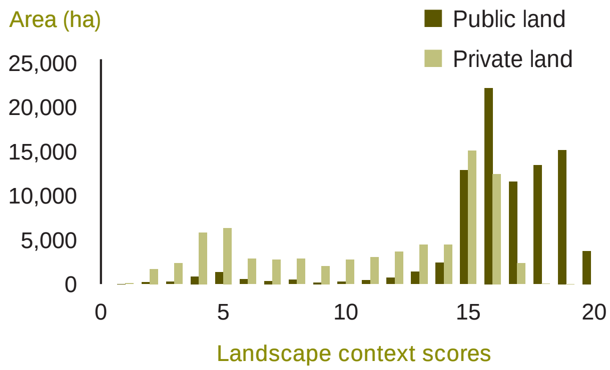
A little more than one third of the original extent of native vegetation remains (37%), of which more than half is on public land, with half of that in conservation reserves. A number of these reserves make up connected linear landscapes along the Murray River. These landscapes are intermittently broken by highly cleared land; notably in the region between Koondrook and Nyah. With the exception of the 1,000+ ha patch size, the proportion by area of all patch size classes on private land is greater than that on public land.

Distribution of site condition scores



Public land median score – 37.8
Private land median score – 33.9
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.0
Private land median score – 12.3
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Murray Fans is characterised by a flat to very gently undulating landscapes on recent unconsolidated sediments with evidence of former river and stream systems and broad floodplains. Alluvial deposits from the Cainozoic period have given rise to the red brown earths and texture contrast soils that support a mosaic of Plains Grassy Woodland, Pine Box Woodland, Riverina Plains Grassy Woodland and Riverina Grassy Woodland EVCs.

Average annual rainfall across the bioregion: 300-400 mm
Daily mean temperature across the bioregion: 15-18°C

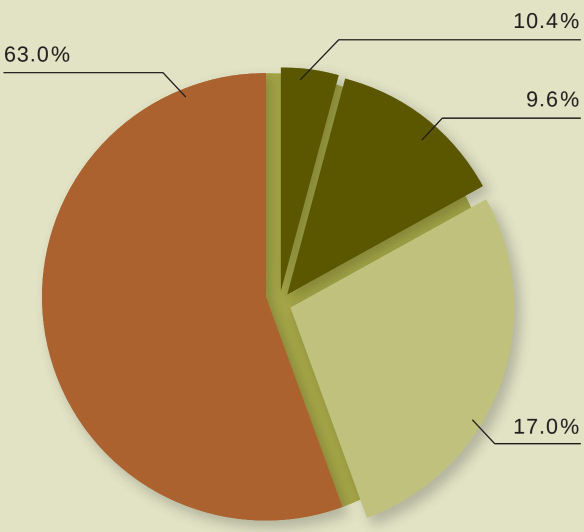
LAND USE HISTORY

The resources of the Murray River and associated forests have sustained European settlement since 1836. The Murray Fans was settled early by pastoralists and the local river red gum forests were heavily cut as fuel for the Murray River paddle-steamers, housing, firewood and a variety of other uses capitalising on its comparative durability particularly when water-logged. Subsequent waves of settlement occurred following World War I and II, when parcels of land were allotted to soldiers returning from war and flood protection and irrigation infrastructure was installed.

CENTRAL VICTORIAN UPLANDS

TOTAL BIOREGION 1,217,609 ha

- Largely-intact landscape 33,282 ha – 2.7%
- Fragmented landscape 1,184,327 ha – 97.3%



FRAGMENTED LANDSCAPE

- Native vegetation extent 527,251 ha – 44.5%
  - On public land [total] 201,969 ha – 17.0%
    - In conservation reserves 52,244 ha – 4.4%
    - In other public land categories 149,725 ha – 12.6%
  - On private land 325,282 ha – 27.5%
- Not native vegetation 657,076 ha – 55.5%

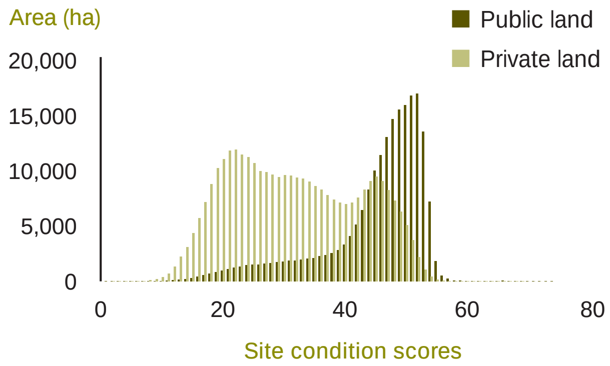
KEY FINDINGS

The Central Victorian Uplands is a moderately cleared bioregion of which 3% is largely intact. In the fragmented landscape, native vegetation remains over almost half the bioregion and more than one third of this is on public land. A relatively small proportion is within the conservation reserve system. Site condition scores of native vegetation on public land are typically higher than those on private land. Overall though, site condition scores are generally much lower than those of other moderately cleared bioregions. Landscape context scores for both public and private land are similar. In all patch size classes, including the largest (1,000+ ha), the proportion of total area on private land is greater than that on public land.

Remaining forest stands are largely on the foothills whilst flatter more fertile plains have been extensively cleared for agriculture. Significant patches of remnant native vegetation of high quality and connectivity adjoin the largely-intact landscape of the Wombat Forest (including, for example, in the Trentham-Daylesford area) or are centred on conservation reserves such as Mt Buangor, Langi Ghiran and Enfield State Parks and Lake Eildon National Park.

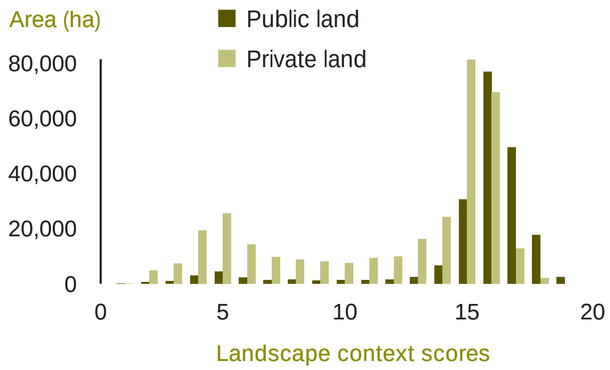
Heavily cleared areas tend to be around older towns on flatter terrain, such as Kyneton and Mansfield.

Distribution of site condition scores



Public land median score – 47.1
Private land median score – 30.4
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.6
Private land median score – 14.0
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Central Victorian Uplands is characterised by gently undulating terrain with occasional steeper slopes, ridges and peaks. Geology is more varied than most bioregions, comprising Palaeozoic sediments transformed and intruded by igneous incursions and raised by earth movements. Subsequently, there has been relatively little geological activity other than erosion subduing the topography, exposing the granitic intrusions and associated metamorphics, and forming features such as outwash fans. The upper slopes and ridges support dry forest and woodland ecosystems. The low lying fertile plains are dominated by open eucalypt (e.g. red box, stringybark, broad-leafed peppermint) and *Allocasuarina* forest and woodlands with a diverse ground layer of grasses, herbs and shrubs. A number of regionally important rivers traverse the region, including the Goulburn, Broken, Campaspe and Loddon Rivers.

Average annual rainfall across the bioregion: 600-1000 mm
Daily mean temperature across the bioregion: 15-21˚C

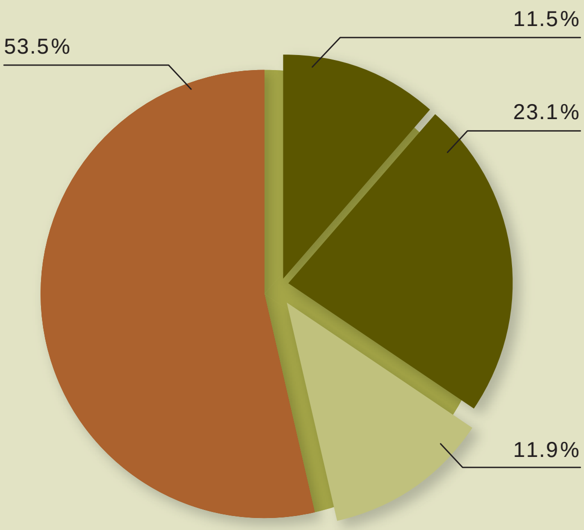
LAND USE HISTORY

The bioregion was first taken up by squatters in the 1830s and then by miners during the gold rush from the 1850s onwards – particularly around Ballarat (the centre of which is just inside the adjoining Victorian Volcanic Plain bioregion) and Clunes. During this period, much of the vegetation of the goldfields was cleared and the top layer of soils dug over. Other major settlement periods included two waves of soldier settlements after World War I and World War II. Currently the main land-use activities are sheep and cattle grazing, cropping, viticulture and – in native forests – apiculture. In more recent times there has been an upsurge of small acreage purchased as lifestyle properties.

GLENELG PLAIN

TOTAL BIOREGION 398,828 ha

- Largely-intact landscape Nil
- Fragmented landscape 398,828 ha – 100%



FRAGMENTED LANDSCAPE

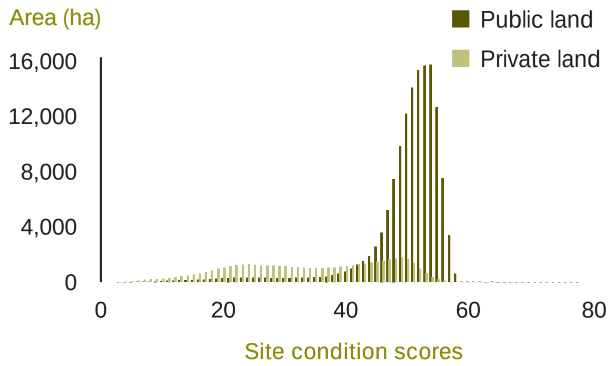
- Native vegetation extent 185,536 ha – 46.5%
  - On public land [total] 138,074 ha – 34.6%
    - In conservation reserves 45,830 ha – 11.5%
    - In other public land categories 92,244 ha – 23.1%
  - On private land 47,462 ha – 11.9%
- Not native vegetation 213,292 ha – 53.5%

KEY FINDINGS

The Glenelg Plain has just over half of the original extent of native vegetation remaining, mostly in substantial patches of relatively intact vegetation. Most remnant native vegetation is on public land and a moderate proportion (11.5%) of the bioregion is in the conservation reserve system. The site condition and landscape context scores for native vegetation are noticeably higher on public land than private land. The proportion by area of patch size categories smaller than 250 ha is greater on private land than public land. Conversely the proportion by area of patch sizes larger than 250 ha is greater on public land, particularly in the 1,000+ ha patch size class.

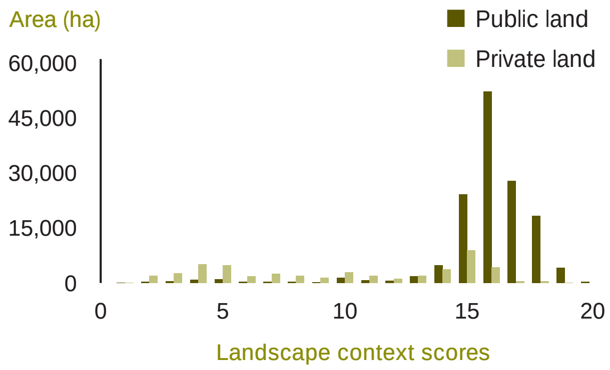
Substantial patches of good quality vegetation are found in largely public land in and adjoining Lower Glenelg National Park in the south and Dergholm State Park in the north, and in an extensive corridor – of mostly state forest – between these two parks. Linear stretches of poor condition native vegetation, associated with ancient sand dunes, are scattered throughout the bioregion.

Distribution of site condition scores



Public land median score – 51.0
Private land median score – 34.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.6
Private land median score – 9.6
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Glenelg Plain is the Victorian part of the Naracoorte Coastal Plain IBRA region. The bioregion is predominantly flat and low lying, ranging from sea level to less than 200 metres above sea level. It features a series of long low narrow parallel dune limestone ridges with intervening swamps, closed limestone depressions and some young volcanoes. These Cainozoic deposits give rise to pale acidic sandy dunes and humic acid sands on the flats.

Floristically, the bioregion is varied. Coastal communities are composed of beach and dune vegetation (Heathy Herb-rich Woodland and Damp Sands Herb-rich Woodland). Wet heathlands occur on infertile soils. Woodlands (Heathy and Plains Woodlands) occur through much of the bioregion, particularly in the north.

The Glenelg River and its tributaries the Wannon and Crawford are the area's most significant waterways. The smaller Fitzroy and Surrey Rivers flow across the south-eastern portion of the Glenelg Plain.

Average annual rainfall across the bioregion: 700-800 mm
Daily mean temperature across the bioregion: 12-15°C

LAND USE HISTORY

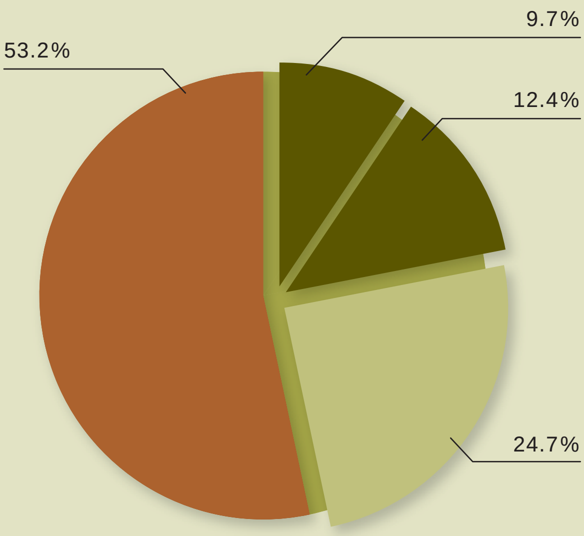
Portland was one of the first European settlements in Victoria with activities generally confined to the coast until native grasslands and grassy woodlands were discovered. An expanding pastoral industry was quickly established in and around the bioregion. Much of the sandy soil areas of the Glenelg Plain have been cleared for agriculture and plantations. Following World War II broad-scale *Pinus radiata* plantations were established in areas bordering South Australia. Establishment of pine and blue gum plantations continues. Centre pivot irrigation has recently become prominent in the area between Strathdownie and the South Australian border.

Broad-scale drainage works have drained numerous wetland (native marsh and riparian vegetation) systems although the nationally significant Mundi-Selkirk wetlands (near the South Australian border west of Casterton) and Lindsay Werrikoo wetlands (between Lindsay near the South Australian border and Wilkin, east of Strathdownie) remain.

NORTHERN INLAND SLOPES

TOTAL BIOREGION 565,808 ha

- Largely-intact landscape 730 ha – less than 1%
- Fragmented landscape 565,078 ha – ~100%



FRAGMENTED LANDSCAPE

- Native vegetation extent 264,187 ha – 46.8%
  - On public land [total] 124,476 ha – 22.1%
    - In conservation reserves 54,650 ha – 9.7%
    - In other public land categories 69,826 ha – 12.4%
  - On private land 139,711 ha – 24.7%
- Not native vegetation 300,891 ha – 53.2%

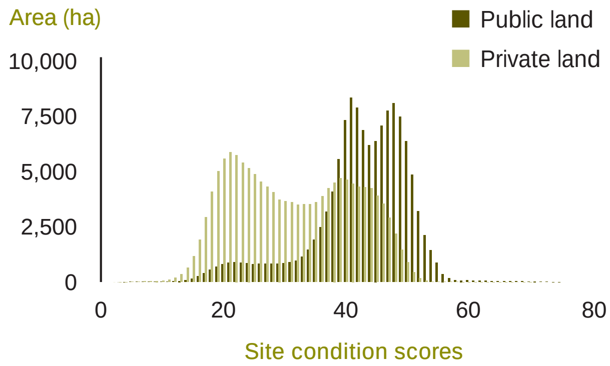
KEY FINDINGS

This bioregion has just under half its original native vegetation remaining, only a very small area of which is largely intact. Almost half of the remnant native vegetation is on public land (22% of the original extent) and almost half of this is in conservation reserves. The median site condition and landscape context scores on public land are greater than those for private land. However, the overall site condition score is much lower than those of other moderately cleared bioregions. In all patch size classes, the proportion by area on private land is greater than that on public land, except for the largest patches (1,000+ ha).

Landscape patterns on both public and private land are a mix of fragmented, variegated and better connected landscapes. Outliers in the west of the bioregion, surrounded by the Victorian Riverina bioregion – including in the Mt Hope and Terrick Terrick area – are most highly fragmented and are more relictual. Towards the east, adjacent to the Highlands – Northern Falls bioregion, more substantial patches of native vegetation of high connectivity occur. Other significant areas of extensively connected landscapes include:

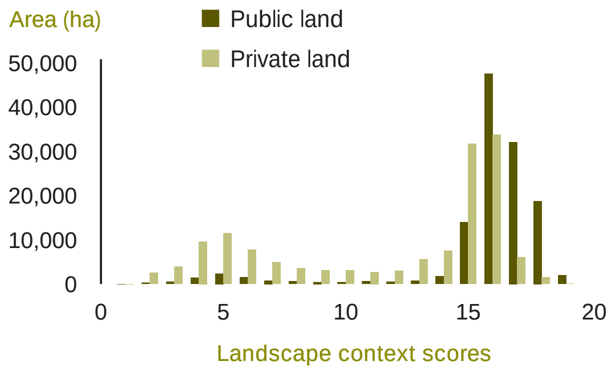
- the Warby Ranges (north-west of Wangaratta)
- landscapes between Beechworth and Chiltern
- areas south of the Murray River, east of Wodonga.

Distribution of site condition scores



Public land median score – 43.0
Private land median score – 30.4
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.9
Private land median score – 14.1
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

This bioregion has clear affinities with the Victoria's Goldfields bioregion but at the national level it forms part of the (New South Wales) South West Slopes bioregion that extends along the inland slopes of the Great Dividing Range well into central New South Wales. Many distinctive characteristics – such as mugga ironbark and white box predominating on low hills, rather than the red ironbark and grey box of the Goldfields – are reflected in this alignment with similar environments to the north. The Northern Inland Slopes consists of small ranges and foothill slopes separated by river valleys that drain from the High Country to the Murray River. The ranges and slopes are a mix of complex geology of granitic and metamorphic origin protruding through the riverine plain. The vegetation is dominated by dry forests and grassy understoreys. The less fertile hills support Box-Ironbark, Heathy and Shrubby Dry Forests. The fertile plains and valleys support riverine and grassy forests. The major rivers draining from the highlands include the Broken, King, Ovens and Kiewa Rivers.

Average annual rainfall across the bioregion: 400-1000 mm
Daily mean temperature across the bioregion: 12-18˚C

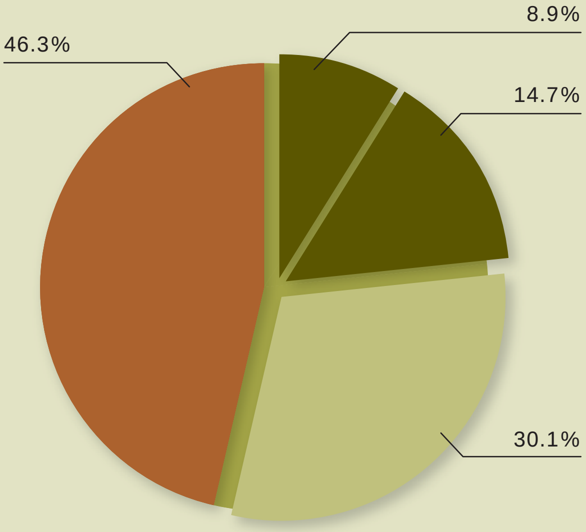
LAND USE HISTORY

Pastoralists were the first European settlers in the district. As with other bioregions in north central Victoria, some areas were mined during the goldrush of the 1850s. Following the exhaustion of goldmining, agriculture became the major human activity in the bioregion. The fertile valleys have been utilised extensively for dairying and cereal cropping. On the less fertile hills sheep and cattle grazing are the major agricultural activities. Until more recent times, timber harvesting – mostly for firewood, rail sleepers and fence posts was also a significant land-use activity.

GOLDFIELDS

TOTAL BIOREGION 1,325,762 ha

- Largely-intact landscape Nil
- Fragmented landscape 1,325,762 ha – 100%



FRAGMENTED LANDSCAPE

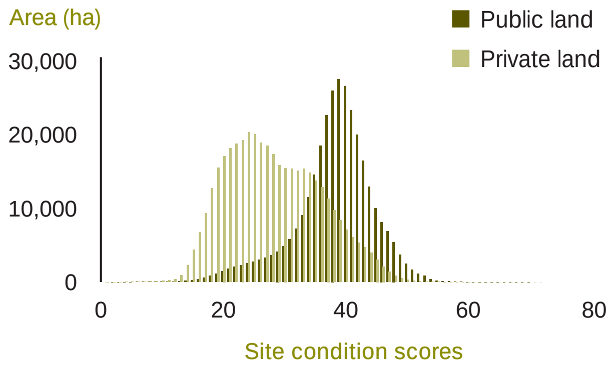
- Native vegetation extent 711, 954 ha – 53.7%
  - On public land [total] 313,496 ha – 23.6%
    - In conservation reserves 117,986 ha – 8.9%
    - In other public land categories 195,510 ha – 14.7%
  - On private land 398,457 ha – 30.1%
- Not native vegetation 613,808 ha – 46.3%

KEY FINDINGS

The Goldfields bioregion is moderately cleared. More than half the bioregion has retained native vegetation and the overall pattern of clearance tends to be a mix of variegated and fragmented. Twenty-three percent of the remaining extent of native vegetation occurs on public land of which less than a tenth is on roadsides. A moderate proportion of the bioregion is in conservation reserves (8.9%). In all patch size classes the proportion of private land by area is slightly greater than that on public land, although they are similar in the 1,000+ ha class. The proportion of cleared land in the landscape increases towards the west, particularly in areas adjoining agricultural land in the Wimmera and Victorian Volcanic Plain bioregions. In some localised areas native vegetation is either relictual or on roadsides.

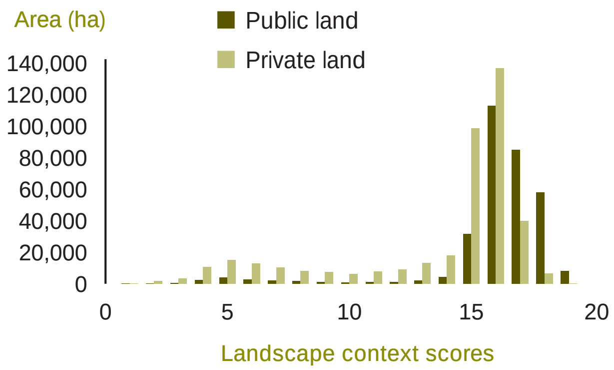
Overall the Goldfields bioregion has a relatively high proportion of remnant native vegetation of high connectivity. On the other hand, site condition scores – and particularly those on private land – are conspicuously lower than the comparable scores of other moderately cleared bioregions. This indicates that the Goldfields contains a high proportion of structurally modified native vegetation, most likely caused by past mining practices. Areas retaining native vegetation that is both highly connected and of good site condition are not extensive. These occur near Fryers Ridge, Castlemaine, St Arnaud Range and south-west of Rushworth.

Distribution of site condition scores



Public land median score – 38.3
Private land median score – 26.9
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.9
Private land median score – 14.8
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Goldfields bioregion is characterised by a series of low hills and rolling plains, mainly sedimentary in origin. Metamorphic and old volcanic rocks form rugged slopes and ridges. The forests and woodlands have relatively poor soils and uncertain rainfall. Grassy Woodland and Grassy Forests dominate the bioregion. Box Ironbark Forest, Heathy Dry Forest and Grassy Dry Forest vegetation types occur on the lower slopes and poor soils. Regionally important rivers that dissect the bioregion include the Wimmera, Avoca, Loddon and Campaspe Rivers.

Average annual rainfall across the bioregion: 400-1000 mm
Daily mean temperature across the bioregion: 15-21˚C

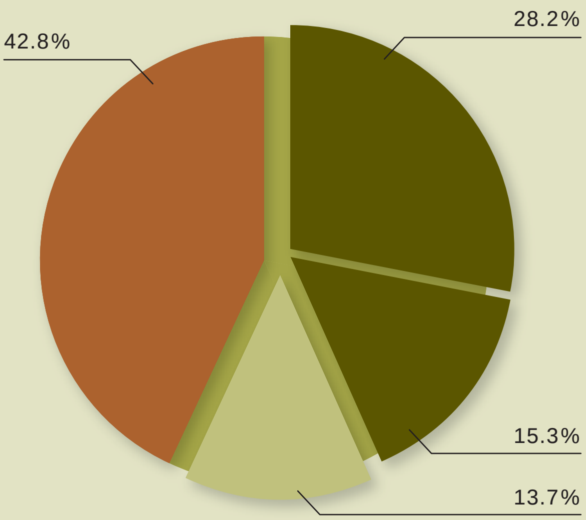
LAND USE HISTORY

Since European settlement, much of the bioregion has been cleared and greatly modified by mining, timber extraction and agriculture. The bioregion was settled early; first by pastoralists, but the discovery of alluvial gold in the 1850s saw a wave of immigration and extensive areas of the region cleared for timber and mined. In more recent times, grazing and timber harvesting have decreased enabling some regeneration. The native forests of the Goldfields comprise the core of Victoria’s large apiculture industry. Some areas in close proximity to Melbourne and the major economic centres have been sub-divided for residential and lifestyle blocks.

LOWAN MALLEE

TOTAL BIOREGION 1,419,874 ha

- Largely-intact landscape 907,039 ha – 63.9%
- Fragmented landscape 512,835 ha – 36.1%



FRAGMENTED LANDSCAPE

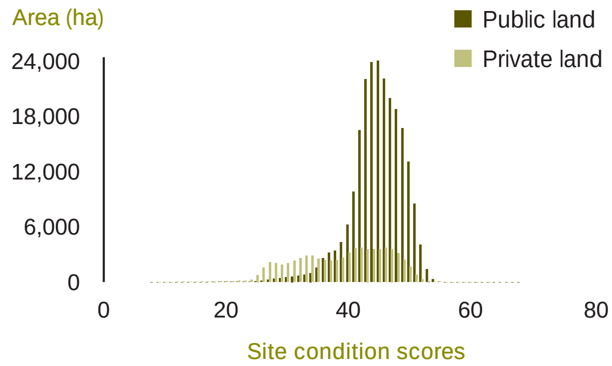
- Native vegetation extent 293,303 ha – 57.2%
  - On public land [total] 223,249 ha – 43.5%
    - In conservation reserves 144,542 ha – 28.2%
    - In other public land categories 78,707 ha – 15.3%
  - On private land 70,054 ha – 13.7%
- Not native vegetation 219,532 ha – 42.8%

KEY FINDINGS

Due to the unsuitability of the dry sandy soils for agriculture, more than half of the Lowan Mallee remains largely-intact. Beyond this – in the fragmented landscape – 57% of native vegetation remains. A high proportion of remnant native vegetation occurs on public land (43.5%), with good representation in the reserve system (28.2% of the total fragmented landscape). The proportion by area of all patch size categories is slightly greater on private land than public land, except the largest patches (1,000+ ha) where the proportion by area is substantially greater on public land compared to private land. These patches contribute to the high site condition and landscape context scores on public land in the bioregion.

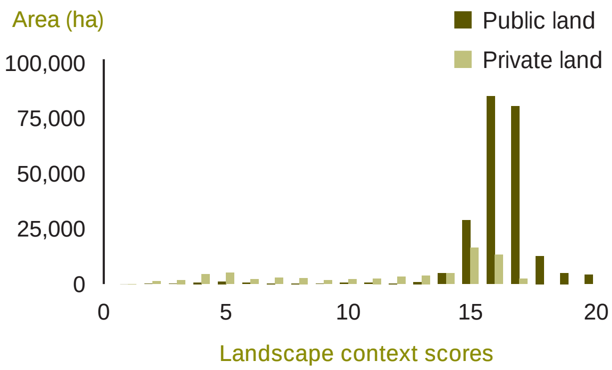
Areas in the fragmented landscape cleared of vegetation occur along the boundary of the bioregion where the sandy soils merge with the heavier, more fertile soils of the Murray Mallee and Wimmera bioregions. This is particularly evident south of the Big Desert Wilderness Area where native vegetation has been cleared for agriculture. Although native vegetation here is fragmented, remnants remain moderate in connectivity and site condition, and linear roadsides feature strongly. Of the remnants that occur at least partly outside the largely-intact landscapes, Annuello, Wathe and Bronzewing Nature Conservation Reserves are exceptionally significant within the state in terms of size, connectivity and vegetation quality.

Distribution of site condition scores



Public land median score – 44.6
Private land median score – 39.5
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.9
Private land median score – 13.3
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

Lowan Mallee is typified by white siliceous sand formed into a complex array of high irregular and parabolic sand-dunes traversing Woorinen Sands at three locations corresponding roughly to the Sunset Country, and the Big and Little Deserts. The vegetation is dominated by Lowan Sands Mallee, with some Chenopod Mallee in the region of the Sunset Country, while Mallee-heath, Loamy Mallee, Scrub Pine Woodland, Broombush and Red-swale mallee vegetation types occur in the Big and Little Deserts, further south in the bioregion.

Average annual rainfall across the bioregion: 300-600 mm
Daily mean temperature across the bioregion: 12-18˚C

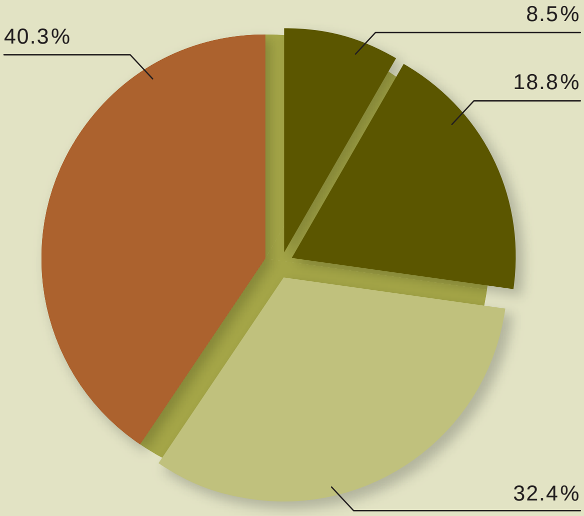
LAND USE HISTORY

The Lowan Mallee is dominated by poor soils, unfavourable for agriculture. Agricultural activities, mostly in the form of broadacre wheat cropping, are generally confined to the margins of the bioregion where the Lowan Sands merge into heavier more fertile soils. Remnant native vegetation of the Lowan Mallee is important to apiarists. As a consequence, much of the bioregion remains intact and contains the Murray-Sunset, Little Desert and Wyperfeld National Parks, the Big Desert Wilderness Area and Annuello Nature Conservation Reserve.

HIGHLANDS – SOUTHERN FALL

TOTAL BIOREGION 1,196,155 ha

- Largely-intact landscape 795,761 ha – 66.5%
- Fragmented landscape 400,394 ha – 33.5%



FRAGMENTED LANDSCAPE

- Native vegetation extent 238,959 ha – 59.7%
  - On public land [total] 109,113 ha – 27.3%
    - In conservation reserves 33,830 ha – 8.5%
    - In other public land categories 75,283 ha – 18.8%
  - On private land 129,846 ha – 32.4 %
- Not native vegetation 161,435 ha – 40.3%

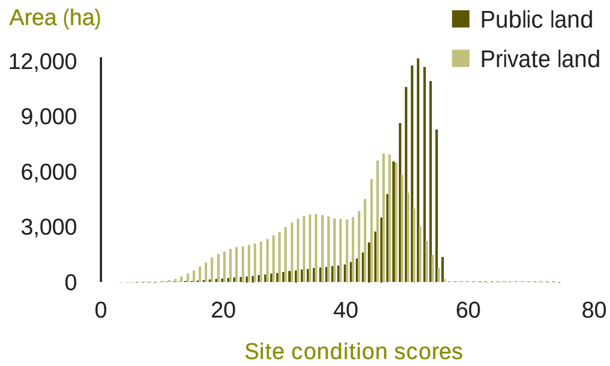
KEY FINDINGS

One third of the Highlands – Southern Fall bioregion is fragmented. Within the fragmented landscape extensive areas of native vegetation remain (59.7%) of which almost half is on public land. A moderate proportion is within conservation reserves (8.4% of the total fragmented landscape), many of which extend into the largely-intact landscape. The largest parks and conservation reserves are Kinglake National Park, Yarra Ranges National Park, Bunyip State Park, Sweetwater Creek Nature Conservation Reserve and Tyers Park. These reserves contribute to the overall higher site condition and landscape context scores for public land compared to private land.

The majority of land clearing and human occupation within the bioregion is at elevations below 300 metres. On the gentle slopes and the fertile lowland valleys where agricultural, timber and semi-rural developments occur, the native vegetation is increasingly fragmented. Areas that have been significantly cleared and modified include the Yarra and Tarago Valleys. Here, many thousands of relictual patches, less than one hectare occur. Outside these valleys a significant proportion of the vegetation is a single patch (46% of the fragmented landscape) contiguous with the largely-intact landscape. The proportion by area of all patch size classes is slightly greater on private land compared to public land, with the exception of the 1,000+ ha class. Areas of public and private land that are variegated in landscape pattern and retain connectivity to the largely-intact landscape include those bounded by:

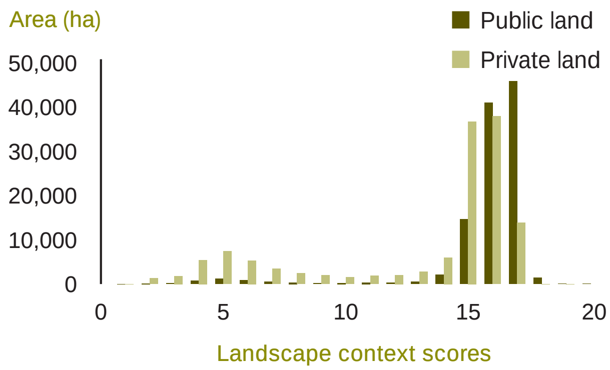
- Mt Dandenong, Ferntree Gully and Belgrave
- Warrandyte, Eltham, Hurstbridge and Christmas Hills and
- between Berwick and Beaconsfield.

Distribution of site condition scores



Public land median score – 50.1
Private land median score – 40.2
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.8
Private land median score – 14.2
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Victorian Highlands – Southern Fall is part of the southern slopes of the Great Dividing Range. These uplands have moderate to steep slopes, high plateaux and alluvial flats along the main valleys. The geology predominantly consists of Palaeozoic sediments and minor volcanics. Brown and red porous earths occur in the upper reaches and yellow and red texture contrast soils graduate down the valleys.

The Highlands – Southern Fall contains Victoria's most extensive areas of Cool Temperate Rainforest. The dominant vegetation types are Shrubby Dry Forest and Damp Forest on the upper slopes. Wet Forest ecosystems occur in the valleys. Montane Dry Woodland, Montane Damp Forest and Montane Wet Forest occur at higher elevations. The gullies and river valleys support a variety of ecological vegetation classes including Riparian Forest, Riparian Thicket and Montane Riparian Thicket.

Average annual rainfall across the bioregion: 700-1200 mm
Snowfall is common above 900 m in winter.
Daily mean temperature across the bioregion: 6-15˚C

LAND USE HISTORY

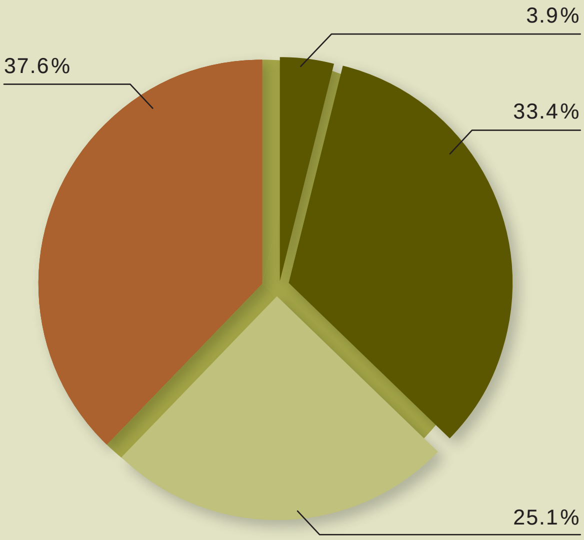
Early European settlement was sparse and concentrated on the gently undulating areas on the fringes of the bioregion. The extensive Mountain Ash forests in the southern and western parts of the bioregion have supported timber harvesting industries since the 19th Century. The bioregion also contains significant areas of pine and eucalypt plantations. Other land-use activities include sheep and cattle grazing and dairying. Some public land areas are also used for grazing and apiculture. Tourism and recreation are significant land uses in some of the more elevated parts of the bioregion.

The highlands are significant water catchment areas supplying the majority of water for Melbourne and irrigated agriculture and power generation in the adjoining Gippsland Plain bioregion. Major impoundments include the Thomson Dam, Lake Glenmaggie, Blue Rock Lake, and the Upper Yarra and Maroondah reservoirs.

EAST GIPPSLAND LOWLANDS

TOTAL BIOREGION 531,830 ha

- Largely-intact landscape 357,394 ha – 67.2%
- Fragmented landscape 174,436 ha – 32.8%



FRAGMENTED LANDSCAPE

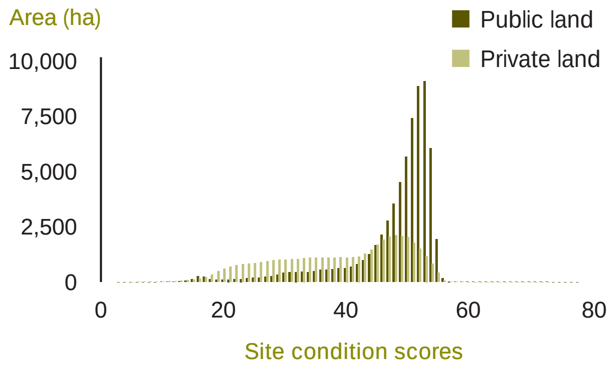
- Native vegetation extent 108,839 ha – 62.4%
  - On public land [total] 65,080 ha – 37.3%
    - In conservation reserves 6,724 ha – 3.9%
    - In other public land categories 58,356 ha – 33.4%
  - On private land 43,760 ha – 25.1%
- Not native vegetation 65,597 ha – 37.6%

KEY FINDINGS

The East Gippsland Lowlands bioregion is moderately cleared. More than half of the original extent of native vegetation in the fragmented landscape remains. Over half is on public land, although only a small proportion (3.9%) is within conservation reserves. Site condition and landscape context scores for public and private land are similar. By area, public land accounts for a large majority of the largest (1,000+ ha) patches, while in other patch size classes private land dominates by area.

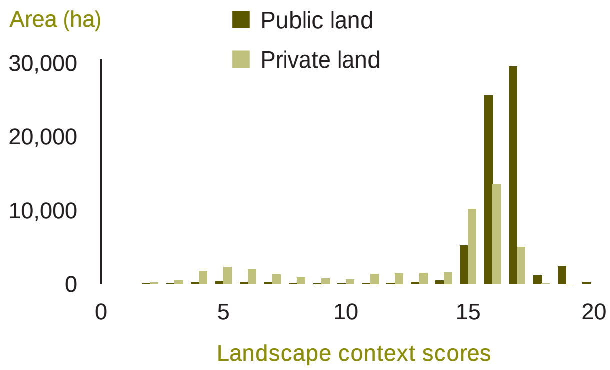
Extensive clearing has been confined largely to the western finger of the bioregion east to Lakes Entrance and Bruthen where agricultural activities dominate. Remnant native vegetation contiguous with the largely-intact landscape is of good site condition and variegated in pattern. The flatter land adjacent to the Gippsland Plain is heavily fragmented. Scattered within the largely-intact landscape are cleared areas associated with major townships along the Princes Highway such as Orbost and Cann River.

Distribution of site condition scores



Public land median score – 50.1
Private land median score – 40.3
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.0
Private land median score – 14.6
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The East Gippsland Lowlands bioregion has gently undulating terraces flanked by coastal plains, dunefields and inlets. The geology is a complex of Palaeozoic and Cainozoic deposits predominantly of granite, sands, marine sediments and beach deposits giving rise to yellow texture contrast soils on the terraces, leached sands of the coastal plains and dunes, friable earths and texture contrast soils along the floodplains and valleys.

The vegetation is dominated by Lowland Forest with Damp Forest and Shrubby Dry Forest interspersed throughout the foothills; Banksia Woodland and Riparian Scrub Complex are common in coastal areas.

Average annual rainfall across the bioregion: 700-1100 mm
Daily mean temperature across the bioregion: 15-18°C

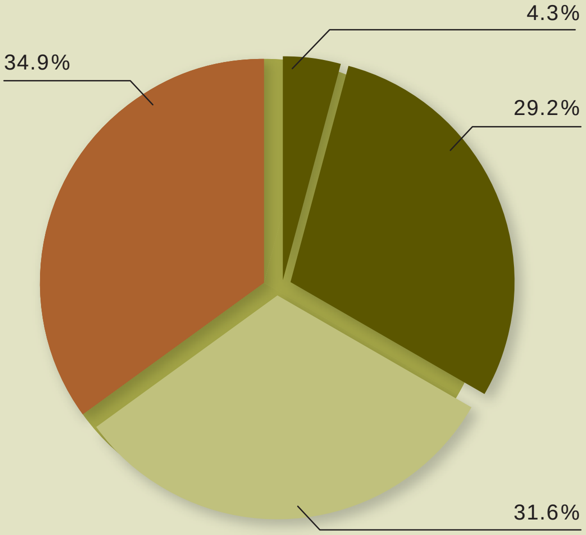
LAND USE HISTORY

Settlement by Europeans has been largely confined to the coastal plains, fertile alluvial valleys and some parts of the tablelands. Settlement was gradual until the late 19th Century when the discovery of gold, the land selection acts, and the arrival of the railway accelerated development. Grazing was the major land-use activity until commencement of the timber industry on a large scale in the 1950s. Tourism is a significant industry in the coastal towns.

MONARO TABLELANDS

TOTAL BIOREGION 74,821 ha

- Largely-intact landscape 27,120 ha – 36.2%
- Fragmented landscape 47,701 ha – 63.8%



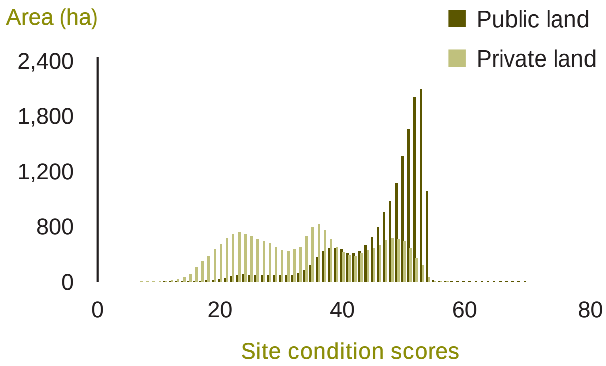
FRAGMENTED LANDSCAPE

- Native vegetation extent 31,065 ha – 65.1%
  - On public land [total] 15,985 ha – 33.5%
    - In conservation reserves 2,052 ha – 4.3%
    - In other public land categories 13,933 ha – 29.2%
  - On private land 15,080 ha – 31.6%
- Not native vegetation 16,636 ha – 34.9%

KEY FINDINGS

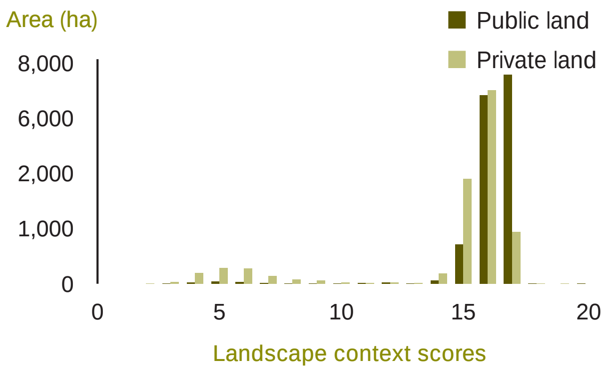
The Monaro Tablelands is a relatively small bioregion surrounded by largely-intact landscapes. Within the bioregion, more than half of the original native vegetation occurs in the fragmented landscape. Of this, half (33.5% of the total fragmented landscape) is on public land with a small proportion in conservation reserves (4.3%). In each patch size class, the proportion by area is similar or slightly greater on private land than on public land. Native vegetation contiguous with adjoining largely-intact landscapes is of good quality and high connectivity. In the more cleared areas, site condition is poor but connectivity is relatively moderate. Vegetation clearance is dominated by variegated and fragmented patterns.

Distribution of site condition scores



Public land median score – 49.0
Private land median score – 33.9
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.9
Private land median score – 15.2
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

This bioregion covers the Victorian section of the Monaro Tablelands, the vast majority of which occurs further north into New South Wales. That is, the bioregion is part of a higher-altitude tableland adjacent to the Alps that consists of undulating rises and occurrences of low hills and depositional flats with soils of high organic content. The geology is Palaeozoic consisting of granitic and sedimentary deposits.

The vegetation is dominated by Montane Dry Woodland, Montane Grassy Woodland, Montane Riparian Woodland and Tableland Damp Forest EVCs.

Average annual rainfall across the bioregion: 700-1400 mm
Daily mean temperature across the bioregion: 6-12˚C

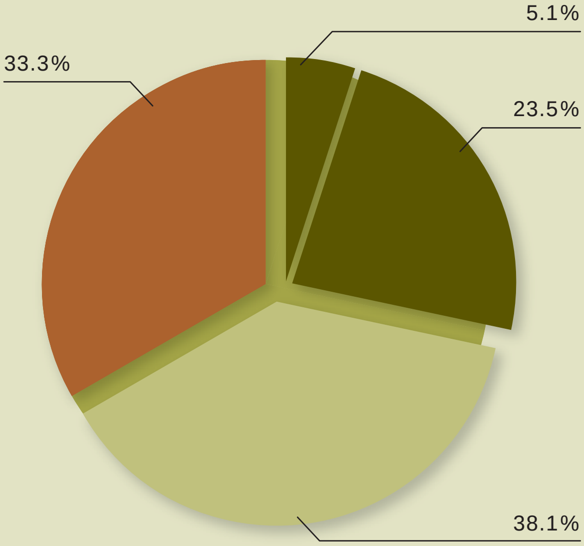
LAND USE HISTORY

The Monaro Tablelands were settled by pastoralists for beef and wool growing. In the climatically favourable areas prime lamb is also farmed. Timber harvesting is a major land use. It commenced around Bendoc in the 1850s and expanded rapidly from the 1950s.

EAST GIPPSLAND UPLANDS

TOTAL BIOREGION 791,031 ha

- Largely-intact landscape 632,514 ha – 80.0%
- Fragmented landscape 158,517 ha – 20.0%



FRAGMENTED LANDSCAPE

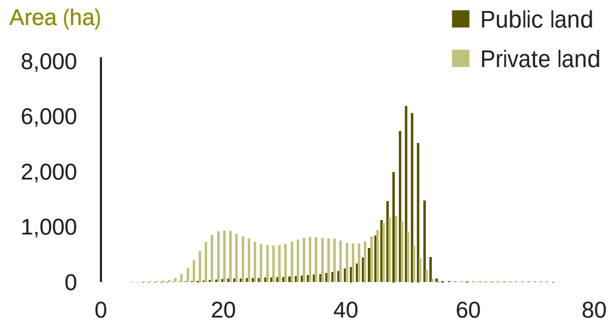
- Native vegetation extent 105,717 ha – 66.7%
  - On public land [total] 45,259 ha – 28.6%
    - In conservation reserves 8100 ha – 5.1%
    - In other public land categories 37,159 ha – 23.5%
  - On private land 60,459 ha – 38.1%
- Not native vegetation 52,800 ha – 33.3%

KEY FINDINGS

Eighty percent of the East Gippsland Uplands bioregion is largely intact. Outside the largely-intact landscape a high proportion of native vegetation remains (66.7%), more than a third of which is on public land with a small proportion in the conservation reserve system (5.1%). In every patch size class, the total area of native vegetation on private land is slightly greater than that on public land.

The pattern of clearance in the fragmented landscape is dominated by variegated and fragmented patches of native vegetation with small areas relatively heavily cleared. Site condition tends to be moderate to poor depending on the extent of fragmentation. Small pockets of fragmented vegetation occur around Buldah and Combienbar in the far east of the bioregion (north of Cann River). A moderate amount of vegetation has been cleared along the Deddick River Road, between Bonang and Deddick in the far north-east of the bioregion. The flatter terrain of the Gelantipy Road (north of Buchan), the southern end of the Great Alpine Road (Swifts Creek to Tambo Crossing), and around Bindi and Omeo has been moderately cleared.

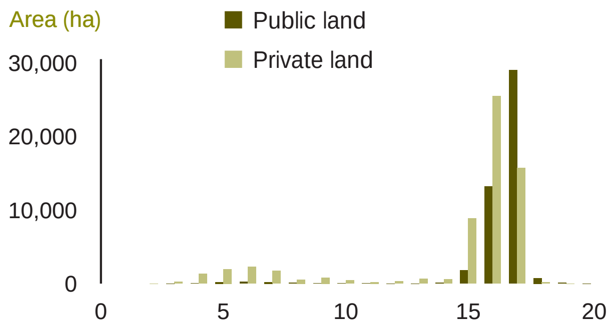
Distribution of site condition scores



Site condition scores

Public land median score – 48.8
Private land median score – 33.9
[Statewide median score – 36.8]

Distribution of landscape context scores



Landscape context scores

Public land median score – 16.2
Private land median score – 15.4
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The East Gippsland Uplands consists of tablelands and mountains up to 1400 metres elevation. The geology stems from Palaeozoic deposits predominantly of granitic and sedimentary origin which give rise to red texture contrast soils and brown and red friable earths. The vegetation is dominated by Shrubby Dry Forest and Damp Forest on the upland slopes and Wet Forest EVCs which are restricted to the higher altitudes; Grassy Woodland, Grassy Dry Forest and Valley Grassy Forest EVCs are associated with major river valleys.

Average annual rainfall across the bioregion: 700-1400 mm
Daily mean temperature across the bioregion: 9-15˚C

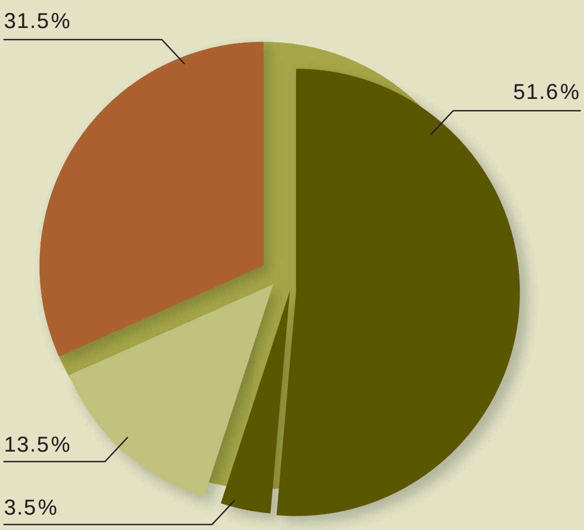
LAND USE HISTORY

The major land use within the East Gippsland Uplands is timber harvesting, but sheep and cattle grazing also occurs. Sheep are grown in areas of lower rainfall around Tubbut. Depending on the elevation, a variety of timbers are harvested from the extensive forests in the region.

BRIDGEWATER

TOTAL BIOREGION 18,110 ha

- Largely-intact landscape Nil
- Fragmented landscape 18,110 ha – 100%



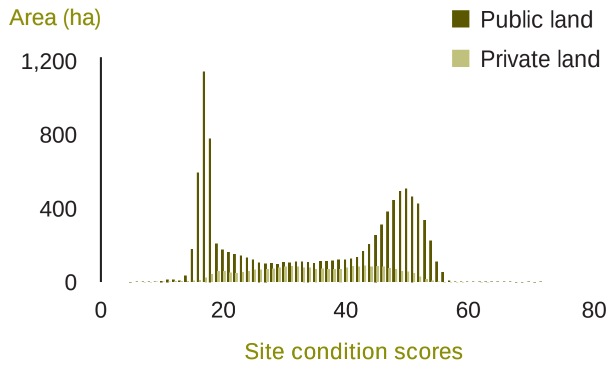
FRAGMENTED LANDSCAPE

- Native vegetation extent 12,414 ha – 68.5%
  - On public land [total] 9,971 ha – 55.1%
    - In conservation reserves 9,337 ha – 51.6%
    - In other public land categories 634 ha – 3.5%
  - On private land 2,443 ha – 13.5%
- Not native vegetation 5,696 ha – 31.5%

KEY FINDINGS

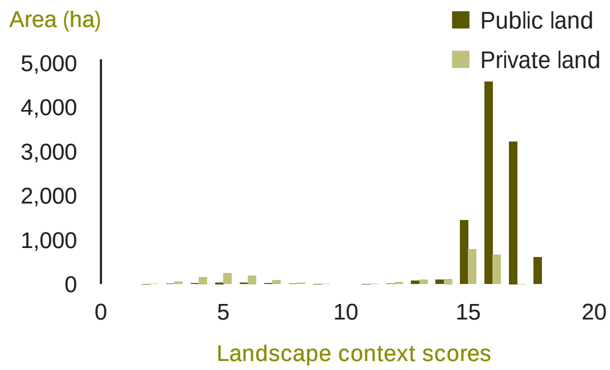
This small bioregion retains a large proportion of the original extent of native vegetation. More than half of native vegetation occurs on public land, mostly within the Discovery Bay Coastal Park and other small reserves (51.6%). Despite these remnants forming a highly connected landscape, overall site condition tends to be poor, interspersed with scattered patches of good quality vegetation. The poor site condition of native vegetation is associated with the highly mobile sand dunes in the east of Discovery Bay Coastal Park. Outside the conservation reserves, with the exception of the coastal fringes, the landscape is heavily cleared. The proportion by area of patch size categories is greater on private land compared to public land with the exception of the 1,000+ ha category which is substantially greater on public land.

Distribution of site condition scores



Public land median score – 36.5
Private land median score – 34.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.7
Private land median score – 14.3
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

Bridgewater bioregion is a thin coastal plain of Tertiary limestones which have been overlain by Upper Pliocene basalts. Along the coastal areas wind and wave action has cut into rock, creating tall cliff faces with overhanging and deep caves. A dune capped sand ridge stretches parallel to the coastline with gently sloping sandy terrain and lagoonal systems behind. The lagoonal system supports a network of deep water pools and collapsed caverns or sink holes. The soils are a combination of siliceous sands on the dunes with underlying calcareous deposits giving rise to Calcarenite Dune Woodland and Coastal Dune Scrub. Wetlands extend intermittently from approximately the Bridgewater Lakes to the shallow estuary of the Glenelg River at Nelson, extending into South Australia.

Average annual rainfall across the bioregion: 600-700 mm
Daily mean temperature across the bioregion: 12-15˚C

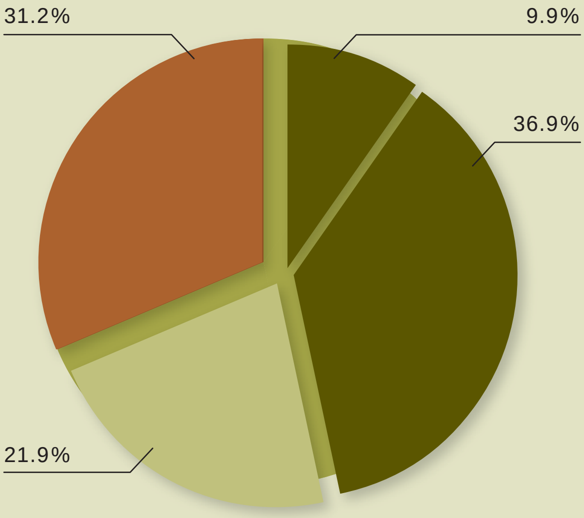
LAND USE HISTORY

Outside the Discovery Bay Coastal Park agriculture is the main land use activity. The dune fields of the bioregion are an unusual feature, constituting the largest area of mobile dunes in Victoria. The extensive areas of bare sand may be partly natural, although it is likely that human activities (pre- and post-European occupation) have extended and accelerated dune erosion. Coastal development of the area, particularly for tourism, is increasing.

HIGHLANDS – NORTHERN FALL

TOTAL BIOREGION 1,415,346 ha

- Largely-intact landscape 770,912 ha – 54.5%
- Fragmented landscape 644,434 ha – 45.5%



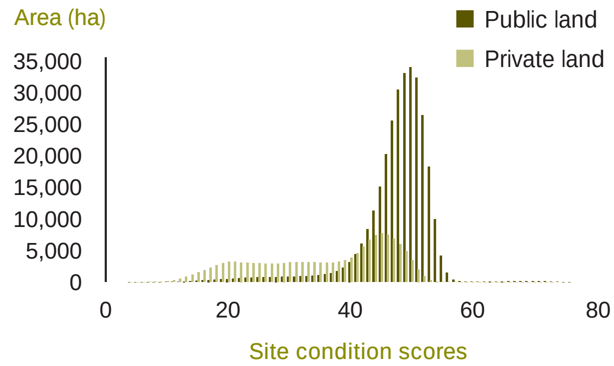
FRAGMENTED LANDSCAPE

- Native vegetation extent 443, 083 ha – 68.8%
  - On public land [total] 301,747 ha – 46.8%
    - In conservation reserves 64,104 ha – 9.9%
    - In other public land categories 237,643 ha – 36.9%
  - On private land 141,336 ha – 21.9%
- Not native vegetation 201,351 ha – 31.2%

KEY FINDINGS

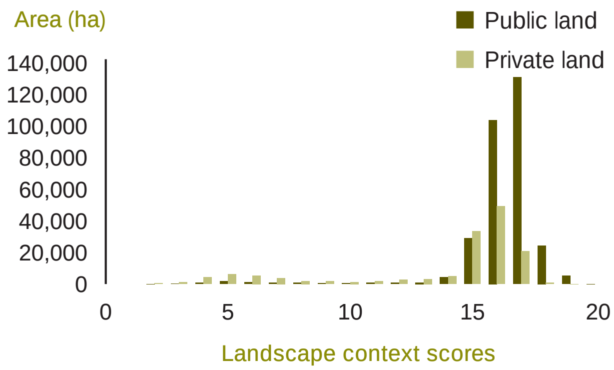
The Highlands – Northern Fall bioregion is one of the moderately cleared bioregions buffered extensively by largely-intact landscapes. The boundary adjacent to the Victorian Alps is largely intact and contiguous with the Victorian Alps. In the fragmented landscape 68.8% of the original native vegetation remains. Most (46.8% of the total fragmented landscape) is on public land with a moderate proportion in conservation reserves (9.9%). Clearing of vegetation is confined to the bioregion boundaries adjacent to the Central Victorian Uplands and the Northern Inlands Slopes as well as around Omeo. Cleared areas are associated with the flatter slopes and river valleys that are more suitable for agriculture. Overall the site condition and landscape context of patches are good. However, much poorer remnants occur in the bioregion isolates surrounded by the Northern Inland Slopes, around Beechworth and Koetong in the far north where extensive softwood plantations have been established. The proportion by area of patch size class is greater on private land compared to public land with the exception of the 1,000+ ha class which is about twice as large on public land.

Distribution of site condition scores



Public land median score – 48.2
Private land median score – 37.8
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.1
Private land median score – 15.0
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

Highlands – Northern Fall bioregion is the northerly aspect of the Great Dividing Range comprising dissected uplands with moderate to steep slopes, high plateaus and alluvial flats along the main valleys. The geology is of Palaeozoic deposits giving rise to predominantly sedimentary and granitic rocks. The brown and red porous earths occur in the upper reaches and yellow and red texture contrast soils graduate down the valleys.

The vegetation is a patchwork of Herb-rich Foothill Forest and Shrubby Dry Forest. Major vegetation types of the lower slopes are Montane Dry Woodland. Heathy Dry Forest EVCs occur on the upper slopes and plateau. Grassy Dry Forest and Valley Grassy Forest occur along the river valleys.

Average annual rainfall across the bioregion: 700-1400 mm
Daily mean temperature across the bioregion: 9-12˚C

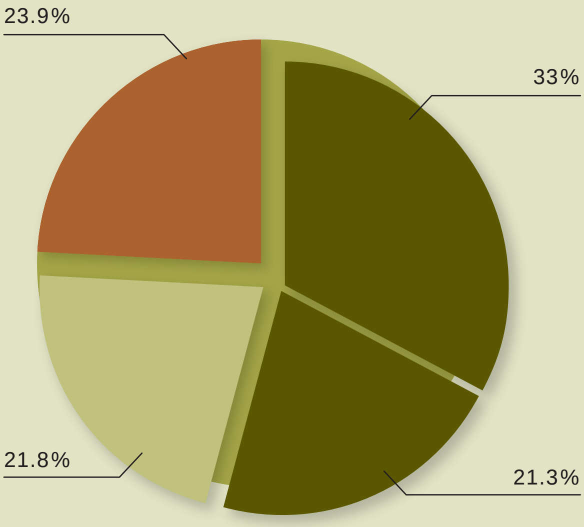
LAND USE HISTORY

The bioregion was settled initially by pastoralists for sheep grazing. The improvement of pastures by the introduction of subterranean clover and super-phosphate has enabled cattle grazing to occur. The bioregion has supported a number of land use activities including mining, dairy farming and timber harvesting.

OTWAY RANGES

TOTAL BIOREGION 149,755 ha

- Largely-intact landscape 47,199 ha – 31.5%
- Fragmented landscape 102,556 ha – 68.5%



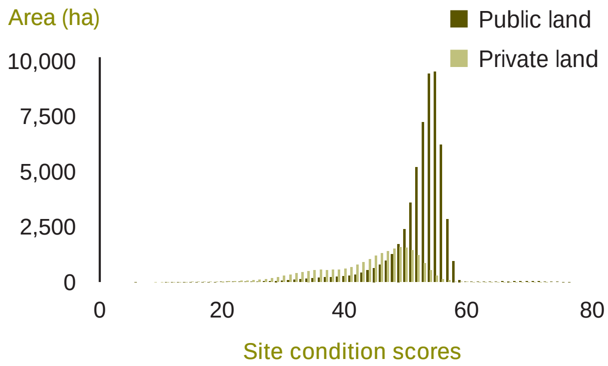
FRAGMENTED LANDSCAPE

- Native vegetation extent 78,064 ha – 76.1%
  - On public land [total] 55,699 ha – 54.3%
    - In conservation reserves 33,874 ha – 33%
    - In other public land categories 21,825 ha – 21.3%
  - On private land 22,365 ha – 21.8%
- Not native vegetation 24,493 ha – 23.9%

KEY FINDINGS

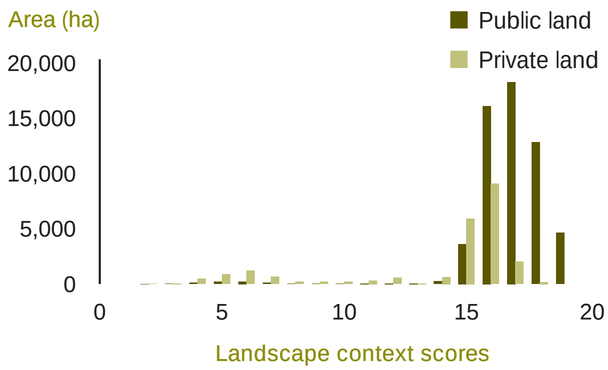
The Otway Ranges bioregion retains most of its original native vegetation. About one third of native vegetation within this bioregion occurs within largely-intact landscapes and a significant proportion in the fragmented landscape (76.1%) remains. About half of the remnant native vegetation is on public land (54.3%). A large proportion is represented in the conservation reserve system (33%) and is part of, and contiguous with, the largely-intact landscape of the Great Otway National Park that makes up most of the northeast of the bioregion. The remainder of the landscape is generally variegated. Remnant native vegetation in these areas is of moderate to good condition suggesting that the structural integrity and/or understorey of the vegetation is intact despite the fragmentation. In the Beech Forest area, native vegetation has been extensively cleared for agriculture and plantations. By area, public land accounts for a large majority of the largest (1,000+ ha) patches, while in other patch size classes private land dominates by area.

Distribution of site condition scores



Public land median score – 53.1
Private land median score – 45.4
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.4
Private land median score – 15.0
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Otway Ranges bioregion is characterised by moderate to steep slopes, deeply dissected blocks of alternating beds of sandstone, siltstone and shales, and swampy alluvial fans in the lowlands. The geology is of Mesozoic non-marine deposits covered with a veneer of younger Cainozoic deposits at lower elevations. Brown earths and brown texture contrast soils occur throughout the bioregion with leached sands in the lowlands.

The dominant vegetation is Wet Forest, Shrubby Wet Forest and Cool Temperate Rainforest on the higher slopes; and Shrubby Foothill Forest on the lower slopes.

Average annual rainfall across the bioregion: 800-2000 mm
Daily mean temperature across the bioregion: 12˚C

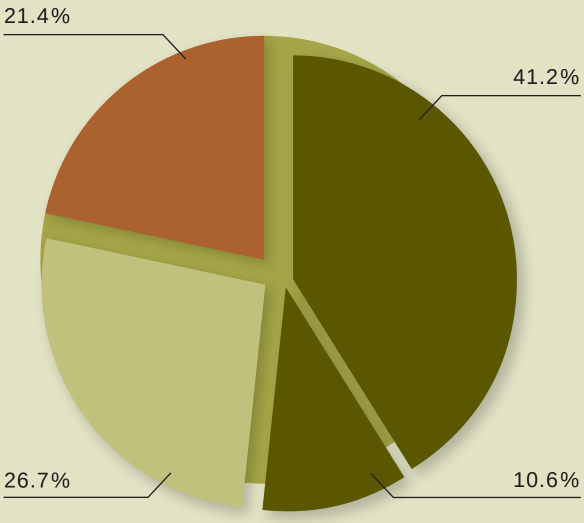
LAND USE HISTORY

Whalers and sealers established the first European settlements at Lorne and Apollo Bay. Timber production followed in the 1850s. Settlement is concentrated between Beech Forest and Lavers Hill and along the coast. Most settlements are based on dairy cattle and sheep grazing, although tourism is a major activity at Apollo Bay, Lorne and Aireys Inlet. Softwood plantation and hardwood forestry continue to be major land-uses in the bioregion. A large part of the bioregion serves as catchment for domestic water supply for communities from Warrnambool to Geelong.

GREATER GRAMPIANS

TOTAL BIOREGION 237,351 ha

- Largely-intact landscape 142,917 ha – 60.2%
- Fragmented landscape 94,434 ha – 39.8%



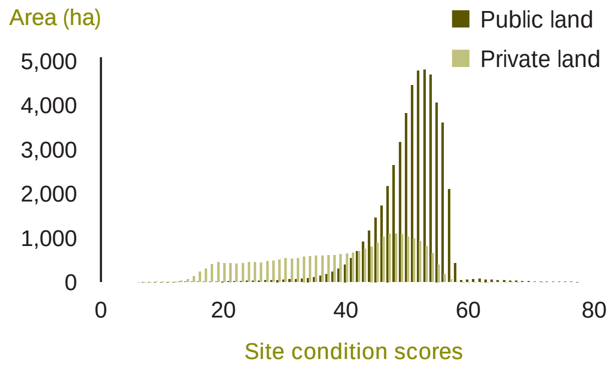
FRAGMENTED LANDSCAPE

- Native vegetation extent 74,195 ha – 78.6%
  - On public land [total] 48,936 ha – 51.8%
    - In conservation reserves 38,877 ha – 41.2%
    - In other public land categories 10,059 ha – 10.6%
  - On private land 25,259 ha – 26.7%
- Not native vegetation 20,239 ha – 21.4%

KEY FINDINGS

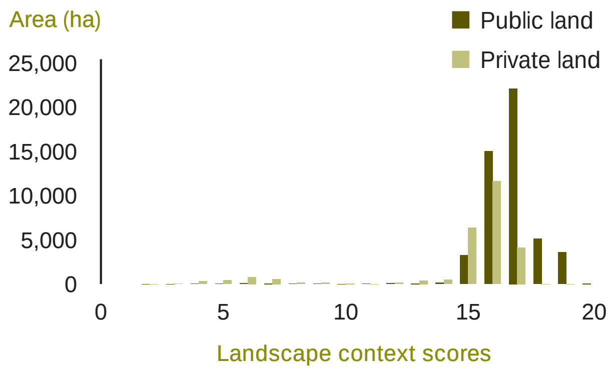
More than half (60%) of the Greater Grampians is largely intact. In the fragmented landscape, a major proportion of the landscape has native vegetation cover (78.6%). Half occurs on public land, of which almost all (41.2%) is in the reserve system. Cleared areas correspond to the foothills of the Grampians, including the Victoria Valley. The Victoria Valley is the only heavily cleared area where the majority of native remnants are small and in poor condition. The remnants within the eastern and the north-west fringes of the bioregion that flank the Grampians National Park are variegated in pattern, and are generally of poor quality but moderately well connected. The proportion by area is greater on private land for patches smaller than 100 ha, mixed for the moderately sized patches, and is about twice the area on public land compared to private land for the 1,000+ ha size class.

Distribution of site condition scores



Public land median score – 51.0
Private land median score – 40.4
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.3
Private land median score – 15.3
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

Greater Grampians is dominated by ridges of resistant sandstone giving rise to striking parallel ranges and valleys which have been cut either in soft shales or deeply weathered granites. The Palaeozoic deposits give rise to deep acidic yellow texture contrast soils and shallow sandy soils.

The Greater Grampians is recognised as an exceptionally rich area for plants, supporting over 40 endemic species. The bioregion is dominated by Dry Foothill Forest Complexes, Inland Slopes Woodland Complexes, Herb-rich Woodland Complexes and Plains Grassy Woodland Complexes with small patches of Heathy Woodland Complexes and Valley Grassy Forest Complexes.

Average annual rainfall across the bioregion: 600-1000 mm
Daily mean temperature across the bioregion: 12-15°C

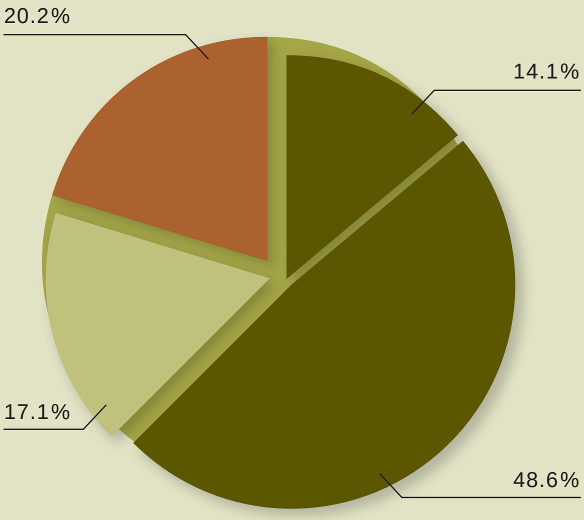
LAND USE HISTORY

The Grampians' heritage includes timber production for mines and farms, gold mining, stone quarrying, water supply, recreation and tourism. Tourism began in the late 19th century with the spread of railways and a developing interest in natural landscapes. Today the Greater Grampians sustains a diverse range of recreational activities including camping, bush-walking, abseiling, birdwatching, four wheel driving and water sports.

ROBINVALE PLAINS

TOTAL BIOREGION 64,186 ha

- Largely-intact landscape 22,132 ha – 34.5%
- Fragmented landscape 42,054 ha – 65.5%



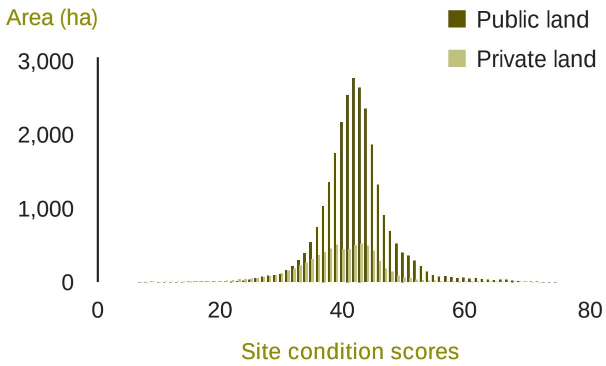
FRAGMENTED LANDSCAPE

- Native vegetation extent 33,576 ha – 79.8%
  - On public land [total] 26,391 ha – 62.7%
    - In conservation reserves 5,934 ha – 14.1%
    - In other public land categories 20,457 ha – 48.6%
  - On private land 7,185 ha – 17.1%
- Not native vegetation 8,478 ha – 20.2%

KEY FINDINGS

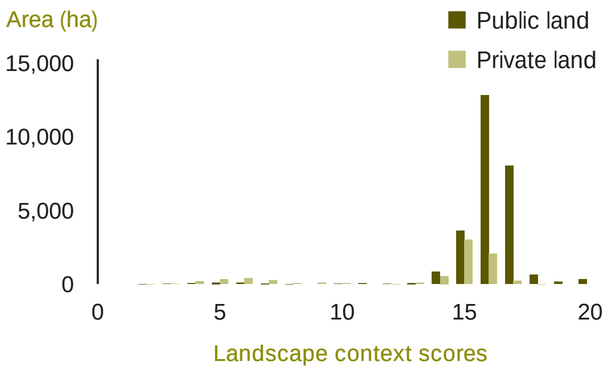
Thirty-four percent of the Robinvale Plains bioregion is within the largely-intact landscape of which most forms part of the Hattah-Kulkyne National Park and Murray-Kulkyne Park. In the fragmented landscape 79.8% of the original extent of native vegetation is retained, of which 62.8% in on public land. The proportion of native vegetation in the fragmented landscape and within the reserve system is moderate (14.1%). These reserves include Lambert Island and Karadoc Nature Conservation Reserves and Gadsen Bend and Kings Billabong Parks along the Murray River. Almost all of the Robinvale Plains that flanks the Murray River is highly connected or at worst, consists of small linear remnants moderately connected. Landscape condition is moderate to poor, probably reflecting a widespread history of overgrazing by native and introduced herbivores. Small areas of good quality habitat occur adjacent to the Hattah-Kulkyne National Park. The proportion by area of patch sizes smaller than 50 ha is greater on private land compared to public land. Conversely the proportion by area of patch sizes larger than 50 ha is substantially greater on public land.

Distribution of site condition scores



Public land median score – 41.6
Private land median score – 39.3
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 15.7
Private land median score – 14.5
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

Robinvale Plains bioregion is predominantly a narrow floodplain or gorge confined by the cliffs along the Murray River - which is entrenched within older up-faulted Cainozoic sedimentary rocks. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils. The soils support Riverine Grassy Forest and Riverine Grassy Chenopod Woodland ecosystems.

Average annual rainfall across the bioregion: 300 mm
Daily mean temperature across the bioregion: 15-18°C

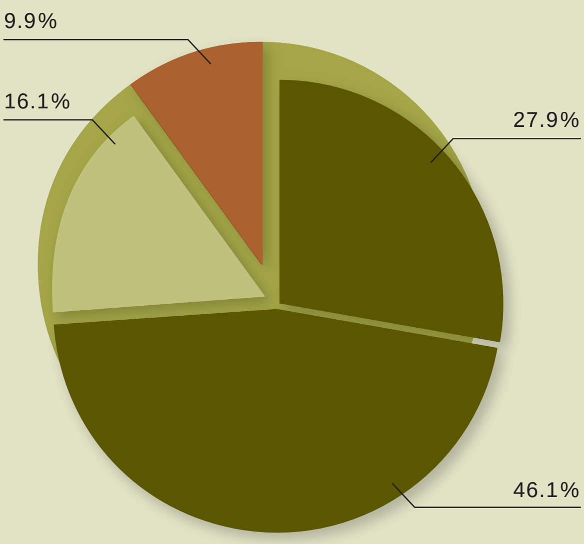
LAND USE HISTORY

Due to flooding, much of this bioregion is unsuitable for agricultural purposes other than grazing. Extensive areas of what is now the Hattah-Kulkyne National Park were used for grazing and much of the local timber was harvested for fencing. Today, some grazing still occurs but the majority of agricultural activities are growing grape, almond and citrus crops. The Murray River is a popular area for recreational activities with camping a predominant activity along the river frontages during the holiday periods.

VICTORIAN ALPS

TOTAL BIOREGION 714,321 ha

- Largely-intact landscape 702,452 ha – 98.3%
- Fragmented landscape 11,868 ha – 1.7%



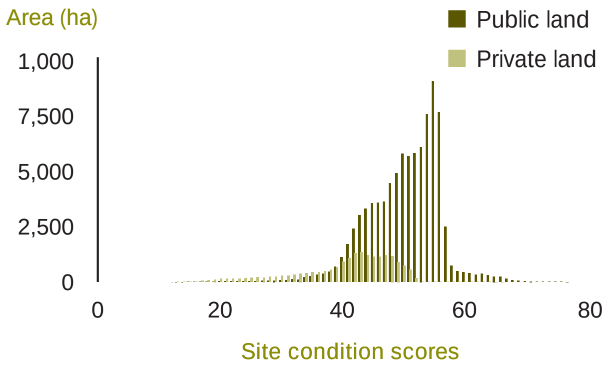
FRAGMENTED LANDSCAPE

- Native vegetation extent 10,688 ha – 90.1%
  - On public land [total] 8,777 ha – 74.0%
    - In conservation reserves 3,311 ha – 27.9%
    - In other public land categories 5,466 ha – 46.1%
  - On private land 1,910 ha – 16.1%
- Not native vegetation 1,180 ha – 9.9%

KEY FINDINGS

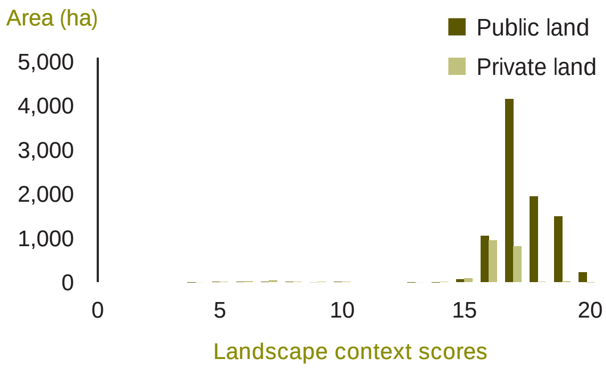
The Victorian Alps is one of the least cleared bioregions with most native vegetation classified as largely intact. The ecological integrity of the Alpine ecosystems is relatively unaltered. About 98% of the bioregion forms part of the largely-intact landscape and of the remaining 2%, nearly all is remnant native vegetation (90.1%). Of this three-quarters (74%) is on public land and 27.9% is within the reserve system. Two fingers of the bioregion have small areas of remnant native vegetation that are contiguous with the largely-intact landscape and they remain highly connected and of good site condition. These areas correspond to the Great Alpine Road and Limestone Road. Several isolated outliers of the bioregion within the Highlands – Northern Fall are also highly connected and of high quality. The proportion by area of patches 1,000+ ha is substantially greater on public land compared to private land.

Distribution of site condition scores



Public land median score – 50.7
Private land median score – 42.0
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.8
Private land median score – 15.9
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Victorian Alps is part of a series of high plateaux and peaks along the Great Dividing Range. The geology consists of Palaeozoic deposits predominantly of granitic and basaltic origin that give rise to friable leached earths, loams and peaty soils.

The bioregion consists of a complex mosaic of ecological communities determined by soils, climate and topography. The vegetation associated with the plateaux are Sub-alpine Woodland, Treeless Sub-alpine Mosaic and Sub-alpine Grassland EVCs. The upper slopes and generally surrounding sub-alpine areas are dominated by Montane Dry Woodland, Montane Damp Forest, Montane Wet Forest and Montane Grassy Woodland. Many of these vegetation types are extremely limited in extent, and often the characteristic species of alpine biota are themselves restricted to only one or two of these EVCs.

Many of Victoria's major river systems, including the Murray, Goulburn, Ovens, King, Kiewa and Mitchell, have their sources in the alpine areas.

Average annual rainfall across the bioregion: 800-1600 mm
Snowfalls occur during winter.
Daily mean temperature across the bioregion: 6-9˚C

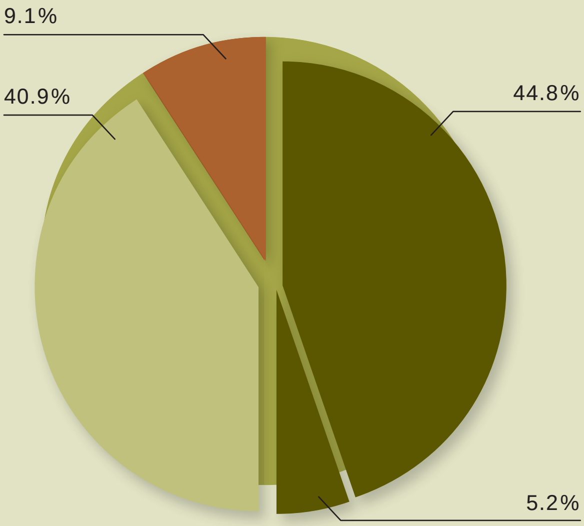
LAND USE HISTORY

The major European land-use activities are conservation, recreation (including commercial tourism), forestry, hydro electricity generation and water production and catchment protection. The alpine areas have no large permanent settlements except for the five Alpine Resort Areas. Inaccessibility, rugged topography and the hostile climate of the alpine area inhibited large-scale permanent settlement, but the high plateaus have been used as summer pasture for cattle and sheep from the 1850s. Early settlements developed in the valleys during the gold rushes of the last century were abandoned. The expansion of forestry operations in the Victorian Alps from the 1940s led to the development of an extensive road system through the area, which had enabled access for other users, particularly recreational users.

MURRAY SCROLL BELT

TOTAL BIOREGION 116,144 ha

- Largely-intact landscape Nil
- Fragmented landscape 116,144 ha – 100%



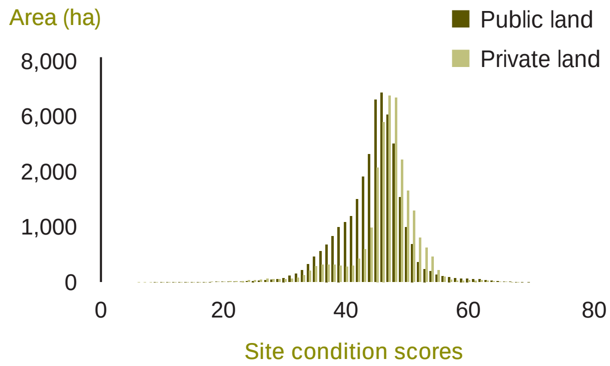
FRAGMENTED LANDSCAPE

- Native vegetation extent 105,551 ha – 90.9%
  - On public land [total] 58,040 ha – 50.0%
    - In conservation reserves 51,963 ha – 44.8%
    - In other public land categories 6,077 ha – 5.2%
  - On private land 47,511 ha – 40.9%
- Not native vegetation 10,593 ha – 9.1%

KEY FINDINGS

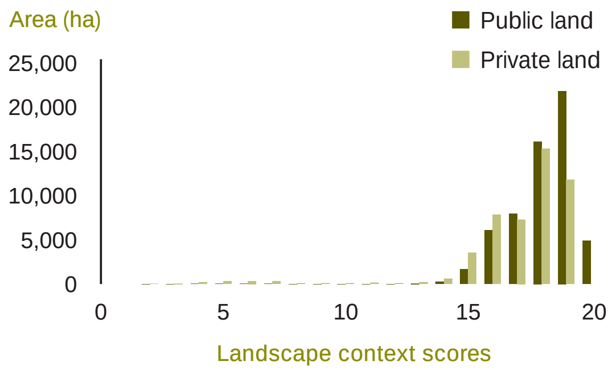
The Murray Scroll Belt, along with Murray Fans and Robinvale Plains form part of native vegetation corridor along the Murray River. Due to the unsuitability of the floodplains for agriculture, much of the native vegetation of the Murray Scroll Belt is retained (90.1%) and comprises of moderate to good condition vegetation. An exception is vegetation along the major water courses, floodplains and billabongs which are of poor quality. Greatly reduced floodplain inundation, weed invasion, reduced canopy cover and recruitment of trees has adversely impacted on the quality of the vegetation, but not the level of connectedness. Fifty percent of the native vegetation is on public land where nearly all is within conservation reserves (44.7%). Clearing of land has been fragmented and restricted to the non-flood prone areas suitable for stock grazing. The Murray Scroll Belt is exceptional in that site condition scores are higher on private land than public land. The proportion by area of patch sizes smaller than 250 ha is greater on private land compared to public land and is slightly greater on public land for patches larger than 1,000 ha.

Distribution of site condition scores



Public land median score – 44.7
Private land median score – 46.7
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 17.8
Private land median score – 17.2
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Murray Scroll Belt is a river valley and associated active floodplains including billabongs, ephemeral lakes, swamps and meander belts. The Murray River forms a valley where fluvial processes dominate. The vegetation communities within the bioregion are predominately characterised by Riverine Grassy Woodland complexes. Higher terraces above the active floodplain support vegetation dominated by saltbush and other succulents.

Average annual rainfall across the bioregion: 200-300 mm
Daily mean temperature across the bioregion: 15-18°C

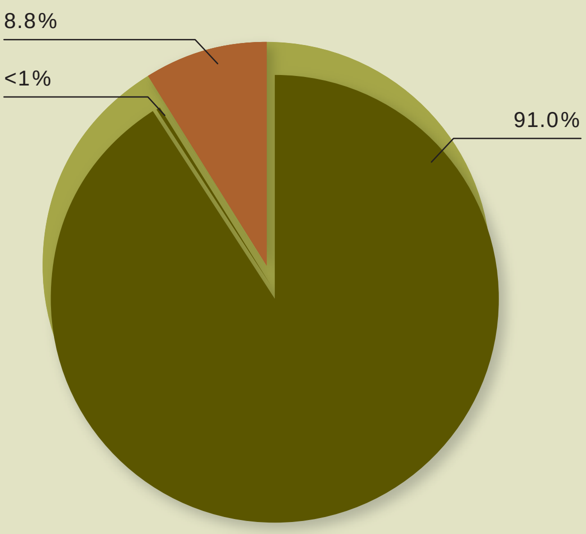
LAND USE HISTORY

Pastoralists were the first Europeans to settle in the bioregion. Land use is largely grazing, timber harvesting and recreation. Due to the susceptibility to flooding the bioregion has only been moderately cleared for agriculture. Intensive stock grazing and the spread of rabbits has compacted soils and degraded vegetation.

WILSONS PROMONTORY

TOTAL BIOREGION 40,361 ha

- Largely-intact landscape 39,682 ha – 98.3%
- Fragmented landscape 679 ha – 1.7%



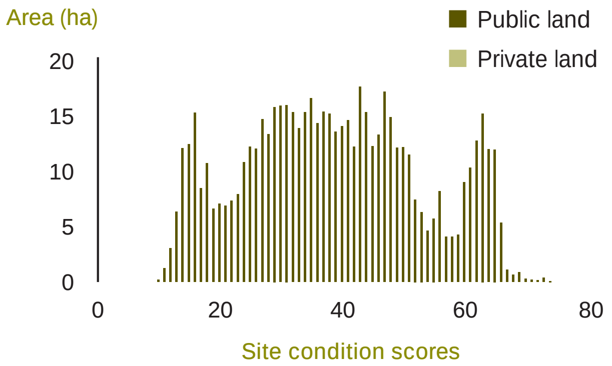
FRAGMENTED LANDSCAPE

- Native vegetation extent 619 ha – 91.2%
  - On public land [total] 619 ha – 91.2%
    - In conservation reserves 618 ha – 91.0%
    - In other public land categories 1 ha – less than 1%
  - On private land Nil
- Not native vegetation 60 ha – 8.8%

KEY FINDINGS

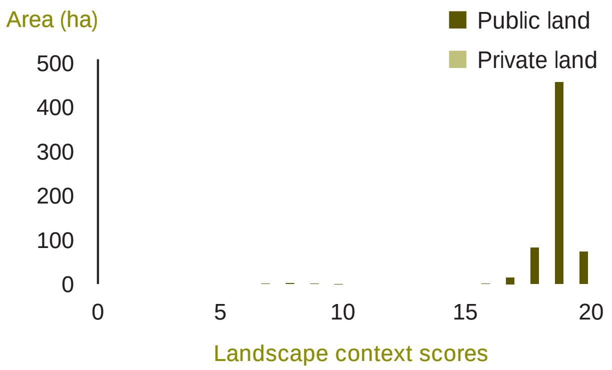
The native vegetation cover within this bioregion is almost all largely-intact landscape with only a tiny proportion (619 ha) of the bioregion fragmented. These areas comprise the lighthouse area and the offshore islands. The intact condition and remote nature of the bioregion means that most ecological processes have been little altered.

Distribution of site condition scores



Public land median score – 37.5
Private land median score – n/a
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 18.5
Private land median score – n/a
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

Wilsons Promontory bioregion is a spectacular area of prominent granite hills and mountains with white sandy beaches surrounded by Bass Strait. The geology consists of Palaeozoic granites and deep Quaternary sand deposits. Vegetation types of the bioregion include Moist Foothill Forests, Coastal Scrubs, Heathlands and Heathy Woodlands. The flora and fauna of the bioregion have similarities to that of parts of the Bass Strait islands which form the Furneaux IBRA region.

Average annual rainfall across the bioregion: 900-1400 mm
Daily mean temperature across the bioregion: 12-15˚C

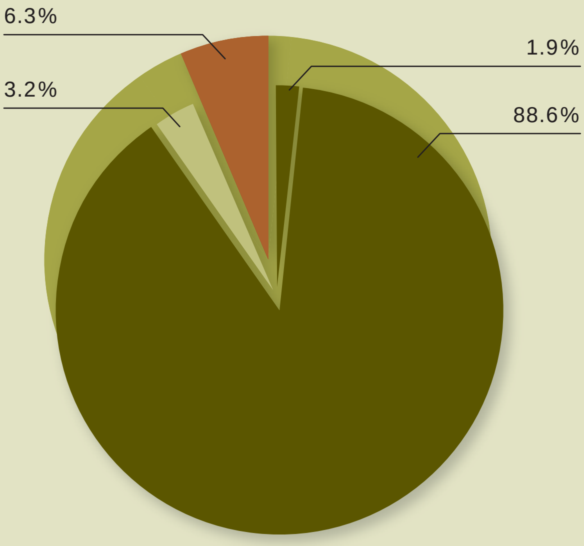
LAND USE HISTORY

The early European history of Wilsons Promontory relates to sealing and whaling activities within its waters – particularly along the eastern coastline at Sealers Cove. Other economic activities were timber harvesting and cattle grazing. Cattle grazing continued (largely confined to the Yanakie Isthmus), but was phased out in 1992. The entire bioregion lies within Wilsons Promontory National Park, Victoria's oldest national park, which was established in 1898. Today Wilsons Promontory is a popular holiday destination and is extensively used for passive recreational activities including camping, bushwalking and diving.

HIGHLANDS – FAR EAST

TOTAL BIOREGION 70,018 ha

- Largely-intact landscape 69,135 ha – 98.7%
- Fragmented landscape 883 ha – 1.3%



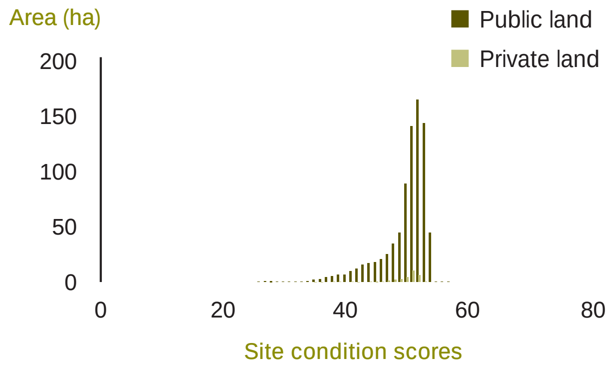
FRAGMENTED LANDSCAPE

- Native vegetation extent 827 ha – 93.7%
  - On public land [total] 799 ha – 90.5%
    - In conservation reserves 17 ha – 1.9%
    - In other public land categories 782 ha – 88.6%
  - On private land 28 ha – 3.2%
- Not native vegetation 56 ha – 6.3%

KEY FINDINGS

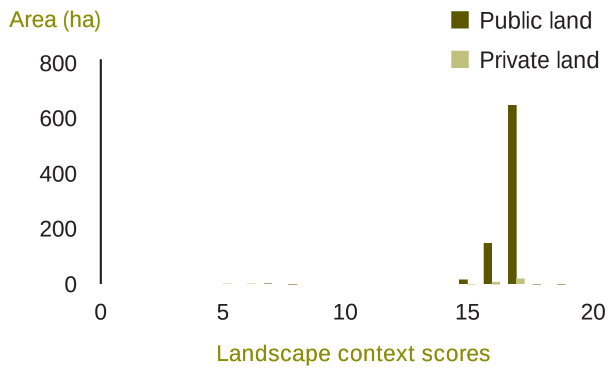
The Highlands – Far East is one of the least cleared bioregions and is of high biodiversity value. Nearly all native vegetation within the bioregion is in the largely-intact landscape. A tiny proportion of native vegetation falls within the fragmented landscape, and of this, nearly all (93.6%) occurs on public land.

Distribution of site condition scores



Public land median score – 50.6
Private land median score – 50.2
[Statewide median score – 36.8]

Distribution of landscape context scores



Public land median score – 16.4
Private land median score – 16.3
[Statewide median score – 14.9]

BIOPHYSICAL BASIS

The Highlands – Far East bioregion covers a broad escarpment around Errinundra where the Monaro Plateau extends into Victoria and then falls sharply to the south-east. The bioregion consists of dissected uplands with moderate to steep slopes and scarps, high and intermediate level plateaux, gorges and alluvial flats along the main valleys. The geology is predominantly Palaeozoic sediments and volcanics. The brown and red porous earths occur in the upper reaches and yellow, brown and red texture contrast soils graduate down the valleys and in lower rainfall areas.

The vegetation is dominated by Wet Forest on the upper slopes in the high rainfall areas with Cool Temperate Rainforest in the protected gullies. Montane Wet Forest occurs on the most sheltered wet sites at higher montane elevations and Damp Forest replaces Wet Forest at lower elevations.

Average annual rainfall across the bioregion: 700-1600 mm
Daily mean temperature across the bioregion: 6-12°C

LAND USE HISTORY

Prior to the 1980s timber harvesting in the bioregion was a limited industry but has since increased significantly.

6

LANDSCAPE PATTERNS, IMPACTS AND THREATS TO BIODIVERSITY

6.1 Factors influencing patterns of fragmentation

The distinctive biophysical attributes of each Victorian bioregion have strongly influenced historical land uses and settlement patterns, which in turn have resulted in non-random landscape change and fragmentation patterns. Bioregions of the high altitudes (Victorian Alps, East Gippsland Uplands and Highlands – Far East), rugged terrain (Wilsons Promontory and Greater Grampians), poor soils (Lowan Mallee) or floodplains (Murray Scroll Belt and Robinvale Plains), have not been heavily cleared because they are unsuitable for agriculture or settlement. Within these bioregions any clearing of vegetation has been variegated in landscape pattern and tends to occur near the bioregion boundaries where land is often better suited for agricultural or other land uses.

Generally bioregions, or landscapes within bioregions with fertile soils on flat country, gently undulating hills or lowland slopes have been disproportionately cleared for sheep and cattle grazing and cropping. In particular, bioregions with predominately grassy plains and scattered woodlands and which were settled early by Europeans (e.g. Victorian Volcanic Plains, Warrnambool Plain, Victorian Riverina and Dundas Tablelands) have much of the original native vegetation cleared. In these bioregions, remaining native vegetation now tends to be fragmented or relictual with a relatively high proportion of vegetation as roadside remnants.

Loss of native vegetation has been greatest in flat fertile lowlands and wetlands.

Bioregions that contain fertile friable soils in areas such as the Wimmera and Murray Mallee and were settled during phases of improved technology have had large expanses of land cleared for broadacre wheat cropping and are denuded of native vegetation. In these bioregions, remaining vegetation is fragmented and relictual. Linear features such as roadside vegetation and narrow riparian zones may be the only native vegetation features for many kilometres. Any existing native vegetation patches also tend to be isolated. However, there are exceptions. The Murray Mallee, for example, retains a large area of high quality remnant native vegetation along the South Australian border west of Mildura.

The moderately cleared bioregions typically have a mixed topography of flat terrain, valleys and slopes with rugged outcrops (e.g. in central and northeast Victoria) which in turn has resulted in a mix of land uses and heterogeneous patterns of clearing. Generally within these moderately cleared bioregions, the more intact native vegetation tends to be associated with slopes and stony outcrops that are less favourable for agriculture. For example, the Highlands – Southern Fall bioregion supports several diverse land uses including dairy-farming, timber harvesting and the peri-urban expansion of Melbourne. These varied land uses have resulted in some local landscapes with remnants that are connected but structurally altered due, for example, to timber harvesting, while other landscapes – such as the Yarra Valley where the expansion of outer Melbourne has encroached – are predominantly highly fragmented and relictual. Similar to the Highlands – Southern Fall, the Otway Plain bioregion has a mixture of clearing patterns reflecting land uses for urban residential housing around Geelong, agriculture and forestry operations.

The Goldfields, Central Victorian Uplands and Northern Inland Slopes have a mixed history of mining, grazing, timber production and small-acre settlement. In these bioregions, landscapes are largely fragmented with linear remnants along roads and waterways. Mining and grazing in particular have structurally modified and degraded much of that which remains, resulting in relatively poor site condition scores despite reasonably high physical connectivity.

Most bioregions are crossed by extensive river and stream systems. Vegetation along many of these riparian zones has been removed or reduced to narrow linear strips, and is often weed infested and of poor quality. The loss of vegetation, compaction of soil from stock, and activities of pest species such as rabbits, are among the many factors that have contributed to the erosion of banks and loss of the native biota they support. Species composition and structure may also have been influenced by alteration of hydrological regimes.

Many of Victoria's bioregions contain wetlands and floodplains that support a distinctive range of plant and animal communities. Victoria has over 13,000 wetlands greater than one hectare in size. A significant proportion occurs on public land (about 70%, inclusive of man-made wetlands).[65] Freshwater meadows are common on the floodplains of the Victorian Riverina, particularly along the Murray, Ovens and Goulburn rivers and in the Kerang–Echuca area. They also occur in the southwest of Victoria in the Edenhope and Hamilton districts. Shallow and deep freshwater marshes are found in the southwest of Victoria and the Gippsland Plain bioregion. Saline wetlands are a feature of the Victorian Volcanic Plain, the Wimmera, Lake Tyrrell and Kerang areas, the Gippsland coast, and Port Phillip and Western Port Bays.

6.2 Impacts of landscape change on biodiversity

Since European settlement, 37% of Victoria's wetland area has been lost. An additional 30% has been degraded through partial drainage or changes in water regime. The greatest losses of original wetland area have been in the freshwater meadow (43%), shallow freshwater marsh (60%) and deep freshwater marsh (70%) categories. The majority of decline (90%) has been on private land.[65]

The vegetation associated with wetlands has been lost or extensively modified. For example the Edithvale-Seaford wetlands, southeast of Melbourne, are all that remains of the once extensive Carrum Carrum Swamp. In the Cranbourne district, the Koo Wee Rup Swamp once covered over 40,000 hectares. A network of drainage channels and extensive alteration to the topography and flooding regimes since the 1870s has removed most of the former wetland system and no substantial areas of swamp remain. In recent years residential and small sub-divisions have replaced many farms. Outside these two large former wetland systems, the areas most affected by drainage are in the southwest of Victoria and irrigation areas around Kerang-Echuca and Shepparton.[65]

6.2.1 SPECIES OCCURRENCE AND POPULATION VIABILITY

Except within largely-intact landscapes, Victoria's biodiversity is declining. The number of taxa listed as of conservation concern is increasing.[3] The non-random nature of landscape modification has important implications for the extent, spatial distribution and community composition of vegetation types and the biota they support. The most productive areas in the landscape (i.e. fertile valleys, flat terrain with rich soils and riparian zones) are those that have been disproportionately cleared or heavily modified for agriculture. Landscapes most productive for agriculture are also often the most productive for many native biota in terms of abundance and distribution. Hence plants and animals characteristic of productive landscapes have been disproportionately depleted and a high proportion of them are threatened. As a result, the current proportion and patterns of species distribution and abundance are likely to be different to those that existed prior to landscape change. This difference is most applicable in the arable parts of the most cleared bioregions such as the grassy plains of the Victorian Volcanic Plain[3] – see box on page 123 for an insight into the decline of threatened species of these plains.

The general pattern of greater vegetation loss in the flat fertile lowlands applies at all geographic and thematic scales – including between bioregions (section 4.2) and between vegetation types. The depletion of Ecological Vegetation Classes (EVCs – the standard unit of vegetation typology in Victoria) varies greatly. In particular, Plains Grasslands, Chenopod Shrublands, and Plains Woodlands and Forests EVC groups have been reduced to less than 20% of their original extent. In contrast EVCs associated with rocky outcrops, escarpments and slopes, montane and sub-alpine ecosystems and rainforests retain over 90% of their original extent.[5] Flood-prone EVCs not suited to agriculture are retained in moderate levels, though their condition is moderate to poor because of reduced flooding.

Many vertebrate species that were once relatively widespread and abundant in productive landscapes have been displaced, although they may continue to persist in marginal habitats in lower numbers (e.g. see regent honeyeater, box on page 124). Marginal habitats have fewer resources and therefore support lower numbers relative to more productive landscapes. These smaller populations are more vulnerable to extinction during periods of extreme climate fluctuations such as drought, and are susceptible to other environmental and random processes that may lead to local population extinction (see section 2.1.2).

The extent and pattern of landscape change has implications for species viability and dispersal. Highly fragmented and relictual landscapes, where patches are small and isolated, are thought to be poor for long-term population viability of biota dependent on native vegetation. Fragmented and degraded landscapes frequently lack sufficient resources such as nest sites, tree hollows and food resources to support viable populations. In fragmented landscapes the configuration and extent of patches may also disrupt social systems, increase parasitism and alter opportunities for dispersal.[43,67] The number of species and abundance of woodland-dependent birds in north east Victoria decline significantly where the extent of tree cover is less than 30 percent. This threshold is thought to represent a point of instability in the landscape at which crucial aspects of natural systems that support woodland birds collapse.[21]

The especially high loss of native vegetation from the most productive land is apparent at all scales – from bioregions to vegetation types – and has led to a correspondingly high loss of biodiversity and a high proportion of threatened species in these areas.

Each bioregion has characteristic changes in the types of landscape features which may be used by various plant and animal species for dispersal in different ways. Roadsides and riparian zones are particularly important for native vegetation in many of the heavily cleared bioregions. In these landscapes, roadsides, small patches with large old trees and single paddock trees provide important habitat for population dispersal and routes between more substantial patches. Where quality patches of vegetation are retained, some species have managed to maintain viable populations (e.g. squirrel glider *Petaurus norfolcensis* on the plains north of Euroa), although their pattern of use differs from that in more intact landscapes.[68]

Although landscape modification poses a range of threats to many species, not all species are adversely affected. Some are able to exploit new opportunities in the matrix or the spatial configuration of native vegetation and prosper in fragmented landscapes. The noisy miner *Manorina melanocephala* is an aggressive edge-specialist bird that has successfully exploited fragmented landscapes.[30] The expansion of the galah in agricultural landscapes is well documented.[69] These species are often considered pests and may compete with other indigenous species.

In contrast to the highly cleared bioregions, several bioregions such as the Victorian Alps and the Otway Ranges retain largely-intact native vegetation of high biodiversity value. These bioregions offer important ecosystem services to Victoria. They provide clean air, renewable resources, water of high quality to the catchments, recreational opportunities, genetic variability as well as the intrinsic value of the biodiversity itself. Fragmented patches of native vegetation are important as they provide opportunities for species to disperse between largely-intact landscapes (e.g. the Sunset Country and the Big Desert/Wyperfeld reserve complex; see mallee ningaui circuitscape, figure 3.6). Intact landscapes provide a source of individuals that assist in maintaining genetic variability in fragmented landscapes and provide individuals to recolonise patches that have been perturbed by natural or man-made events.

6.2.2 ALTERED ECOSYSTEMS

Modified landscapes resulting from human activities frequently lead to substantial changes to physical environmental processes. Deterioration of the physical environment includes processes such as erosion by wind and water, dryland and irrigation salinity, soil compaction, mass movement of soil, chemical contamination and water and soil acidification. Most of these processes are interconnected and can have significant impacts on vegetation structure and composition, and the fauna they support. Activities such as timber harvesting and firewood collection, although less obvious, often alter the structural complexity of forests and reduce the suitability of vegetation for many species.[20]

The bioregions most heavily cleared and irrigated have widespread salinity, soil compaction and erosion issues. The structural decline, erosion and acidification of soil vary across the state depending on the topography, soil type and land uses. The largest areas of dryland salinity in Victoria occur in the northern plains (Wimmera and Victorian Riverina bioregions) where regional aquifers discharge into low points in the landscape such as waterways and wetlands. Other affected bioregions include the Dundas Tablelands, Victorian Volcanic Plain, Otway Plain, Murray Mallee and Goldfields.[3]

DECLINE OF NATIVE GRASSLANDS AND THE EASTERN BARRED BANDICOOT ON THE VICTORIAN VOLCANIC PLAIN

Grasslands

Native grasslands are among Victoria's most heavily cleared ecosystems and are now endangered in Victoria. The Victorian Volcanic Plain was originally dominated by Plains Grasslands and Grassy Woodlands containing kangaroo grass *Themeda australis*, wallaby grass, *Austrodanthonia* spp., and other tussock-forming grasses interspersed with a variety of native herbs. Clearing remains the main cause of loss of native grasslands and now as little as 0.1% of high quality grasslands remain in the bioregion.[5]

Grassland remnants provide habitat for a diversity of animal species; notably skinks, snakes, birds of prey and ground-dwelling birds. The grasslands of the Victorian Volcanic Plain provide important habitat for a range of threatened species such as the plains wanderer *Pedionomus torquatus*, golden sun moth *Synemon plana*, grassland earless dragon *Tympanocryptis pinguicolla*, striped legless lizard *Delmar impar* and spiny rice-flower *Pimelea spinescens*.

Grasslands within the Victorian Volcanic Plain were heavily targeted for early pastoral settlement because of their suitability for grazing sheep without the need for clearing of trees and shrubs. The introduction of superphosphate, exotic clovers and grasses, and ploughing, accelerated the decline of grasslands after World War II.[70] More recent pressures include the removal and degradation of grasslands for residential and industrial development, particularly in areas immediately west of greater Melbourne.

Eastern barred bandicoot
Perameles gunnii

Prior to European settlement, the eastern barred bandicoot was abundantly distributed across the volcanic plains of western Victoria and into South Australia occupying grassland and open woodland habitats. Three factors – climate, fire and predation by dingoes and Aboriginal people – were thought to be the major controlling influences on their abundance. With European settlement of the western plains from the 1830s, populations began to decline. Marked declines in numbers and distribution had occurred by the 1960s. Today the species was last recorded in the wild near Hamilton in 2002 but there are small re-introduced populations at sites in various parts of western Victoria.

Factors involved in the decline of the eastern barred bandicoot include habitat loss, landscape modification, and introduced predators and competitors. The alteration of native vegetation as a result of the introduction of sheep and cattle and the replacement of structurally diverse native grasses (e.g. *Themeda, Austrodanthonia, Austrostipa* and *Poa*) with exotic pastures that form a sward of habitat of similar height and density is thought to have contributed to their decline. These changes are thought to have reduced both shelter from predators and the bandicoots' invertebrate prey.

The introduction of the red fox *Vulpes vulpes* in particular had an immediate effect on numbers. The persistence of the eastern barred bandicoot in Tasmania, where foxes are absent, suggests that this introduced predator was a particularly significant factor in the eastern barred bandicoot decline on the mainland. Other factors such as cats, competition with rabbits, catastrophic natural events (floods and fires) and increased urbanisation have all been implicated in its decline.[71]

REGENT HONEYEATER – A HIGH QUALITY HABITAT SPECIALIST

The regent honeyeater *Anthochaera phrygia* is mostly associated with dry woodlands and forests dominated by box and ironbark eucalypts; especially woodlands associated with moister more fertile sites along creeks, broad river valleys and on the lower slopes of foothills. The species was once widespread in south-eastern Australia. In Victoria it was reported as common in east and south Gippsland, in suburban Melbourne and the Bendigo, Stawell and Ararat areas.

The range and numbers of the regent honeyeater have since contracted greatly and it is now rarely recorded in Victoria, mainly due to the loss, fragmentation and degradation of high quality habitat as a result of agricultural use and poor eucalypt recruitment. Silvicultural practices – now mostly historic – have also been implicated. Furthermore, vegetation fragmentation may have allowed populations of aggressive native honeyeaters such as friarbirds *Philemon* and miners *Manorina* to expand, increasing both disturbance to regent honeyeaters and competition for food and nest sites.[72]

6.2.3 RIPARIAN AND WETLAND VEGETATION

Riparian and wetland ecosystems are key environmental features of the landscape. Riparian and wetland margins are the interface between aquatic and terrestrial environments and mediate the flow of energy, nutrients and biotic matter.[73] Consequently, they are usually highly productive and disproportionately rich in biota, supporting many species of plants and animals not found in other ecosystems. In the agricultural landscapes of central Victoria, riparian vegetation is a key element for bird diversity and contributes to the proportion of uncommon species in local landscapes.[74]

In the most cleared landscapes, the vegetation associated with riparian and wetland margins is frequently the only remaining local vegetation. A national assessment of river conditions found that 80% of Victorian river lengths assessed in detail were degraded. Forty-nine percent of the rivers assessed had altered vegetation and 25% were substantially modified.[75] Removal and degradation of native vegetation of riparian and wetlands zones hinders the effectiveness of their function in mitigating man-made impacts on waterway quality[76] and decreases the abundance of plants and animals and species diversity.[74]

Wetlands are characterised by a high rate of nutrient recycling, are rich in invertebrate fauna providing an important food source for many vertebrate species. Victoria has 11 wetland systems that are listed in the RAMSAR Convention on wetlands of international importance. These wetlands are crucial for many frog species, nomadic wetland and migratory birds. About one third of the original wetland systems within Victoria have been lost.[65] Most of the small ephemeral wetlands have been drained and replaced by agriculture, while many of the larger systems have been degraded by greatly altered water regimes. The continued loss and degradation of wetland and riparian ecosystems has resulted in major reduction in the diversity and abundance of fauna and flora species. An assessment of 175 wetlands in Victoria in 2006/07 found 71% to be below the reference standard. Just under half were slightly below reference standard and the remaining 32% were moderately or well below standard. Increased salinity and/or near permanent inundation have caused large-scale tree death and in the western district, the profound increase in salinity has killed eels in many lakes.[3]

6.2.4 CONSERVATION RESERVE SYSTEM REPRESENTATION

The history of landscape change and land use in the Victorian bioregions is also reflected in the conservation reserve system. Bioregions that were settled and cleared early by Europeans tend to have the poorest representation in conservation reserves. All of the heavily modified bioregions have little or no area of largely-intact landscapes and for many of them the proportion of remnant native vegetation represented in protected areas is in the order of 10% or less. Many of these bioregions are Victoria's largest (more than 1 million hectares or 10,000 square kilometres: Murray Mallee, Wimmera, Victorian Volcanic Plain, Victorian Riverina and Goldfields).

6.3 Current and future threats

The continued loss of native vegetation in Victoria is now largely through degradation rather than broad-scale clearing.[2] The current threats causing vegetation degradation are well known. When threats persist without the implementation of counter measures, species loss will increase and ecosystem function will continue to deteriorate.

6.3.1 CLEARING AND FRAGMENTATION OF VEGETATION

During the phase of European settlement and agricultural expansion, clearing of vegetation was systematic and widespread and the effect of such clearing on the biophysical functioning of landscapes was poorly recognised. In recent decades, measures to address landscape degradation and mitigate further disruption of ecological processes have been introduced. For example, planning controls for the retention of native vegetation were introduced in the late 1980s and the net gain policy of the current native vegetation framework in 2002, and broad-scale clearance has ceased. Nevertheless incremental clearing continues for residential housing, infrastructure such as the upgrading of roads, subdivision of land for life-style properties, agricultural activities, and for protection from fire. These activities remove patches of native vegetation decreasing the available habitat, increase habitat isolation, and alter the matrix of the landscape usually in a manner that results in less favourable habitat for many species.

In total, about 1,600 hectares of woody native vegetation and 3,000 hectares of grassy native vegetation extent are being lost annually in Victoria[2] – the latter figure representing a substantial portion of the remaining extent of grassy native vegetation. This loss is almost completely on private land, much of it resulting from losses that are either illegal or exempt from regulations to retain native vegetation, such as conversion of native pasture to more intensive forms of agriculture.

As at 2005, approximately 1,600 hectares of woody native vegetation extent and 3,000 hectares of grassy native vegetation extent were being lost annually in Victoria, mostly from private land. Gains in the extent of native vegetation (all woody) totalled about 400 hectares per year.

These figures are averages over the decade 1994-2004. Comparison with the annual rate of loss of woody native vegetation leading up to 1995 – estimated at 2,500 hectares/year – suggests that the rate of loss of woody native vegetation extent may be slowing. However, this can only be a tentative conclusion given the different measurement technologies used in the two assessments. Further assessments would be invaluable in confirming trends for woody native vegetation and for ascertaining trends for grassy native vegetation extent for which there are no earlier estimates.

The incremental loss of small patches of native vegetation and even single 'paddock trees' adds to the loss of habitat and the degradation of landscape processes. Single trees contribute to the viability of wildlife populations by providing habitat and connectivity between larger patches, and they perform a number of other ecosystem functions such as the mitigation of salinity and soil erosion and aiding in nutrient cycling. Single trees in agricultural landscapes are utilised by many guilds of birds[77], and are important landscape features for bats[37] and arboreal mammals[78] – see box on page 129.

6.3.2 DEGRADATION OF NATIVE VEGETATION

Continued degradation of remaining native vegetation is currently the major threat to Victoria's biodiversity. The degradation of native vegetation is caused by the complex interaction of abiotic and biotic factors (see table 6.1). Many threatening processes have straightforward causes and effects. However, at the wider landscape scale, the complex interaction of all these variables is frequently unknown and unpredictable (e.g. long-term population demographics). Given this, management of these issues needs to be adaptive.

Table 6.1
Factors contributing to the degradation of vegetation

ABIOTIC
changes in land use
natural resource demand
unregulated recreational vehicle use causing erosion and the spread of pathogens
uncontrolled stock grazing, particularly along water courses
soil erosion by wind and water
soil compaction and acidification
salinity
altered water and fire regimes (scale, frequency and intensity)
climate change (global, seasonal and micro-level changes)
changes in solar radiation
changes in carbon dioxide concentrations
BIOTIC
invasive weeds and the introduction of exotic pest species (including changes in distribution and abundance due to climate change)
overabundant species
invertebrate infestation
lack of recruitment – leading to loss of mature trees and shrubs and ground-layer plants
increased disease and parasites
habitat simplification
structural modification by timber harvesting
firewood collection

In total, this loss of vegetation quality has been quantified at 15,830 habitat hectares per year[2] – see section 3.1.3 for details of the habitat hectares methodology. This loss of quality amounts to more than 90% of the total loss of native vegetation (quality and extent) – with the losses of extent detailed above accounting for the rest. Despite there being very similar total areas of native vegetation on public and private land in fragmented landscapes, more than 80% of the loss of quality is calculated to be occurring on private land. This finding is not surprising given that public land accommodates most large patches of native vegetation which are generally more resilient to factors reducing vegetation quality, especially edge effects. That said, there will still be extensive, generally relictual landscapes in which nearly all native vegetation on public land has essentially the same highly fragmented pattern of occurrence as that on private land – and consequently the same high annual loss of vegetation quality.

Changes in native vegetation quality, as opposed to extent, account for more than 90% of the statewide overall annual loss of native vegetation. Public land accounts for less than 20% of this loss of quality and more than 60% of the offsetting gains in quality.

As well as having, on average, a lower annual loss of vegetation quality, public land also has a higher average annual gain in vegetation quality. Over 60% of the overall gain in vegetation quality between 1994 and 2004 was generated on public land, mostly through grazing management and weed control in conservation reserves.[2]

6.3.3 EXTINCTION DEBT

Many species in Victoria may be yet to pay the 'extinction debt' for habitat loss and fragmentation that occurred over one hundred years ago. Evidence suggests that extinction debt may be responsible for the decline of several bird species in fragmented landscapes of the Gippsland Plain following habitat fragmentation 100 years ago[30] for reasons already described (see section 2.1.2).

Species dependent on hollow trees in the agricultural landscape or heavily harvested forests are likely to face an extinction debt because it takes many hundreds of years to produce trees large enough to produce sufficiently sized hollows. Once these trees senesce, the lack of recruitment of a new cohort of mature trees will deprive hollow-dependent species of crucial habitat for many decades.[34,79]

The peril to biodiversity in Victoria and elsewhere is that if we simply maintain the status quo on the current extent, configuration and condition of native vegetation, future extinctions of extant populations or species may not be prevented. If no action is taken to improve site condition and connectivity in landscapes, even if further degradation of habitat is halted, it is likely that some populations and species will not persist in the long term.

6.3.4 CHANGES IN THE MATRIX

Although the landscape matrix between patches of native vegetation is mainly on private land and outside the scope of VEAC's investigation, the complex interaction of ecosystem processes means that the functional status of native vegetation on public land cannot be considered in isolation of the surrounding matrix.

Changes in the matrix – of which the majority is agricultural land – can influence nearby native vegetation and the biota it supports. Changes in agricultural activities can alter the 'permeability' of the matrix to individual species. For example, the introduction of centre-pivot irrigation or broadacre cropping alters the matrix because 'paddock trees' and small patches that are used by many species of animal need to be removed (box on page129). Other changes in agricultural land use may increase pesticide and herbicide use, introduce invasive weeds, or attract new species of animals to an area. Many studies have highlighted the importance of the matrix in agricultural areas to the conservation of biodiversity.[80]

6.3.5 INAPPROPRIATE FIRE REGIMES

Fire is a major force determining the structure, distribution and abundance of Australia's biota. Fire is both friend and foe to much of Australia's biota. Fires directly kill individuals, but many species are dependent to varying degrees on fire and its regimes for their continued existence. For species dependent on vegetation of a certain fire age, fire is essential to renew senescing vegetation. Within any single locality there may be species with a range of fire sensitivities or those that require a mosaic of fire age classes to meet different requirements of their life history.

The response of species to fire is multi-faceted and complex. Fire varies in intensity, seasonality, frequency and scale.[81] Climate, rainfall, the seedbank in the soil, nutrient cycling, patch size and successional changes in vegetation structure are several of many additional factors that influence species responses to fire in the short and long term. This infinite complexity of species responses to fire and the paucity of scientific data makes ecological fire management difficult.[1,82]

There are many dimensions and consequent threats posed to native biodiversity from habitat fragmentation, including changes to fire regimes, climate and the suitability of areas between patches of native vegetation.

Prior to European settlement, the unfragmented landscape supported a suite of different fire age classes of native vegetation in many spatial configurations. Now, fire regimes and their effects on population viability need to be considered in the context of a landscape which is highly modified and native vegetation is fragmented. Because species respond spatially as well as temporally to landscape changes, it follows that species responses to fire in small patches may differ to those of intact landscapes. Incomplete knowledge of ecological process within fragmented landscapes – particularly long-term population dynamics – may undermine the ability of managing agencies to implement appropriate fire regimes. In turn this may have adverse consequences for the quality of remnant vegetation and its ability to support fauna.

Climate change is predicted to result in an increase in the number of high fire index days for south-eastern Australia with a likely increase in fire frequency.[48] Vegetation that is sensitive to more intense and frequent fires would be at increased risk.

6.3.6 CLIMATE CHANGE

Climate change is an additional factor that adds to and interacts with a range of existing stressors that have already contributed to the decline in Australia's biodiversity. Predicting the changes caused by climate change to native vegetation and the biota it supports is difficult because of the confounding factor of current stressors and the paucity of knowledge about much of Australia's biodiversity and ecosystem processes. Climate change will also influence land use and socio-economic trends in Victoria in many ways.[83] Changes in climate will change land uses. For example, several stakeholders have reported a shift from sheep grazing to dryland cropping in southwest Victoria with drier conditions in recent years. Other examples include conversion of now rarely-inundated wetlands to cropping or improved pasture, reduced floodplain inundation along the Murray River and its tributaries, increased clearing in response to heightened fire risk and increased weed problems as weeds suited to the new climate are introduced or proliferate. These sorts of changes are likely to be as significant as more direct impacts of climate change on indigenous biodiversity, and add to uncertainty.

Physical changes

Climate change predictions suggest that Victoria will warm at a slightly faster rate than the global average with much warmer summers and springs.[47] Climate change will alter physical processes such as those relating to solar radiation, carbon dioxide concentrations, wind speed, water fluxes, the frequency and intensity of fire and snowfall. Changes in the physical environment affect physiological processes in plants such as the rate of photosynthesis, respiration, metabolic rate and water efficiency.

These changes will alter ecological processes involving plants. Given that the edges of patches function differently to interiors (see section 2.1.2), the impact from climate change is therefore likely to present itself first and be most evident at the edges of patches. Edges are most prominent in fragmented and relictual landscapes, particularly edges of small patches and linear features. It follows that the greatest rate and magnitude of changes to species assemblages in response to climate change is likely to occur in such patches and landscapes.

Changes to biodiversity

Although our scientific knowledge of Australian biota is incomplete, our understanding of ecological principles and the characteristics of plants and animals enable us to make some generalised predictions about impacts to species and ecosystems due to climate change.[1]

Evidence indicates that climate change influences life history traits of organisms, such as the timing of breeding or flowering, distribution, movement patterns, population dynamics, behaviour, morphology and physiology. Many of these changes disrupt normal ecological processes to the detriment of many species.[84,85]

Adaptation to climate change is predicted to work in two, non-mutually exclusive ways. Adaptation could involve in situ changes (i.e. without geographic change) and includes behavioural changes, acclimatisation and genetic adaptation. Adaptation may also involve changes to dispersal patterns. This may result in changes to a species' geographic range.[1] Because adaptation will be individualistic, some species may become extinct, species composition of communities will change, and novel ecosystems may result.

Climate change will have significant effects on biodiversity, particularly in fragmented landscapes. These effects will be complex and difficult to predict, and include indirect effects caused by alterations to human land uses in response to climate change.

Habitat quality and refugia

Typically, species naturally occur as scattered populations, with suitable habitat intermittently or never occupied. During periods of environmental stress or catastrophes, such as prolonged drought or fire, high quality habitat frequently provides 'refugia' for a given species until more favourable conditions return. Refugia are usually sites that have escaped or are minimally affected by the ecological turbulence occurring elsewhere. In the face of climate change, species distributions are more likely to be restricted to refugia as habitat quality decreases. Fragmentation and isolation of vegetation reduces the opportunity for species to retreat to refugia and, conversely, to emigrate from refugia and recolonise.

Stepping stones, connectivity and dispersal

An underlying premise of the role of connectivity in assisting species to adapt to climate change is that habitat niches of species will shift geographically with shifts in climate. Connectivity will assist highly mobile species such as birds, but there are many reasons why connectivity will fail to conserve some species in the future under climate change.

Dispersal rates for many species are very low. Many plants, for example, have poor long-distance dispersal capabilities. In the future, soils that support a given community of plants and their climate niche are unlikely to match, particularly where the resulting move in the climate envelope is geographically distant. A major shift in climate is likely to result in new community compositions. For example, a species of plant found today in the north of the Murray Mallee bioregion may be able to shift its range to the south of the bioregion. Improving connectivity may aid dispersal and species adaptation within the scale of the bioregion. However, if the climate niche suited to the given species of plant moves further south to the Wimmera bioregion, the soils may be unsuitable and the species will become extinct. Specialist species, whether plant or animal, intolerant of environmental variability and change will be more likely to be adversely affected by climate change.

Patches of vegetation are an important component of the landscape in providing habitat for species and maintaining wider ecosystem functions. In the future, expansions of native vegetation across the landscape will be needed to develop robust ecosystems so that components may withstand various threatening processes, adapt and sustain themselves under new environmental conditions.

THE VALUE OF SCATTERED TREES AND SMALL REMNANTS IN RURAL LANDSCAPES

In south-eastern Australia small patches comprising of one or a few large old ‘paddock trees’ are a conspicuous and iconic component of the rural landscape and are valued for their aesthetic appeal. Scattered trees provide an economic benefit such as shade to stock and, in a landscape context, lower the risk of dryland salinity and soil erosion. They are keystone structures because they provide disproportionately large ecological values and ecosystems services relative to the area they occupy. They provide habitat for many animal and plant species.

For example, scattered trees provide important habitat for bats,[37] several guilds of birds,[77] including the endangered red-tailed black cockatoo[5] and various species of possums.[78] Bats make extensive use of scattered trees as foraging habitat and possibly play an important role in the survival of scattered trees by regulating invertebrate numbers, particularly where insectivorous woodland birds are scarce.[37]

The number of scattered trees is declining due to clearing, dieback caused by defoliation by invertebrates, natural senescence and the lack of recruitment. Many scattered trees are estimated to be several hundred years old and recruitment is poor. It has been suggested that there may be a total loss of scattered trees from intensively managed rural landscapes in 40 to 185 years. The loss of scattered trees will result in loss of habitat for many species and a significant increase in the distance between patches which may have consequences for movement of flora and fauna.[86] Furthermore, scattered trees may have an important role in strategies to facilitate adaptive responses of organisms to climate change by providing habitat and connectivity.[87]

7

FUTURE DIRECTIONS

The preceding chapters have highlighted three areas. Firstly there is a pressing ecological need for and significant commitment across the Victorian community to connectivity and the conservation of remnant native vegetation. This has translated into a large number and variety of impressive efforts including many supported or undertaken by the State government, community volunteers and individual landowners. Secondly, there is a large body of scientific theory and analysis related to ecological connectivity, with a significant contribution from Victorian researchers. Thirdly, there is a large amount of spatially explicit digital information about the landscapes of Victoria that can be analysed to inform decision making.

The challenge is to integrate community support, science and spatial data to set directions for the future.

The challenge is to integrate these elements to establish scientifically-based directions for the future. Then the community – and particularly people working to improve connectivity – can be confident that the most effective use is being made of available resources. However, the profusion and complexity of questions that typically arise in the analysis of information can make it difficult to set directions for the future (see appendix 5).

The key overall question is what actions, and at which locations, would make the best contribution to the conservation of remnant native vegetation in Victoria? The answer to this question essentially comes down to comparisons of the costs, benefits and uncertainties of alternative courses of action, relative to specified objectives. When a course of action can be formulated from the large number of possibilities that exist, there can be significant achievements. Restoring habitat for the endangered grey-crowned babbler is one such achievement (see box, right).

In the following section, some of the possible barriers to translating information and analysis into effective action are addressed, and future directions and opportunities are proposed.

GREY-CROWNED BABBLER – A GOOD NEWS STORY

Despite the complexities of choosing what actions to pursue and where, there are many examples of people working to achieve great success in conserving biodiversity in fragmented landscapes. Often these examples start with educated guesses at the strategic level – the selection of broad landscapes and representative values that present the best opportunities for significant gains. Success is then very often associated with persistent commitment and extensive research and monitoring feeding back into subsequent decision making. These are all characteristics of the grey-crowned babbler recovery effort, particularly the two decades of work on the plains of the Victorian Riverina north of the Hume Highway between Avenel and Benalla.

The plight

Grey-crowned babblers *Pomatostomus temporalis* are charismatic birds found in open forest and savannah woodlands of northern, central and eastern Australia, and southern New Guinea. They are known for their delightful yahoo chatter and lively social behaviour.[90]

The grey-crowned babbler was once common and widespread through much of western, central and northern Victoria,[91] but by the 1960s naturalists began to note its decline. Since European settlement, the total Victorian population size is estimated to have declined by about 94% and the distribution has contracted significantly.[92] disappearing from south-west Victoria and most areas south of the Great Dividing Range.[90] The grey-crowned babbler is listed as a threatened species under the *Flora and Fauna Guarantee Act 1988*. Vegetation clearance and landscape modification are the main factors in its decline.[90, 93]

The research

The plight of the babbler in Victoria prompted investigations into its ecology and distribution. Monitoring of populations, family groups and detailed research into their breeding biology by scientists and community groups since 1992 has revealed crucial aspects of their life history, habitat requirements and the underlying processes causing decline.

Babblers are gregarious, living in territorial cooperative breeding groups. Groups typically consist of a single breeding pair and 1-12 'helpers', that assist with raising young and defending territories. Like many cooperatively breeding birds, the number of non-breeding helpers in the group is a significant determinant of breeding success – larger groups raise more offspring. Small groups frequently fail to produce any offspring.

About 75% of all surviving babbler groups in Victoria utilise remnant woodlands along roadsides. Grey-crowned babblers prefer sites with high densities of large trees for foraging, scattered understorey of small shrubs or trees for nesting and a sparse ground-layer.

Habitat extent and quality influences population size. Babbler groups are smaller and produce fewer offspring in areas with less woodland cover and poorer quality habitat.[92] Such small groups are at risk of dying out, further increasing the isolation of remaining groups and increasing the risk of local population extinction. Habitat fragmentation, loss and degradation, coupled with the species social behaviour has therefore contributed to their ongoing decline.

The guardians

Research into the ecology of the grey-crowned babbler has enabled specific actions to be developed and implemented to aid the recovery of populations. Over the past 20 years, numerous interested people (landholders, Friends of the Grey-crowned Babbler Group, scientists, local and state governments and conservation agencies) have collectively implemented actions at several sites across Victoria to prevent further decline of habitat and the populations they support. Actions include:

- research into threatening processes and ongoing detailed population monitoring
- the development by shires of roadside management plans identifying valuable babbler habitats
- fencing – to protect current stands of habitat from grazing by domestic stock, enable natural regeneration and to widen roadside habitat (public and private land), has been undertaken extensively in some areas
- habitat restoration on private and public land specifically targeted to grey-crowned babblers
- development of an up-to-date Flora and Fauna Guarantee Action Statement detailing future conservation objectives and actions.

An optimistic future

There are many other activities that could have potentially assisted in babbler recovery – such as pest plant and animal control, revegetation to connect isolated patches, captive breeding, protection and recruitment of isolated large trees. The key point is that research and monitoring has underpinned the selection of those combinations of actions and locations that are most likely to produce the greatest benefits for babbler conservation.

Where extensive habitat protection and revegetation programs have been undertaken, babbler populations have held their own and even increased in numbers. On the plains between Avenel and Violet Town, over 15 years of habitat restoration and protection have resulted in a significant increase in the number of babbler groups at sites where those works have occurred, compared with sites where no works have happened. The widening of existing roadside habitat through buffers on adjacent private land proved to be the most effective method of increasing habitat quality.[93]

Improvement in numbers has also occurred near Barmah, Rutherglen and the Lurg Hills near Benalla and where restoration and protection of woodland vegetation is being undertaken for the grey-crowned babbler and other woodland birds such as the regent honeyeater.[92] By increasing habitat protection and restoration at strategic sites that are known to be potential habitat, it is likely that the trend in increasing numbers will continue.

7.1 Clarity of terminology and objectives

The task of dealing with the complexity inherent in landscape ecology is often undermined by the imprecise use of several terms – of which the most common examples are connectivity, habitat fragmentation and biolinks (see glossary). All suffer from use varying from broad, loosely defined terms to one or more quite specific subsets of the umbrella term. 'Habitat fragmentation', for example, has been used to mean the isolation, loss, subdivision, degradation and spatial pattern of habitat or vegetation, as well as things such as edge effects and, finally, the broader term covering all these things. Similarly, 'connectivity' can mean habitat connectivity for individual species, landscape connectivity for the physical connectedness of patches, or ecological connectivity for connectedness of ecological processes.

Clarity of terminology and objectives is essential to moving forward.

Even when terminology is clear, the objectives of a landscape intervention may be loosely defined, and outcomes may be compromised or difficult to measure as a result.

For example, if the objective of improving connectivity is 'for all biodiversity', explicit surrogates to cover all biodiversity need to be specified and targeted. Improving connectivity for, literally, all biodiversity is a larger and less certain undertaking than more specific and limited objectives.

7.2 VEAC's approach to developing future directions

Environmental decision analysis is currently a very active area of scientific enquiry, with several researchers suggesting approaches to the difficulties in policy and planning for improving ecological connectivity (e.g. Hodgson et al. 2009, Moilanen et al. 2005).[88,89] The following principles have been applied to the currently available data and knowledge base to distil the key issues and discussion points detailed below.

- strategic level – VEAC is a statewide strategic-level planning advisory body so the identification of future directions should focus on those that are applicable over a number of landscapes in Victoria
- consensus – where there is broad consensus in the scientific community and stakeholders who have contributed to the investigation to this point, it is sensible to translate that consensus into future directions
- prioritise certainty – by addressing uncertainties more certain options may be neglected; known or current needs should be addressed over less certain or predicted needs (other things being equal), particularly where the costs of doing so are unlikely to be high.

The Council's intention is that the key issues and discussion points below be used as a basis for community input in the 60-day public consultation period for this discussion paper. This input will feed into the formulation of Council's approach to improving ecological connectivity, to be published in its final report to government due in March 2011. Details for making a submission are provided on the inside front cover of this discussion paper and on VEAC's website www.veac.vic.gov.au.

7.3 Key issues and discussion points

Several of the issues raised below are already being addressed in many of the government and non-government programs and activities listed in appendix 4 – which is not surprising given the role of consensus in the formulation of this list. Reiterating these issues here reinforces their importance in the context of this systematic statewide assessment of remnant native vegetation priorities.

7.3.1 RESOURCING

The level of government resourcing – principally funding – for remnant native vegetation was an important issue for several submitters and regional workshop attendees. There was clear consensus among these stakeholders that considerably greater investment was required for any substantial improvement in remnant native vegetation, and perhaps even just to maintain the status quo. Long-term under-funding of small public land blocks was frequently highlighted. This consensus is mirrored in other assessments and the scientific literature. A key point here is that additional investment is required for new initiatives but also for many current activities that would be much more effective with additional resourcing.

Nineteen key issues and discussion points are presented as a starting point for community response to this discussion paper. Details for making a submission are provided on the inside front cover.

Adequate financial and staff resources would be required for implementation of the measures flagged below, recognising that they include a number of substantial new initiatives and extensions to current programs that will require additional set up and ongoing resources.

7.3.2 PREVENTING FURTHER LOSS

By far the strongest consensus on any issue in the scientific literature is that for the retention of existing native vegetation. Even scientific papers advocating other courses of action typically emphasise the primacy of minimising the loss of existing native vegetation before moving on to other options. Many scientists argue that no other activities substitute for retaining existing vegetation.

The key influence on the extent of native vegetation in Victoria is the government's Net Gain policy, with the primary goal of 'a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation, leading to a net gain'. The policy is supported by a native vegetation accounting system to provide transparency and consistency in decision making. Under the policy, three steps are applied to decisions on the protection or removal of native vegetation: (1) *avoid* the removal of native vegetation, (2) *minimise* the removal of native vegetation through appropriate planning and design, and (3) appropriately *offset* the loss of native vegetation. The first assessment of the implementation of the Net Gain policy noted that around 1,600 hectares of woody native vegetation and 3,000 hectares of grassy native vegetation are being lost annually in Victoria – a small proportion of which is matched by offsets. The assessment noted that this represents a very significant loss of grassy native vegetation and noted measures to address it. Even for native woody vegetation there is a danger that, without sufficient emphasis on the 'avoid' component of the 'avoid-minimise-offset' approach, this level of loss will continue into the future and amount to many tens of thousands of hectares in the long term. Neglecting that emphasis in the context of emerging threats may even lead to increased levels of loss.

The government's Native Vegetation Framework repeatedly emphasises the primacy of avoiding clearing. However, some stakeholders have noted that the presence of options to minimise and, in particular, offset native vegetation loss encourages a tendency for the emphasis to drift towards those options and away from the avoid component. Vigilance is required to combat this tendency.

Maintaining and, where possible, strengthening existing measures to minimise any loss of native vegetation and to offset unavoidable losses is the most reliable, cost-effective and widely supported action to conserve remnant native vegetation.

7.3.3 PRIORITISING PATCHES OF HIGH SITE CONDITION IN LANDSCAPES WHERE THESE ARE RARE

As shown in section 5 there are many bioregions – or large parts of bioregions – with very few areas of high site condition (i.e. with a high aggregate site condition score of 50 or more). The ecological characteristics of these places – species composition, ecological processes, and community and habitat structure – are likely to most closely resemble the natural state of these otherwise highly altered landscapes. Accordingly, they are of exceptional importance for scientists wishing to understand or study the natural state of these habitats. They are also very important in providing direction for revegetation and habitat restoration. Finally, because of their naturalness they are likely to be good habitat for many species and likely to remain so even if the species composition changes with, for instance, changing climate.

Occupying a very small part of the landscape, it would seem cost-effective to identify larger patches of these high site condition areas and take appropriate steps to maintain or improve their condition. The steps to be taken would vary according to such things as land tenure (these areas are mostly on public land), the nature of the different site condition components (such as weediness, abundance of large trees) and threats to these values.

There is considerable merit in a program to find, document and maintain or enhance the condition of patches of vegetation with more than half a hectare of aggregate site condition score greater than 50 in the relictual and fragmented landscapes of the Victorian Volcanic Plain, Wimmera, Murray Mallee, Victorian Riverina, Dundas Tablelands, Murray Fans, Goldfields, Northern Inland Slopes and Lowan Mallee bioregions.

7.3.4 ROADSIDES

One of the key findings of this investigation has been the importance, by area, of native vegetation on road reserves in many Victorian landscapes – probably constituting around half the native vegetation in some areas. In this setting, native vegetation along road reserves is not just the connecting link between the important remnant habitat; it *is* the remaining habitat. This conceptual shift has significant management implications. When revegetating to increase extent, for example, the priority changes from adding to the end of long narrow strips for connectivity, to revegetating the sides of long narrow strips to increase patch thickness and hence resilience to edge effects and other threats. Another course of action in areas with significant roadside vegetation might be to realign roads to nearby cleared areas to facilitate the consolidation of the significant vegetation. Roads are commonly realigned outside road reserves for other reasons.

Also, in many landscapes road reserves retain features that are now rare elsewhere – such as vegetation types on fertile soils that have been heavily cleared, or large trees which have often been harvested from other private and public land categories.

However, this newly recognised information about the extent of roadside vegetation also poses a challenge in that there are large areas to be assessed in order to find those where action will be most effective. Fortunately, in many areas much of this work has been done by catchment management authorities, local government authorities and state government agencies. In some cases this has proceeded to on-ground management. It remains for assessments to be undertaken in areas that have not yet been surveyed and for the resulting information to be integrated with what has already been compiled to produce a coherent statewide coverage of the landscapes with the largest proportions of their native vegetation in road reserves. The priorities are the ten most cleared bioregions, and the Central Victorian Uplands, Northern Inland Slopes, Goldfields and Highlands – Southern Fall.

This inventory would be most effective if it focused on identifying characteristics important to improving connectivity and conservation of remnant native vegetation, including:

- road reserve patches to protect, augment extent (laterally and longitudinally), and improve condition
- road reserve patches with adjoining small areas outside the road reserve to protect, augment extent, and improve condition
- small strategic gaps to revegetate to improve connectivity.

Key threats to address include: inadvertent clearing (including dozing and slashing), deliberate clearing, planned and unplanned inappropriate fire, legal and illegal removal of fallen and standing wood (especially firewood), legal and illegal grazing, legal and illegal inappropriate slashing, and new and established pest plants.

There has been some concern expressed in the community about the role of roadside vegetation in the 7 February 2009 bushfires. Counsel Assisting the 2009 Victorian Bushfires Royal Commission concluded from the evidence about roadside vegetation and fire behaviour that: "in the overwhelming majority of instances, the severe weather conditions on 7 February 2009 … had the effect that roadside vegetation had no significant impact on the overall spread or shape of the fires". They also concluded that the presence of fallen logs and tree debris on the sides of roads has little impact on fire behaviour.[i] The Royal Commission will report in July 2010, and its findings and recommendations and the government's response will be taken into account in VEAC's final report.

A program is required to compile and complete assessments of native vegetation on road reserves in priority landscapes, and then to develop and implement management actions to protect and enhance remaining examples.

7.3.5 FIRE

Fire has been a prominent issue in public consultation through the early part of the investigation. All stakeholders appreciated the need to strike a balance between the competing factors in the management of fire and native vegetation, and the difficulties associated with doing so. There are many aspects to the relationship between fire and native vegetation, including:

- the effect of native vegetation on the spread of wildfire and on the ease or difficulty of fire fighting and escape from wildfire
- the effect of wildfire or managed fire on sustaining or depleting biodiversity
- the effect of managed fire on the frequency and spread of wildfire.

A key theme of the analysis for this investigation to date has been the diversity of landscape patterns across Victoria. There is great variation in the extent, condition, landscape context and vegetation types in different landscapes across the state. As a result of this variation, the relationships between fire and native vegetation will differ in different landscapes. It is important for both native vegetation and fire management, that the current development of new responses to the wildfire threat in Victoria incorporates this variation and is appropriate for the characteristics of that landscape. Submissions made by the State of Victoria to the 2009 Victorian Bushfires Royal Commission identify that the limitations and complexities raised by planned burning include the ecological impact of fire and acknowledgement that different ecosystems have differing requirements for and tolerances to fire.[ii]

The management of native vegetation and fire should vary across Victoria according to the specific characteristics of the diverse range of landscapes across the state.

[i] *Submissions of Counsel Assisting – Roads and Roadsides. 15 April 2010. SUBM.800.001.110*
[ii] *Submissions of State of Victoria on planned burning. 14 April 2010. RESP.3000.006.0064*

7.3.6 DIFFERENT APPROACH FOR WETLANDS

The policy emphasis on terrestrial native vegetation can result in the neglect of issues associated with the connectivity of wetlands, floodplains, riparian areas and, in particular, waterways. During the development of this discussion paper, wetlands, waterways, floodplains and riparian areas have emerged as an issue in several different contexts.

There are questions about the framework for quantifying site condition of dynamic or ephemeral ecosystems, in particular, relating to the reversibility of excessively poor site condition as a result of extended periods without flooding. For waterways with significant floodplains (chiefly but not exclusively along the Murray River and its tributaries), specific native vegetation issues are overwhelmed by the absence in recent decades of large-scale overbank flooding that sustains the vegetation and provides connectivity along and across the floodplains and between the rivers and their floodplains.

In some areas, particularly in southwest Victoria, as well as deteriorating due to reduced inflows in recent years, many ephemeral wetlands on private land are being lost to cropping as a result of that drying out.

Some large wetlands (e.g. Lake Corangamite) are mapped as native vegetation and so have misleadingly high landscape context scores. From one perspective, this is as it should be – the wetland and its margin are reasonably close to their natural state when native habitats covered the landscape and landscape context was high. From another perspective, particularly when the lake and its margin comprise a significant proportion of the remnant native vegetation in a region, this could create a misleadingly optimistic impression for much of the strictly terrestrial biota. That is, in reality large bodies of open water are probably barriers rather than conduits for the movement of many plant and animal species that live in adjoining terrestrial habitats – e.g. small skinks living in the scrubby vegetation around the margins of such wetlands are much more likely to disperse via the terrestrial vegetation around the lake margins than across the open water of the lakes. Some additional interpretation of landscape context is probably required in such situations.

Ultimately, several of these questions stem from the fact that ‘native vegetation’ is not always the best vehicle for addressing ecosystem issues – the same would be largely true, for example, for the introduced predator issue – rather than any problem with the method as such.

> Special approaches need to be developed to address a number of issues specific to wetlands, waterways, floodplains and riparian areas.

7.3.7 STREAM FRONTAGES

Victoria is fortunate that most of the frontages of permanent streams have been retained as public land, and that most of these frontages support native vegetation. As a consequence, a significant proportion of remnant native vegetation in many landscapes occurs along stream frontages. This native vegetation is significant in terms of both extent (in the order of 100,000 hectares (see table 3.2) and is of ecological importance, occurring generally in long narrow ‘connecting’ strips and often being among the most biodiverse, biologically productive and ecologically resilient parts of the landscape. Stream frontages have a number of characteristics relevant to discussion points on roadsides, wetlands and maximising effectiveness (sections 7.3.4, 7.3.6 and 7.3.10). It follows that, like the areas to which those discussion points pertain, stream frontages warrant special attention to maximise their contribution to ecological connectivity. The government recently completed a review of Crown frontages which has led to some measures to this end.

> Actions to maintain, improve and augment native vegetation on stream frontages are among the most likely to be highly beneficial for improving ecological connectivity and conserving biodiversity.

7.3.8 SMALL PUBLIC LAND RESERVES

In the most relictual and fragmented – and therefore most threatened – landscapes of Victoria, a relatively high proportion of remnant native vegetation is in a large number of small patches on public land. As well as road reserves and stream frontages, many of these patches are in small reserves such as bushland areas, streamside areas and nature conservation reserves. The analysis in section 4.2.6 has shown that the site condition of native vegetation on public land in these landscapes is often higher than for native vegetation on private land. However, it is unlikely that there will ever be sufficient resources to manage each of these blocks individually to the level that their scarcity and fragility warrants. Their management may be most effective if grouped into more or less homogeneous landscapes and managed as part of that landscape rather than as separate reserves.

Small public land reserves are an important element of relictual and fragmented landscapes. However, they are difficult to manage effectively and new approaches may be required to increase management effectiveness and community support for these reserves.

7.3.9 REVERSING GENERAL LOSS OF SITE CONDITION

With measures in place to control the reduction in extent of native vegetation (see 7.3.2 above), it is clear that deterioration in the condition of remnant native vegetation is now the main ongoing cause of native vegetation decline across Victoria. The scope of this issue is very large, in terms of the extent and diversity of areas and threats involved. While many initiatives are planned or underway to address elements of deteriorating site condition, the general improvement of site condition across the state is of such a scale that a significant increase in resourcing and planning is appropriate.

A program is required to maintain and improve the condition of remnant native vegetation generally, giving priority to the relictual landscapes of the Victorian Volcanic Plain, Wimmera, Murray Mallee, Victorian Riverina, Gippsland Plain, Dundas Tablelands, Murray Fans, Central Victorian Uplands, Goldfields and Northern Inland Slopes bioregions.

7.3.10 MAXIMISING LIKELY EFFECTIVENESS

At all spatial scales from the statewide to individual farms, there is variation across a wide range of environmental parameters, from the relatively simple such as elevation to complex parameters such as modelled habitat suitability. However a relatively small number of readily measured parameters can greatly assist in identifying and pursuing the most effective and certain directions for conserving remnant native vegetation. These parameters include:

- **biodiversity and biological productivity**
  Areas supporting more native species or individuals, or with high natural levels of biological productivity, are likely to continue to do so into the future and may be more stable and robust in the face of change.
- **endemism**
  Species with small geographic ranges often show limited ability to colonise other areas making them vulnerable to climate change and other threats. They tend to cluster in a relatively small number of places of limited geographic extent ('centres of endemism'). These sites have high irreplaceability and are a prime focus for conservation efforts.
- **irreplaceability**
  Ecological values other than endemic species may also be irreplaceable.
- **environmental heterogeneity**
  As well as often supporting greater species diversity, areas of environmental heterogeneity (especially with steep climate or elevation gradients) provide opportunities for populations to survive various environmental extremes – such as those predicted under climate change – by shifting between different types of vegetation, soils, aspects or elevations.
- **current threat**
  Generally, uncertainty will be reduced by addressing known current threats for which there are known solutions before addressing less certain threats with uncertain solutions.

Within any landscape, other things being equal, places that score highly on these parameters are more likely than others to produce the most effective outcomes for a given level of effort or resourcing. However, it is not simply a matter of cataloguing the relevant locations; the interaction of these parameters is critical, and decision-making tools that integrate these factors are required to incorporate such things as complementarity of locations in formulating the best outcomes.

In order to maximise the effectiveness and certainty of remnant native vegetation conservation, there is a need to identify and take steps to maintain and enhance the condition and extent of areas of native vegetation with high levels of biodiversity, biological productivity, endemism, irreplaceability, environmental heterogeneity and current threat.

7.3.11 INTEGRATING NATIVE VEGETATION MANAGEMENT ACROSS TENURES

Particularly in the most cleared landscapes, a high proportion of native vegetation occurs close to a public land-private land boundary, often in patches that cross the boundary. Especially in these landscapes, it is important to minimise potential constraints on the effectiveness of efforts to conserve remnant native vegetation, including real or perceived administrative barriers. The government's existing Good Neighbour program does this in the context of pest plant and animal control, focusing on the large proportion of pests that are a particular problem along the boundaries between public and private land and cleared and uncleared land. However, this issue is much broader than pest species, and cross-boundary cooperation should be encouraged anywhere it is required for effective remnant native vegetation conservation. Many private landholders express this sentiment, and suggest that the emphasis be not just on removing impediments but on providing encouragement through means such as the provision of expertise, and motivational and financial incentives.

Where patches of remnant native vegetation extend across private land-public land boundaries, there is demand for information, and motivational and financial incentives in order for private landholders to work with public land managers to improve and integrate the conservation of that remnant native vegetation.

7.3.12 ISOLATED LARGE TREES

Recent ecological research has highlighted the significance to connectivity of the intervening landscape or 'matrix' between patches of native vegetation, and in particular the importance of large isolated trees. In addition, in many areas these large trees make a significant contribution to the visual distinctiveness of rural landscapes and people's appreciation of them. However, in most places these large trees are ageing and there is limited recruitment of new trees to replace them. Active intervention is required if such trees are to be a feature of landscapes in the future. Because it has not been possible to detect and incorporate isolated trees into remote-sensed statewide-level vegetation analyses, targeted efforts may be required to address this problem.

Specific efforts are required to maximise the retention and replacement of large trees and very small patches isolated from other native vegetation.

7.3.13 ONGOING REPORTING, MONITORING AND MAPPING

Participants at VEAC's regional workshops appreciated the great value of the spatial data and analysis of remnant native vegetation used for this investigation, with many advocating for regular (e.g. five-yearly) updates of the assessments so that the information on which future planning for remnant native vegetation is based is not out of date and, in particular, so that trends can be evaluated and reported on. Such assessments would require ongoing maintenance and improvement of the key native vegetation mapped datasets such as the ecological vegetation class (EVC) and native vegetation extent datasets. It would be a major lost opportunity if DSE plans for updating native vegetation data were not realised.

DSE should be supported to continue to regularly update and report on the acquisition, modelling and analysis of native vegetation extent, condition and landscape context data and, in particular, use future updates to monitor and report on changes and trends in key parameters such as extent and site condition.

7.3.14 PUBLIC LAND MAPPING

The interim 1:25,000 statewide map of public land use generated by DSE for this investigation has led to several important findings and has the potential for many more. DSE is currently in the process of completing and refining this mapping. The modest cost of completing, refining and maintaining this mapping is likely to be outweighed by the benefits of its use for future assessments of remnant native vegetation alone, not to mention the benefits from many other potential applications. Without this mapping it would not be possible to differentiate the characteristics of remnant native vegetation on private land from that on public land, nor between different public land use categories. This differentiation is required to identify potential issues that need to be addressed, and strategies and management to address them.

Completion and ongoing maintenance of the statewide mapping of public land use at 1:25,000 scale is essential for reliable tenure information on which to base planning and management decisions.

7.3.15 NEW APPROACHES

Victoria has been a leader in using new approaches to understanding and conserving its remnant native vegetation – notably in the modelling of vegetation extent, condition and landscape context, and in the development of the habitat hectares method to account for changes in native vegetation. This strength needs to be maintained through continual commitment to new research and emerging approaches in order to make the most effective use of the limited resources available for conserving remnant native vegetation. The recently released draft Victorian Biodiversity Strategy 2010-2015[4] proposes a new approach by DSE to biodiversity conservation information for biodiversity practitioners called NaturePrint, which will be a dynamic tool designed for integrated analysis of conservation opportunities.

It is important to investigate, develop and incorporate new developments and approaches to assessing ecological connectivity (such as Circuitscape analysis and NaturePrint) into future planning for remnant native vegetation.

7.3.16 PUBLIC ACCESS TO INFORMATION

Stakeholders at VEAC's regional workshops in late 2009 were keenly interested in and greatly appreciative of the data and analyses that were presented. Many were unaware that some of the information of greatest interest to them was already available, albeit not always in an easily understood form. DSE has compiled and analysed the largest and most comprehensive native vegetation spatial data sets in Australia. The NaturePrint initiative described above is a further development of the information that will be made available in the future for biodiversity practitioners, However, to maximise the benefits and community appreciation of this work, there is a clear need for improved public communication as well, in particular:

- a single internet access point for data, analysis and maps with a simple guide to the location of the key elements
- improved interpretation to assist understanding of each piece of information and, in particular, how different pieces of information relate to each other and the overall approach
- greater awareness among key stakeholders of the availability of this information.

There is demand for ready public access to and interpretation of data, analysis and policy on remnant native vegetation.

7.3.17 EXPLAINING THE BASIS OF POLICY IMPLEMENTATION

As with the previous point, community understanding and support for measures to enhance remnant native vegetation would be greatly increased if there were a clear statement of why such measures were selected for implementation ahead of other options. That is, how the costs, benefits and uncertainties associated with selected measures better meet specified objectives than those of other potential measures. Explicitly stating this rationale will also improve clarity with monitoring and reporting of the implementation of selected measures.

There is a need for a readily accessible accounting framework documenting the objectives, costs, benefits and uncertainties of actions for the conservation of remnant native vegetation, to enable the public to understand the basis for the selection of favoured actions, and as a basis for monitoring and reporting on the implementation of those actions.

7.3.18 QUANTIFYING BENEFITS

As noted above, the quantification of benefits expected to arise from investment options is an essential element in comparing options, but is a topic that requires considerably more development to provide a satisfactory level of reliability. The habitat hectares approach is a significant step to this end, but continued support is required to further improve aspects of it – such as improving the capability to compare benefits in greatly dissimilar environments, and investigating the relationship of habitat hectares to long term biodiversity persistence. Continued support is also needed to account for other benefits of conserving remnant native vegetation such as carbon sequestration, soil and water quality, and groundwater hydrology.

Improved quantification of benefits is essential for reliable comparisons of alternative courses of action to improve connectivity and remnant native vegetation conservation.

7.3.19 INCREASING APPRECIATION

Almost unanimously, stakeholders actively engaged in the conservation of remnant native vegetation felt that both its importance and the level of threat it is under needed to be much more keenly appreciated by the broader public if it is to receive the support required to address the issues raised here.

It is important to improve public awareness, appreciation, education and interpretation of remnant native vegetation in Victoria, and particularly in relation to its importance for ecological sustainability, biodiversity conservation and buffering the impacts of climate change.

ABBREVIATIONS AND ACRONYMS

BOM	Bureau of Meteorology
CRG	Community Reference Group for VEAC's Remnant Native Vegetation Investigation
DCC	Department of Climate Change, Australian Government
DPC	Department of Premier and Cabinet, Victoria
DPI	Department of Primary Industries, Victoria
DSE	Department of Sustainability and Environment, Victoria
ECC	Environment Conservation Council, Victoria
EVC	Ecological Vegetation Class
IBRA	Interim Biogeographic Regionalisation for Australia
IPCC	Intergovernmental Panel on Climate Change
LCC	Land Conservation Council, Victoria
VEAC	Victorian Environmental Assessment Council
VCMC	Victorian Catchment Management Council

GLOSSARY

Biodiversity

The variety of all life forms, including different plants, animals and micro-organisms, encompassing their genes, species, ecosystems and their interactions.

Biota

The total assemblage of living organisms in an area

Biolinks

Broad geographic areas managed to increase ecological function and connectivity, improving the potential of plants and animals to disperse, recolonise, evolve and adapt

Bioregion

Large, geographically distinct areas of land characterised by landscape-scale natural features and environmental processes that influence the function of entire ecosystems. Bioregions are delineated by physical characteristics such as geology, landforms and climate.

Carbon sequestration

Capture and long-term storage of carbon in forests, soils and the ocean, reducing atmospheric carbon dioxide concentrations

Climate change

Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Climatic envelope

Spatial extent of the climate range encompassing the distribution of a species

CO_2

Carbon dioxide

Composite provenancing

Sourcing of seeds from multiple locations

Connectivity/Landscape connectivity

Structural connectivity:
the physical relationship between landscape elements

Functional or ecological connectivity:
the degree to which landscapes actually facilitate or impede the movement of organisms and processes. Functional connectivity is a product of both landscape structure and the response of the organisms and processes to this structure. Connectivity can be considered as connectedness 1) between patches of suitable habitat for an individual species

(single-species perspective) 2) of patterns of vegetation in the landscape (human perspective) 3) of ecological processes at multiple scales (ecosystem perspective).

Corridors

Strips of a particular patch type that differ from the adjacent land on both sides and connect two or more patches. See also 'wildlife corridor', below.

Disturbance

Any relatively discreet event in time that disrupts ecosystem, community or population structure and changes resources or the physical environment. The disruption event may be natural such as fire, snow, disease, wind, earthquake or flood or artificial in origin including timber harvesting, prescribed burning, slashing, clearing, or pollution.

Ecological connectivity

Connectivity between ecological processes at multiple scales

Ecological Vegetation Class (EVC)

One or a number of floristic communities that appear to be associated with a recognisable environmental niche, and which can be characterised by a number of their adaptive responses to ecological processes that operate at the landscape scale

Ecotonal boundary

The transition zone between two communities

Ecosystem

A system functioning together as a unit that includes all living organisms, the physical components of the environment and their relationships

Ecosystem resilience

The ability of a system to absorb and recover from disturbance while retaining the same basic function

Ecosystem services

The processes and conditions by which natural environments sustain and fulfil human life. Broadly, ecosystem services include a stable climate, clean air, water cycling and purification, nutrient cycling, soil formation, biomass production, waste disposal, crop pollination, provision of food and minerals, and the maintenance of genetic diversity.

Edge effects

Changes in biotic and abiotic conditions that occur at an ecosystem boundary

Endemic, endemism

Referring to a species which is native to a single geographic region and is found nowhere else

Erosion

The wearing away of land surface by wind, water, land-clearing practices or other natural or man-made processes

Extinct

A species or population is Extinct when there is no reasonable doubt that the last individual has died.

Extinction debt

The time lag between an environmental perturbation and the consequent extinction of a population, species or proportion of all species

Fire regime

Seasonality, frequency, intensity and extent of fires over a prolonged period

Floodplain

Lands adjacent to waterways that are subject to flooding

Flow regime

The pattern of changes in the season, timing, frequency, volume, rates of rise and fall, and duration of flows in a waterway. The flow regime or hydrology influences the physical nature of river channels, the biological diversity, and the key processes which sustain the aquatic ecosystem and ecosystem services.

Functional diversity

The variety and number of species that fulfil different functional roles in an ecosystem or ecological community

Gene

The basic unit of heredity of an organism – a region of genomic sequence, corresponding to a unit of inheritance which is associated with cellular processes

Gene complex

A group of genes that are located close together on a chromosome and, because of their close linkage, are inherited together acting as a functionally related unit

Genetic provenance

Sourcing of plants from local stock, with the implication that the genetic composition of local stock is best adapted to local conditions

Habitat

The physical space within which a species lives, and the abiotic and biotic entities in that space. Not synonymous with vegetation.

Habitat availability

The accessibility and procurability of physical and biological components of a habitat by animals relevant organisms

Habitat degradation

The reduction in quality or condition of an area of habitat for a given species thereby impairing the reproductive success or demographics of individuals or populations of the species

Habitat fragmentation

Functional separation of habitat patches for a given species

Habitat loss

Loss of habitat for a given species from an area, precluding that species from persisting there

Habitat quality

The ability of an area to provide conditions appropriate for individual and population persistence

Heterogeneity

A mix of two or more different landscape or vegetation elements

Inbreeding depression

Reduced fitness or vigour of a population as a result of breeding among related individuals

Landscape

A mosaic of heterogeneous landforms, vegetation types and land-uses

Landscape permeability

The degree to which regional landscapes, encompassing a variety of natural, semi-natural and developed land cover types, are conducive to wildlife movement and sustain ecological processes

Matrix

A component of the landscape, altered from its original state by human land-use, which may vary in cover from human-dominated to semi-natural and in which corridors and habitat patches are embedded

Meta-population

Spatially discrete populations functionally connected via dispersing individuals

Niche

The strength and frequencies of interactions between an organism and entities (e.g. resources, other animals) in its habitat

Patch

A discrete, relatively homogenous and non-linear area of vegetation that differs from its surroundings

Population demographics

The make-up of sex, age and breeding status of cohorts in a population

Recolonisation

The restoration of a population to an area within its range

Refugia

Places that escape or are minimally affected by a given ecological turbulence and thereby provide habitat for biota until more favourable conditions return

Resilience

The capacity of a system to absorb disturbance and re-organise so as to retain essentially the same function, structure and feedback loops

Riparian

Relating to or located on the banks of a river or stream

Robustness

A related concept to resilience, it is the ability to maintain some desire characteristics in the behaviour of its component parts or its environment

Scale

The spatial and/or temporal dimension in which a species or process operates

Vegetation remnant

Patch of native vegetation remaining after an area has been cleared or modified

Wetlands

Areas featuring permanent or temporary shallow open water that do not exceed a depth of 6 m at low tide. They include billabongs, marshes, swamps and lakes.

Wildlife corridor

Components of the landscape that facilitate the movement of given species and processes between areas of intact habitat – includes three different types:

Migration corridor: used by wildlife for annual migratory movements between source areas (e.g. winter and summer habitat).

Dispersal corridor: used for one-way movements of individuals or populations from one resource area to another.

Commuting corridor: link resource elements of a species' home range to support daily activities including breeding, resting and foraging

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APPENDIX 1

ADVISORY GROUPS

Community Reference Group

Ms Christine Forster AM, *Chair*

Mr Russell Costello, *Victorian National Parks Association*

Ms Ailsa Fox, *Victorian Farmers Federation*

Dr Jenny Lau, *Victoria Naturally Alliance*

Ms Jill McFarlane, *Victorian Conservation Management Network Advisory Group*

Mr Euan Moore, *Birds Australia*

Mr Luke Murphy, *Municipal Association of Victoria*

Mr Ian Stevenson, *Country Fire Authority*

Mr Glen Terry, *Greening Australia, Victoria*

Scientific Advisory Committee

Mr Rod Gowans PSM, *Chair*

Professor Andrew Bennett

Dr Sue McIntyre

Dr Denis A Saunders AM

APPENDIX 2

TECHNICAL PROTOCOL FOR STATEWIDE VEGETATION CONDITION AND LANDSCAPE CONTEXT MODELLING

Statewide vegetation condition modelling

Between 2003 and 2007 DSE staff compiled a database of vegetation condition (habitat hectares – see section 3.1.3 for details) from 15,067 sites. This information came from a variety of different research programs and government incentive schemes. The majority of these field sites were stratified across the landscape by vegetation type, tenure, and patch size. Other data were used opportunistically where available.

These field-based data were used to construct statistical models of native vegetation that were ecologically coherent across the whole of Victoria. These statistical models used a series of predictor variables such as climate variables, soil information (represented in remote-sensed radiometric data), solar radiation, terrain variables, land-use, vegetation, and median LANDSAT imagery. This imagery was calculated and collated as pixel-based median and standard deviation values from nine LANDSAT datasets (1989-2005) obtained from the former Australian Greenhouse Office. In total 58 variables (GIS and remote-sensed data) of biophysical and spectral data were assembled and examined for usefulness in model prediction.

The habitat hectare site condition field assessments were used as the dependent variable in a 'neural network' modelling procedure[94] that identified relationships between site condition scores and predictor variables. Neural networks are part of a family of 'machine-learning' techniques, which means that the computer is given a general task to produce the best fitting model possible, given the field site data and predictor variables (i.e. biophysical variables). The statistical models produced were developed to predict the scores assessed at sites in the field. This approach is preferable as it can account for significant non-linearity and spatial auto-correlation within both the predictor variables and field-based data. The modelling process uses an extensive cross-validation process during model development. This means that for each model iteration approximately half of the data is randomly allocated to build the statistical model, one quarter is used to assess peak model performance to avoid over-fitting the model, while the final remaining one quarter of the data is used to validate or check the model (i.e. how well the model predicted the site condition score, or the individual component score). This randomised process is repeated many thousands of times with all combinations of the predictor variables. These models were then used to predict 'unknown sites' (or pixels in the GIS environment) where site condition assessments have not been done previously. In this way the statistical model is spatially extrapolated across the whole of Victoria using 25 m x 25 m pixels. Data from further sites were then collected to validate the final map. Using this method the site condition score can be expressed across the whole of the state.[56,95] Statewide models of native vegetation have been published as spatial data by DSE, and these data are currently used for a variety of purposes concerned with policy formulation and setting, and as contextual information to inform investments in the management of Victoria's natural resources.

The outputs from the modelling are a useful interpretation of native vegetation cover, connectivity and quality, but users need to be aware of the limitations. The dataset:

- is designed for use at a large scale (1:25,000 to 1:100,000) and is not definitive at fine-scales. Any actions or interpretation at the site-scale should be informed through individual site assessments
- includes areas of native vegetation that have been significantly altered (e.g. areas that are now grassy due to the loss of trees)
- may exclude small areas of native vegetation that have not been adequately predicted by the model

Statewide landscape context modelling

Landscape context relates to the spatial component of remnant native vegetation which makes up the habitat hectare score. Landscape context describes the spatial characteristics of a patch within the local landscape. The context of a vegetation patch is important as it describes the spatial characteristics of patches that are considered to be biologically meaningful to biota. The general spatial characteristics (or metrics) considered important to biota can be divided into two categories:

i spatial characteristics of individual patches and,

ii spatial characteristics of landscape patterns.

Many geospatial studies have used a range of metrics to describe patches and landscape patterns. Generally a combination of one or more patch and landscape metrics is used. In the study used for DSE's landscape context layer, four patch and landscape metrics – patch size, patch shape, landscape proximity and landscape connectivity – were modelled by GIS to provide an assessment of landscape context for the state of Victoria at 25 m x 25 m pixel resolution.[96]

Patch metrics

Patch metrics aim to describe the combined qualities of patch size and shape. In reality there are innumerable patch size and shape combinations and, furthermore, patch definition can be subjective (e.g. species perspective dependent), with small differences in definition potentially leading to very large differences in patch statistics. The working definition of a patch used here would be 'remnant native vegetation first divided into linear strips less than 100 m wide and remaining larger patches'. For landscape context, several patch definitions were explored in GIS and the metrics selected were those considered most biologically meaningful. Patch rating was based on minimum patch thickness and patch area (table A2.1a), combined to give a patch rating score of 0-100 (table A2.1b).

Landscape metrics

Proximity and connectivity in the landscape were modelled using two metrics – the amount of vegetation surrounding patches and distances between patches of varying size and shape. For vegetation surrounding patches the percent of native vegetation in a series of concentric circles from a focal point was calculated (neighbourhood rating). Weighted distance analysis between a series of defined patches was calculated to obtain a connectivity rating. In this analysis, distance was only considered where no native vegetation existed – that is, native vegetation was not considered a constraint. The landscape rating was determined by adding the neighbourhood rating and connectivity rating.

The final landscape context rating was calculated as the sum of the patch rating and landscape rating.

Table A2.1
Landscape context metrics and scores[96]

a) Components contributing to landscape context

LANDSCAPE CONTEXT						
Patch Rating#				**Landscape Rating**		
Area Rating		Patch Thickness Rating		Neighbourhood Rating		Connectivity Rating
Patch Area (ha)	Rating	Thickness (m)	Rating	Neighbourhood (m)	% cover veg.	
≤ 1	1	≤ 25	0	100	**x**	**x**
1-5	2	26-50	1	250	**x**	
6-10	3	51-100	2	500	**x**	
11-20	4	101-200	5	1,000	**x**	
21-50	5	201-500	8	5,000	**x**	
51-100	6	>500	10			
101-250	7					
251-500	8					
501-1000	9					
>1000	10					

x = variable

= see part **b)** below

b) Patch ratings based on area rating (size) and patch thickness rating (shape)

SIZE CLASSES (ha)		**<1**	**1-5**	**5-10**	**10-20**	**20-50**	**50-100**	**100-250**	**250-500**	**500-1000**	**>1000**
Maximum thickness (m)	Rate	1	2	3	4	5	6	7	8	9	10
<25	0	5	10	15	20	25	30	35	40	45	50
25-50	1	10	15	20	25	30	35	40	45	50	55
50-100	2		20	25	30	35	40	45	50	55	60
100-200	5			40	45	50	55	60	65	70	75
200-500	8					65	70	75	80	85	90
>500	10						80	85	90	95	100

APPENDIX 3

SUMMARY STATISTICS FOR EACH BIOREGION

Most cleared bioregions | Moderately cleared bioregions | Least cleared bioregions

BIOREGION	TOTAL AREA (hectares)	FRAGMENTED LANDSCAPE						
			NATIVE VEGETATION EXTENT					
		Fragmented landscape area (% of bioregion area)	Area of RNV in fragmented landscape (% of fragmented landscape area)	Area of RNV on public land (% of all RNV in fragmented landscape)	Area of RNV in conservation reserves (% of all RNV in fragmented landscape / % total fragmented landscape area)	Median site condition score	Median landscape context score
Victorian Volcanic Plain	2,355,732	2,355,732 (100.0)	366,456 (15.6)	128,947 (35.2)	30,201 (8.2 / 1.3)	30.6	9.6
Wimmera	2,011,321	2,011,069 (100.0)	340,045 (16.9)	123,026 (36.2)	30,525 (9.0 / 1.5)	35.0	10.8
Warrnambool Plain	264,110	264,110 (100.0)	44,783 (17.0)	24,089 (53.8)	13,892 (31.0 / 5.3)	42.3	13.3
Murray Mallee	2,919,064	2,621,625 (89.8)	453,790 (17.3)	315,969 (69.6)	157,617 (34.7 / 6.0)	43.0	14.3
Victorian Riverina	1,890,328	1,890,328 (100.0)	362,815 (19.2)	73,885 (20.4)	10,896 (3.0 / 0.6)	29.7	9.7
Gippsland Plain	1,208,072	1,202,792 (99.6)	308,320 (25.6)	156,911 (50.9)	62,785 (20.4 / 5.2)	37.9	14.5
Dundas Tablelands	688,164	682,612 (99.2)	183,895 (26.9)	49,711 (27.0)	4,078 (2.2 / 0.6)	30.1	12.9
Strzelecki Ranges	342,179	342,179 (100.0)	105,683 (30.9)	46,086 (43.6)	5,208 (4.9 / 1.5)	47.2	13.7
Otway Plain	237,190	227,661(96.0)	73,910 (32.5)	46,189 (62.5)	23,442 (31.7 / 10.3)	49.9	15.2
Murray Fans	435,153	435,153 (100.0)	160,856 (37.0)	86,966 (54.1)	45,268 (28.1 / 10.4)	36.2	15.0
Central Victorian Uplands	1,217,609	1,184,327 (97.3)	527,251 (44.5)	201,969 (38.3)	52,244 (9.9 / 4.4)	38.0	14.7
Glenelg Plain	398,828	398,828 (100.0)	185,536 (46.5)	138,075 (74.4)	45,830 (24.7 / 11.5)	49.6	15.3
Northern Inland Slopes	565,808	565,078 (99.9)	264,187 (46.8)	124,476 (47.1)	54,650 (20.7 / 9.7)	38.7	15.1
Goldfields	1,325,762	1,325,762 (100.0)	711,954 (53.7)	313,497 (44.0)	117,986 (16.6 / 8.9)	33.2	15.3
Lowan Mallee	1,419,874	512,835 (36.1)	293,303 (57.2)	223,248 (76.1)	144,542 (49.3 / 28.2)	44.0	15.6
Highlands – Southern Fall	1,196,155	400,394 (33.5)	238,959 (59.7)	109,113 (45.7)	33,830 (14.2 / 8.4)	46.1	15.2
East Gippsland Lowlands	531,830	174,436 (32.8)	108,839 (62.4)	65,079 (59.8)	6,724 (6.2 / 3.9)	47.7	15.6
Monaro Tablelands	74,821	47,701 (63.8)	31,065 (65.1)	15,985 (51.5)	2,052 (6.6 / 4.3)	43.4	15.5
East Gippsland Uplands	791,031	158,517 (20.0)	105,717 (66.7)	45,258 (42.8)	8,100 (7.7 / 5.1)	43.9	15.8
Bridgewater	18,110	18,110 (100.0)	12,414 (68.5)	9,971 (80.3)	9,337 (75.2 / 51.6)	35.8	15.5
Highlands – Northern Fall	1,415,346	644,434 (45.5)	443,083 (68.8)	301,747 (68.1)	64,104 (14.5 / 9.9)	46.5	15.7
Otway Ranges	149,755	102,556 (68.5)	78,064 (76.1)	55,699 (71.4)	33,874 (43.4 / 33.0)	51.8	15.9
Greater Grampians	237,351	94,434 (39.8)	74,195 (78.6)	48,936 (66.0)	38,877 (52.4 / 41.2)	49.1	15.9
Robinvale Plains	64,186	42,054 (65.5)	33,576 (79.8)	26,391 (78.6)	5,934 (17.7 / 14.1)	41.3	15.5
Victorian Alps	714,321	11,868 (1.7)	10,688 (90.1)	8,778 (82.1)	3,311 (31.0 / 27.9)	49.2	16.6
Murray Scroll Belt	116,144	116,144 (100.0)	105,551 (90.9)	58,040 (55.0)	51,963 (49.2 / 44.7)	45.6	17.5
Wilsons Promontory	40,361	679 (1.7)	619 (91.2)	619 (100.0)	618 (99.8 / 91.0)	37.5	14.5
Highlands – Far East	70,018	883 (1.3)	827 (93.6)	799 (96.6)	17 (2.08 / 1.9)	50.6	16.4
STATEWIDE TOTAL	**22,698,620**	**17,832,299 (78.6)**	**5,626,379 (31.6)**	**2,799,460 (49.8)**	**1,057,904 (18.8 / 5.9)**	**36.8**	**14.9**

RNV = remnant native vegetation; all areas in hectares

More information can be accessed on the interactive page of the VEAC website: www.veac.vic.gov.au

APPENDIX 4

EXAMPLES OF ACTIVITIES TO IMPROVE CONNECTIVITY

The following list provides an overview of the diverse range of activities underway, with weblinks to assist those who would like to know more. It is not intended to be a comprehensive list which could include a vast number of activities – such as research, pest and erosion control, environmental water management, the Good Neighbour program and ongoing policy and programs such as the state government's Native Vegetation Framework[54] (see section 1.7.1) – many of which are part of the normal business of environmental management by private land managers and government. For example, the draft Victorian Biodiversity Strategy 2010-2015[4] quantifies the following examples of non-government networks working to protect and manage Victoria's biodiversity:

- Landcare networks (60) and groups (772)
- Conservation Management Networks (9)
- Land for Wildlife properties (5,900)
- Trust for Nature property owners (933 covenants – 38,490 ha, 51 reserves – 45,480 ha)
- 'Friends of' groups (800 parks, zoos etc.)
- Botanic Guardians and Bush Guardians (54 DSE, 16,229 ha)
- Coast Action groups (more than 150 groups, 15,000 volunteers)
- Committees of Management (1,300)
- Waterwatch groups (612 groups, 2,329 participants).

Websites that provide further examples include *app.iucn.org/dbtw-wpd/edocs/FR-021.pdf* (especially for research and international examples), *www.environment.gov.au/biodiversity/publications/conservation-incentive-design.html* and *www.globalrestorationnetwork.org/countries/australianew-zealand/*

The list below includes activities undertaken by government agencies and non-government organisations but many activities are partnerships involving many groups and individuals, often too numerous or dynamic to list here; see relevant websites for details. Similarly, many of the activities listed below overlap with others in various ways: smaller programs as subsets of larger initiatives, or networks of geographically complementary projects or activities, for example. For each example in the list, the following information is provided (in order): name, location, description or objective, and website.

Victorian activities (including some extending to nearby areas of other states)

Conservation Management Networks (CMNs)
Several areas in Victoria and New South Wales up to about 500,000 ha in size

A CMN is a network of sites with native vegetation. A CMN is also a network of people who work together to protect and restore these sites, and expand and link them across the landscape.
www.dse.vic.gov.au/cmn

Habitat 141 (Outback to Ocean); includes former Project Hindmarsh
Along Victoria-South Australia border and into southwest New South Wales

Restore the links between major national parks and nature reserves.
www.greeningaustralia.org.au/index.php?nodeId=91

Yarrilinks
Yarriambiack Shire, northwest Victoria

Bringing refugees and new immigrants to plant with local farmers for the protection, enhancement and restoration of native bushland, focusing on Buloke woodlands.
www.victorianaturally.org.au/page.php?nameIdentifier=yarrilinkschanginglivesandlandscapes

Buloke Biolink Project
Buloke Shire (northwest of Bendigo)

A remnant protection and enhancement project that also establishes new vegetation across the landscape.
mc2.vicnet.net.au/home/buloke-bio/web/frontpage.html

Regent Honeyeater Project
Lurg Hills near Benalla

Engages a whole farm community in restoring remnant box-ironbark habitat for endangered species and attracts ongoing support from a wide cross-section of the community to help farmers with on-ground works.
regenthoneyeater.org.au

Dookie Biolinks Program
Dookie region, west of Benalla

Community initiative to protect and connect existing vegetation, creek lines and wetlands throughout the Dookie region.
www.dookie.unimelb.edu.au/research/biolinks.html

Living Links

Southeast Metropolitan Melbourne

Establish a series of habitat corridors, linking existing open space, conservation reserves, recreation areas and fragmented patches of native vegetation.
www.ppwcma.vic.gov.au/projects_key_links.htm

Yarra4Life Biolink

Yarra Valley between Lilydale, Gembrook and Woori Yallock

Establish habitat corridors to connect Yellingbo Reserve with parks that surround the Yarra Valley to protect the Helmeted Honeyeater and other important local species.
www.ppwcma.vic.gov.au/projects_key_yarra.htm

Phillip Island Wildlife Corridor

Phillip Island

Establish a network of corridors across that will provide safe passage for birds and animals.
www.landcare.net/default.asp?action=page&catID=10&pageID=11

Upper Goulburn Catchment Waterway Restoration Project

Goulburn River, Howqua River, Jamieson River and King Parrot Creek

Protect and improve waterway frontage along four high-priority river reaches.
www.gbcma.vic.gov.au/theuppergoulburn/

Connecting Country

Mt Alexander Shire, central Victoria

Increase, enhance and restore biodiversity, and encourage new ways for the community to live compatibly within the landscape.
www.connectingcountry.org.au/

BushTender™

Various areas across Victoria

Auction-based approach to improving management of existing private land native vegetation. Landholders competitively tender for contracts to protect and improve their native vegetation. Successful bidders offer the best value for money and are paid under agreements signed with DSE for management commitments beyond those required by current obligations and legislation. Note that many CMAs have also run ‘BushTender’ projects focussing variously on river frontages, wetlands, grasslands and the like.
www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/15F9D8C40FE51BE64A256A72007E12DC37EBE3A50C29F4F8CA2573B6001A84D5

BushBroker™

Victoria (statewide) – subject to demand for native vegetation offsets

The Victorian government established BushBroker to help improve the quality and extent of native vegetation in the state. BushBroker facilitates the location of sites that could generate Native Vegetation Credits. These could potentially be used as offsets, on different properties to where native vegetation is being cleared (this is called a third party offset). Details of these sites are maintained on the BushBroker Database. Offsets can often be generated on the permit holder’s own property but there are situations where this is not possible. For example, where there is no suitable site on the property or the permit holder is not able to manage the native vegetation in the long-term. In most cases the clearing of any native vegetation that requires planning approval must be offset by a gain elsewhere. Offsets are permanently protected and linked to a particular clearing site.
www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/90D1EEF7733B9CD7CA256FA4001617CE4F65BBF1E5A3A721CA25720C00167A65

EcoTender

Pilot and trial areas scattered across Victoria

Auction-based approach that expands BushTender to include multiple environmental outcomes such as salinity, biodiversity, carbon sequestration and water quality.
www.dse.vic.gov.au/ecotender

Activities in other Australian states

Trees for Evelyn and Atherton Tablelands (TREAT)

Southern Atherton Tablelands, north Queensland

Community-based tree planting group.
www.treat.net.au/

Gondwana Link

Southwest Western Australia

Landscape scale vision to reconnect country across south-western Australia in which entire ecosystems, and the fundamental ecological processes that underpin them, are restored and maintained.
www.gondwanalink.org

NatureLinks (linking to Trans-Australia Eco-Link into NT)

Five corridors covering much of South Australia

A practical approach to conserving South Australia’s plants and animals by managing and restoring large areas of habitat across the state.
www.naturelinks.sa.gov.au/

Kosciuszko to Coast (K2C) – part of Great Eastern Ranges Initiative (see below)

Kosciuszko and Namadgi National Parks to the far south coast of New South Wales

Community partnership to help landholders reconnect isolated woodlands and grasslands.
www.k2c.org.au/index.htm

Slopes to Summit (S2S) – part of Great Eastern Ranges Initiative (see below)
Kosciuszko National Park to the western slopes near Albury

Partners working together to link natural areas.
www.environment.nsw.gov.au/ger/conservation.htm#slo

River Recovery
Hawkesbury-Nepean River Basins

Rehabilitating 2,500 km of river and stream banks to ensure the future of water quality, biodiversity and recreational values.
www.greeningaustralia.org.au/index.php?nodeId=36

Box Gum Stewardship Program
Wheat-sheep belt from Queensland to Victoria

Provides eligible land managers with the opportunity to competitively bid (voluntarily) for Australian government assistance for up to 15 years to actively manage and conserve box gum grassy woodland on their land.
www.nrm.gov.au/stewardship/box-gum/index.html

Australian continental-scale activities

WildCountry program
Australia-wide

Science-based, continent-wide approach to conservation planning and understanding of large-scale connections.
www.wilderness.org.au/articles/wc_science/?searchterm=%20WildCountry%20Program

Great Eastern Ranges Initiative (formerly Atherton to Alps – A2A)
2,800 km along the Great Dividing Range

Build awareness to inspire people to take action through regional partnerships.
www.greateasternranges.org.au

International activities

Global Restoration Network
Global

Web-based information on restoration in order to link research, projects and practitioners and foster an innovative exchange of experience, vision, and expertise.
www.globalrestorationnetwork.org/

Yellowstone to Yukon Conservation Initiative
Western Canada and USA

Ensure that the region retains enough connected, well-managed and good-quality wildlife habitat so that animals can safely travel between protected areas in search of food and mates.
www.y2y.net/

National Ecological Network (Ecologische Hoofdstructuur, EHS)
Netherlands

Intended to be a continuous network of high-quality nature areas to enable the sustainable preservation of both common and rare plant and animal species in the Netherlands. By 2018, the network should comprise 750,000 hectares, or roughly 18% of the Netherlands' area.
www.mnp.nl/mnc/i-en-1298.html

Wildlands Network (formerly Wildlands Project)
USA

Restore, protect and connect North America's best wild places.
www.twp.org/about-us

USDA Conservation Reserve Program Continuous Sign-up
USA

Voluntary program that helps agricultural producers safeguard environmentally sensitive land – participants plant long-term, resource-conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat in return for rental payments and cost-share assistance.
www.fsa.usda.gov/FSA/newsReleases?area=newsroom&subject=landing&topic=pfs&newstype=prfactsheet&type=detail&item=pf_20060601_consv_en_crpcsup06.html

EECONET Action Fund
Eurasia

Funds third parties (semi-state government organisations e.g. National Parks, and non-governmental organisations) to buy or lease important natural sites which contribute to the Pan European Ecological Network.
www.eeconet.org/eaf/network/index.html

Terai Arc Landscape Project (TAL)
Nepal and India

Promotes conservation by local community action while enhancing the quality of life for local people by encouraging their involvement. Covers 11 protected areas and large non-protected areas between them, including corridors and bottlenecks that are critical for wildlife movement from one protected area to another.
nepal.panda.org/our_solutions/conservation_nepal/tal/project/

Pumlumon
Wales

Work with local people to guide a major change in the way the land is managed, to create a more varied landscape that is rich in wildlife and to give the local communities a better future.
www.montwt.co.uk/pumlumon.html

APPENDIX 5

QUESTIONS THAT MAY COMPLICATE FUTURE DIRECTIONS

An array of complex, difficult and often quite specific questions, such as those listed below, can frustrate the setting of directions for the future. For this and other reasons, VEAC has taken a more strategic approach (see section 7).

What actions should be taken and in what circumstances?

- minimise further loss of native vegetation extent
- recreate or revegetate areas devoid of native vegetation – active (e.g. planting or seeding) or passive (e.g. removing stock grazing to allow vegetation to re-establish itself)
- restore or improve the condition of existing native vegetation (i.e. improve site condition) – active (e.g. planting or removing weeds) or passive (e.g. mitigating threats such as firewood collection or soil disturbance)
- other management actions to improve ecosystem health (e.g. reinstating flood regimes or controlling feral animals)
- revegetate to increase the size or reduce the edge-to-area ratio of isolated patches
- revegetate to link or unite isolated patches
- improve conservation reserve system representation
- provide market-based incentives for improving conservation of remnant native vegetation
- establish local groups such as conservation management networks
- acquire private land for management within the public estate
- improve the information base and people's access to it
- prepare for future threats (e.g. build ecosystem resilience)

To what degree should these actions be pursued (e.g. how much revegetation or improvement in condition is desirable or optimal)? Are there thresholds at which the cost-effectiveness of actions declines or increases steeply?

What are the advantages and disadvantages of considering remnant native vegetation and ecological connectivity from different perspectives or parameters?

- landscape 'structure' (physical patterns)
- landscape and ecological processes and functioning
- at the landscape scale or patch scale?

How significant is the role of the intervening 'matrix' between identified patches of native vegetation – including rocks and other landforms, isolated indigenous trees, non-indigenous trees and shrubs, exotic ground vegetation, and built infrastructure?

What are the characteristics of landscapes, or areas within them, that might be used to identify where to act?

- areas supporting values that are rare or not found elsewhere (endemism)
- areas with greater richness or abundance of species or threatened species
- areas of environmental diversity/heterogeneity
- productive areas
- riparian areas
- roadsides
- refuges
- biolinks
- most depleted areas (most cleared, poorest landscape context or site condition)
- moderately depleted areas – may result in greater benefits than more depleted areas
- areas with least uncertainty of specified objectives being met

Are there settings or places where the cost or cost-benefit ratio of any actions are so unfavourable that they should be abandoned (i.e. acceptance of the loss of some values)?

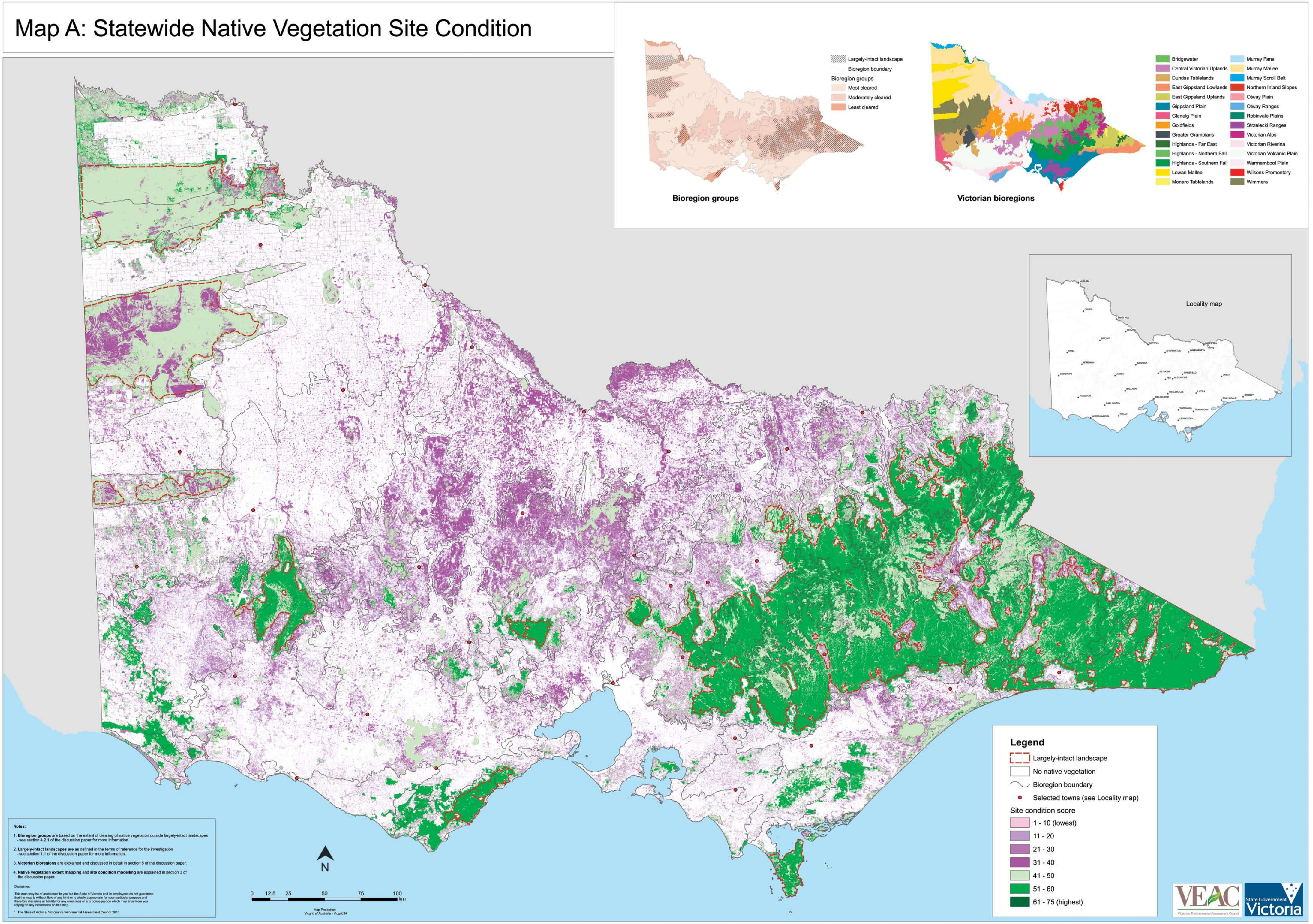
What are the specific objectives of improving connectivity and why?

- for one or more particular species
- for all species with limited dispersal capabilities
- for ecological processes
- to mitigate the effects of climate change
- for all biodiversity, with an emphasis on one or more specified species
- for all biodiversity
- for landscape sustainability

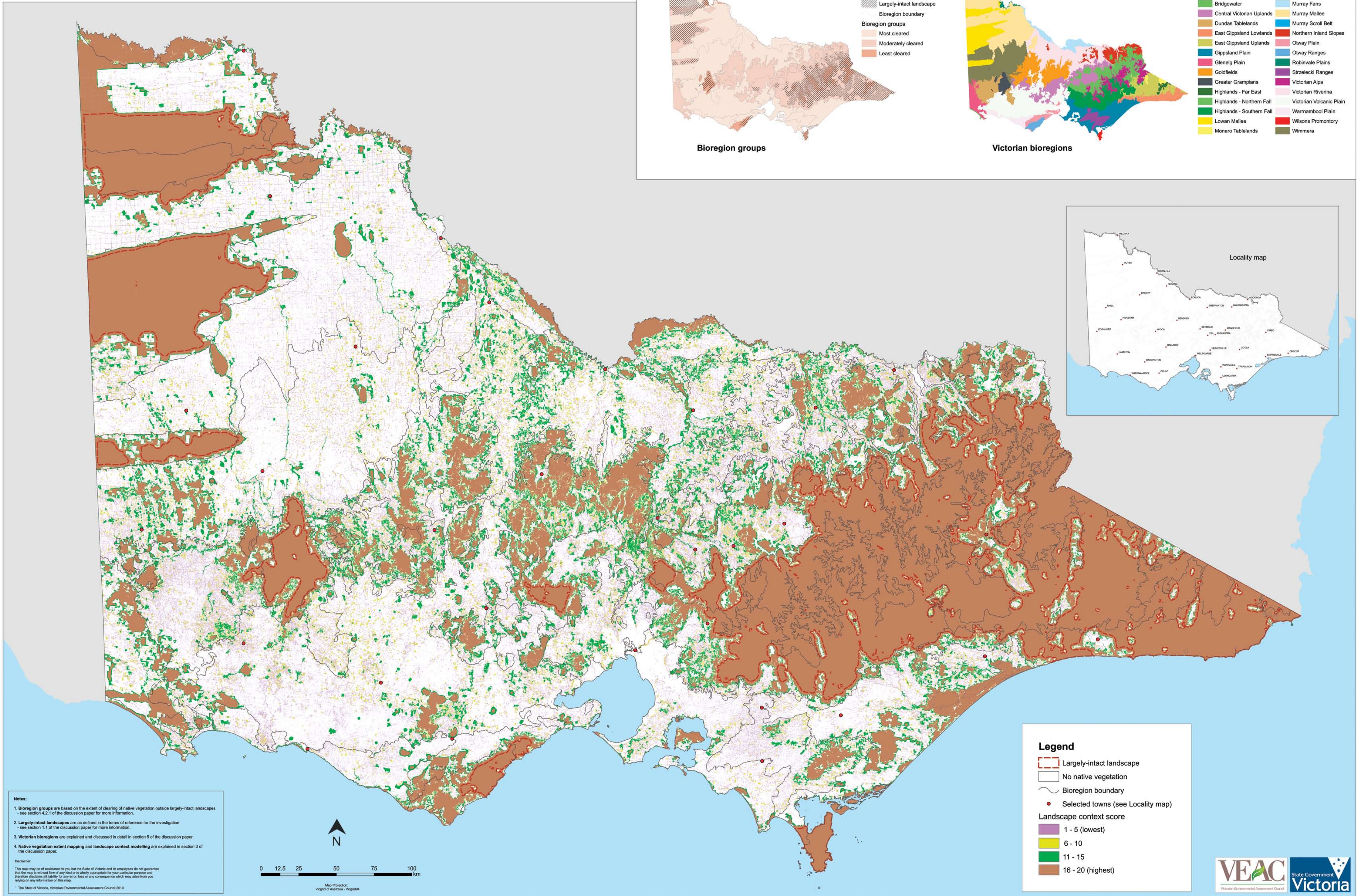
What measures would best deal with the effects of climate change?

- identifying and safeguard key places such as refuges, climate gradients or likely paths of retreat
- developing elaborate predictive tools such as models
- increasing the extent of the protected area system
- increasing physical or ecological connectivity
- improving site condition

Map A: Statewide Native Vegetation Site Condition



Map B: Statewide Native Vegetation Landscape Context



Notes:

1. **Bioregion groups** are based on the extent of clearing of native vegetation outside largely-intact landscapes - see section 4.2.1 of the discussion paper for more information.
2. **Largely-intact landscapes** are as defined in the terms of reference for the investigation - see section 1.1 of the discussion paper for more information.
3. **Victorian bioregions** are explained and discussed in detail in section 5 of the discussion paper.
4. **Native vegetation extent mapping** and **landscape context modelling** are explained in section 3 of the discussion paper.

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